Reading Questions: Encouraging Students to Read the Text Before Coming to Class

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College science teachers know that students get the most out of class if they have completed the assigned reading. To reinforce this expectation, we ask our introductory physics students to submit a question they had about the reading. In this paper we describe the rationale and logistics of this assignment.

In most introductory science courses, professors tell students that they should read the relevant sections of the textbook before coming to class. Yet most faculty complain that their students rarely do this (e.g., Felder and Brent 1996). One proven way to encourage students to read before class is to have a reading quiz (Felder and Brent 1996; Mazur 1997). This is a short quiz that students either take online or at the beginning of class to determine if they have a basic understanding of the reading material. We believe that this approach has several pedagogical and procedural problems and have begun using “reading questions” in our introductory physics courses as an alternative. A reading question is a question that each student poses to the instructor via email after completing the assigned reading, but before the next class. In writing the question, students are expected to describe a difficulty they had understanding some aspect of the material and ask a specific question. This article will first clarify why we are not satisfied with reading quizzes, describe the way that we use reading questions in our introductory physics courses, and, finally, present some data representing student attitudes towards reading questions and their performance in courses where reading questions are used.

The problems with reading quizzes

In our opinion there are two basic problems with the use of reading quizzes as a technique to encourage students to read introductory science texts. The first is that it is very difficult to write quiz questions at an appropriate level. Since our classes focus on meaningful understanding of physics concepts, a good question will go beyond checking to see if a student has simply memorized the bolded definitions and formulas in the text. We do not want to do anything to sustain students’ naïve beliefs that physics is all about memorizing and applying formulas (Redish, Saul, and Steinberg 1998). On the other hand, a reading quiz cannot contain difficult questions that require students to have already developed a meaningful understanding of the topic. After all, if they were able to develop such an understanding just from reading the text instructors would be redundant. Our purpose in assigning reading is for students to have an introduction to the topic so that we can spend valuable class time discussing the topic together rather than essentially reading the text to them. The second problem with the reading quiz approach is that it is a teacher-centered approach. Significant research suggests that students learn better when teachers attempt to understand and build on student ideas (NRC 1999). Although quiz results do allow a teacher to gain some understanding of student ideas, a reading quiz only collects information that the teacher thinks to ask about. We have often found that students have ideas that we could never have imagined. Further, in reading quizzes students rely on the teacher to assess their understanding. We would like students to become better at assessing their own understanding.

Reading questions

As a result of this dissatisfaction with reading quizzes and a desire to have students delve into the text in a meaningful way before class, one of us (AR) developed the idea of using reading questions[1]. A reading question is a question that a student has after reading the assigned section of the text. In our introductory physics classes, students are asked to submit one or more reading questions after each reading assignment—typically about once per week. The actual assignment that we give students is shown in Figure 1.

Strengths of reading questions

In using reading questions for the last three years in our large-lecture introductory physics courses we have found that there are at least five significant strengths of this pedagogical tool.

1. Instructor gets valuable information about student understanding. We have found student responses to be quite enlightening and help us better shape the course to meet their learning needs. Reading questions can:
   - Provide a glimpse into the way that students conceive of the physics concepts. Table 1 shows examples of some representative student submissions and our analysis of the underlying student thinking in the context of an introductory physics course. Note that we can learn about problems that students are having both directly (e.g., student explicitly describes the problem in a reading question) and indirectly (e.g., inferences about student understanding can be made from the way student asks the question). Issues that come up in only one reading question can be addressed with an individual email, but issues that come up in several reading questions are probably most effectively addressed with the whole class.
   - Identify significant weaknesses in the textbook. All textbooks have misleading or even incorrect content. The use of reading questions has helped us to identify some of these aspects of our current introductory physics text.
   - Identify important concepts that are adequately addressed by the textbook. We have found that some important concepts from the reading do not seem to result in reading questions. Informal assessments in class suggest that when there are no reading questions about a particular topic it is generally safe to assume that most students were able to understand it from the reading alone and little further work in class is necessary.
   - Identify an issue that may not be central but is the source of such consternation that further explanation is useful. For example, in a reading assignment dealing with calculating magnetic fields, a reasonable number of students were troubled by the fact

that the magnetic field exterior to a solenoid is assumed to be negligible while the field exterior to a bar magnet is not.

2. Students actually read the text. By having students read the text in advance, class time need not be used presenting basic ideas, but rather can be used to help students gain a better understanding of these ideas. Thus, we are able to use a significant portion of our class time having students engaged in small group work.
3. Classroom atmosphere is enhanced. We want to promote a class atmosphere where students and teachers work together to learn the material. Reading quizzes emphasize the adversarial aspects of the student-teacher relationship since the teacher is in the role of judge. In addition, many students are quite anxious about taking any sort of quiz. Reading questions emphasize the cooperative aspects of the student-teacher relationship since the teacher is working with students to address their concerns. Students know that they can get full credit on a reading question assignment if they actually do the reading and think about their understanding.
4. Opportunity for one-on-one interaction between students and faculty. By answering a small portion of student questions individually, students get a sense that they are noticed in class, their concerns are taken seriously, and the instructor cares about them and their understanding.
5. Reading questions can serve as a basis for lectures. There are several ways to do this. One is to put a student question on the overhead (with the student name removed) and ask the class to discuss with their neighbors how they would counsel you to respond to the question. Another is to identify issues that came up in several questions, read a representative question or two, and then provide an answer. Students seem to pay much more attention to this mode than a simple presentation of the topic.

Using reading questions—logistical considerations

Both authors have used reading questions with their introductory calculus-based physics courses. These are mid-sized courses, typically having about 70 students per section. We base these logistical suggestions on our experience with reading question assignments in this context.

- Assign some portion of the course grade to reading questions. We often make reading questions count for 5% of the final course grade.
- At the beginning of the course (first one or two reading assignments) it is worth the extra time required to respond to unsatisfactory questions, suggesting ways for students to improve.
- Answer some reading questions by email. We usually try to answer about 1/3 of the submitted questions individually. This is most important at the beginning of the course.
- Refer to reading questions in class and show examples. Students need to see that you are reading their questions and taking them seriously. Some questions are a good source for class discussions. This has the added benefit of showing students what a “good” reading question looks like. Some can be referred to in class (e.g., “a number of students indicated confusion about ___ in their reading questions”).
- Grading is fairly quick. It usually takes about one hour per class of 70 students to grade an entire set of reading questions and respond individually to about 1/3 of the class. Although grading is somewhat subjective, neither of us has ever had a student complain about a reading question score.

- Set up a separate email account to receive reading questions. We instruct our students to submit the questions via WebCT (our campus-wide course management system). All of the reading questions can then be read at once and they do not clog up our normal email inbox.

Do students like reading questions?

Overall, students appear to be fairly neutral about being assigned reading questions. This is a positive finding in the sense that students are often resistant to reformed methods of instruction (Felder and Brent 1996; Slater 2003), but a negative finding in the sense that students may not take the reading assignment seriously if they do not view it as important. In end-of-year surveys we ask students to rate various aspects of the course in terms of how much they feel each aspect has contributed to their learning (on a 5-point scale from 1 = very harmful to 5 = extremely helpful). In Fall 2004, for example, the average rating of reading questions was a 3.0. Students also responded to the question: "Having to write a reading question encouraged me to read the textbook carefully and think about the material." Again, in Fall 2004, 28% responded "quite often" or "almost always," 28% responded "sometimes," and 44% responded "hardly ever" or "not very often."

Do reading questions contribute to student learning?

One way to examine the success of an instructional innovation is to look at student course outcomes. The Conceptual Survey in Electricity and Magnetism (Maloney et al. 2001) is a 32-item, multiple-choice test that we routinely use as a course assessment instrument. It probes student understanding of many topics commonly covered in the second semester of an introductory calculus-based physics course. Table 2 shows that student outcomes in our courses are significantly higher than those in similar courses at other universities. Reading questions are only one aspect of our student-centered introductory physics courses, so it is impossible to attribute positive course outcomes to reading questions. Others have argued, however, that in order to spend time having meaningful discussions of important issues in class it is necessary to have students read the text in advance (Felder and Brent 1996; Mazur 1997). Thus, we believe that reading questions are an important part of our instructional system that contribute to our positive course outcomes.

Another way to examine the effectiveness of reading questions is to see how reading question scores correlate with other valued aspects of the class. The class was broken into four groups based on their reading question scores. Students who submitted fewer than half of the reading assignments were put in the "not serious" category. Their average reading assignment score was 6%. The remaining students were put into three groups: Low (reading assignment score was between 30% and 60%, average of 47%), Medium (reading assignment score was between 61% and 89%, average of 79%), and High (reading assignment score was greater than 90%, average of 98%). Figure 2 shows that students who score well on reading questions tend to do better on the final exam than students who score poorly on reading questions. The difference in final exam scores between the Low and High group represents a full letter grade. This suggests that students who have the skill and motivation to read the text reflectively and submit a thoughtful reading question benefit from this experience. An interesting question for further exploration is whether we can explicitly teach students to write better reading questions and, if so, whether this will lead to improved learning.

Conclusions

In this article we have presented our rationale for using reading questions, information about how to use reading questions, and limited data that suggests reading questions are an effective part of our introductory physics courses. Specifically, reading questions

- provide instructors with information about student understanding,
- encourage students to read the text before class,
- promote a positive, student-centered class atmosphere,
- facilitate one-on-one interactions between the students and instructor, and
- provide instructors with readymade material for classroom discussions.

We have enjoyed experimenting with reading questions and we hope that this article encourages other instructors to do the same.

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Notes

1. The idea of asking students to pose a question via email about a reading assignment has previously been published in the context of an introductory biology course (Marbach-Ad and Sokolove 2000). We were unaware of this work until we conducted a literature search in preparation of this manuscript. Their use of reading questions is somewhat different from ours.

References

Felder, R.M., and R. Brent. 1996. Navigating the bumpy road to student-centered instruction. *College Teaching* 44 (2): 43–47.

Maloney, D., T. O'Kuma, C.J. Hieggelke, and A. Van Heuvelen. 2001. Surveying students' conceptual knowledge of electricity and magnetism. *American Journal of Physics* 69 (7): S12–S23.

Marbach-Ad, G., and P.G. Sokolove. 2000. Can undergraduate biology students learn to ask higher-level questions? *Journal of Research in Science Teaching* 37 (8): 854–870.

Mazur, E. 1997. *Peer instruction: A user's manual*. Upper Saddle River, New Jersey: Prentice Hall.

National Research Council (NRC). 1999. *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

Redish, E.F., J.M. Saul, and R.N. Steinberg. 1998. Student expectations in introductory physics. *American Journal of Physics* 66 (3): 212–224.

Slater, T.F. 2003. When is a good day teaching a bad thing? *Physics Teacher* 41 (7): 437–438.

Figure 1: Description of the reading assignment that we distribute to students.

Reading questions
A physics text cannot be read like a cheap novel. Reading it requires active engagement and is best done with pencil in hand. Keep notes of the important ideas and any questions that come to your mind. Make sure you understand all the worked examples, not just their algebraic details but also more importantly the strategy that is used to work them out. At the end of a section of text you will almost certainly have unanswered questions about the material. You are asked to submit one or more of these “reading questions” by email.

Reading questions will be judged on the seriousness of thought that goes into them. A casual reading several minutes before class and an in-depth reading the previous night will result in different kinds of questions. These differences will be reflected in the grading.

0 = nothing turned in
1 = no evidence of significant thought
2 = evidence of significant thought
3 = shows deep and sustained thought

Reading questions should be submitted using the mail feature on the course WebCT site.

<u>Examples of good and poor questions</u>

<u>Good:</u>
“In figure 5, how can the same electric current go through resistors #1 and #2? Doesn’t some of the current get used up in heating resistor #1?”
<u>Poor:</u>
“In figure 5, how can the same electric current go through resistors #1 and #2?”

<u>Good:</u>
“I didn’t understand the minus sign in equation 15. The sign should describe the velocity of the ball in figure 12, and because the ball is moving to the right, in the positive x direction, I think the sign should be positive.”
<u>Poor:</u>
“I didn’t understand the minus sign in equation 15.”

If you don’t have any questions of your own, look at the ones at the end of the chapter. If you want to turn in one of these you will have to show that you seriously thought about it.

Figure 2: Relationship between score on reading questions and final exam for Fall 2004 introductory calculus-based physics course.

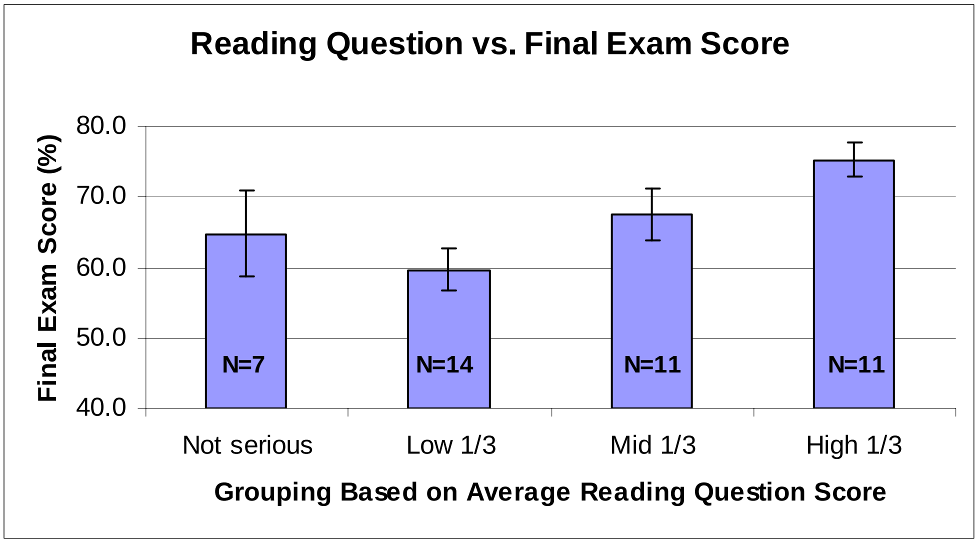

Table 1: A few representative reading questions and the inferences that we have made about student thinking based on them. The reading questions were all from a single reading assignment and are unedited.

Question	Inferences about student thinking
When you ground out the electroscope with your hand, why does it ground? You are wearing shoes and rubber is a good insulator, so is it just absorbed into your body and not really truly grounded?	The word “ground,” although explained in the text as referring to contact with any relatively large conductor, has not yet been internalized.
If electrons are not free to move in an insulator then why is it that there can be a realignment of charges in the molecules when you bring a charged particle toward an insulator?	Student has overgeneralized the phrase “charge is not free to move in an insulator” as applying to molecular distances.
If a positive charge is placed close to but never touches a hollow metal sphere with a negative charge q inside, what reaction will q take? I wasn't sure because I don't understand if there can be a transfer of charge through the air for the positive charge to have an effect on q. Or if the sphere will just block the charges from each other almost.	A conductor placed between two charges somehow “blocks” their effects on each other. Student fails to appreciate the polarization of the conductor and the effect this polarization has on nearby charges.
Why is the Earth a "sink" to electrons only? Is the Earth ultimately positively charged or are all of the negative charges in the Earth towards the core, and all the positive charge on the surface?	The student has not seen an example where positive charge flows to ground and incorrectly assumes that this cannot happen.
Why can't Coulomb's number be more accurate? It first started out as only a couple percent off and now it is 10^16 but why can't it get to be a more accurate number? It would seem that a computer would be able to get it to be very, very specific.	Student does not appreciate that physical constants, unlike mathematical ones, are acquired by experiment. This is not a rare misconception!
I don't understand what they mean by full deflection of a galvanometer. I understand it's the component of ammeters and voltmeters, but deflection of the galvanometer I assume is the max reading a voltmeter or ammeter can give?	Student is confused by use of an outdated terminology. The student has probably never seen an analog electrical measuring instrument (which is what a galvanometer is).

Table 2: Comparison of CSEM scores between national data and WMU data for classes using reading questions. All data represent the same set of students pre and post.

	CSEM Pre (%)	CSEM Post (%)
National data (*N* = 1213) (Maloney et al. 2001)	31 ± 0.3	47 ± 0.5
WMU average over four classes (*N* = 173)	31 ± 0.8	58 ± 1.4