Reading questions in large lecture courses.

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Available at: https://works.bepress.com/elizabeth_vierling/21/
The basic challenges associated with teaching undergraduate biochemistry are not significantly different from those of teaching other undergraduate science courses. The class sizes are often greater than 100 students, the content is complex and challenging, and instructors frequently puzzle over how to motivate students in their courses. Like their colleagues in other scientific disciplines, biochemistry faculty commonly ask their students to read the textbook before coming to class, generally with mediocre success. Such was the case for the faculty team-teaching an upper-level, large-lecture course for biochemistry majors. Fewer and fewer students seemed to be reading the textbook each semester, causing faculty to forgo extension activities in class because they felt constrained to use class time for coverage of the basic material. Conversations among frustrated faculty at weekly meetings evolved into brainstorming sessions focusing on how to encourage students to engage with basic material prior to class, thereby laying the foundation for in-class activities and discussions of more complex ideas.

After several discussions, the faculty team was strongly considering the adoption of reading quizzes. Although reported in the literature as a successful instructional strategy (Klionsky 2001; Fitzpatrick 2004), the faculty decided to implement reading questions (Henderson and Rosenthal 2006) as an alternative to reading quizzes. Here we present the faculty team’s experiences with implementing reading questions in an upper-level biochemistry course. Unexpected positive outcomes of this instructional method were realized, as well as limitations of the method within this setting. Outcomes and limitations of the reading-question strategy as well as suggestions for their more efficient implementation will be discussed.

Reading quizzes versus reading questions—The debate

A reading quiz is one of many strategies used by instructors to increase the likelihood that students will have interacted with instructional material prior to coming to class. Although reading quizzes can take different forms, they are generally no more than 5 to 10 questions and are administered either during the first few minutes of class or, with increasing popularity, via the internet prior to students’ arrival in class. In their article, Henderson and Rosenthal (2006) discuss two main limitations of traditional reading quizzes. The first is the difficulty involved in writing reading-quiz questions at an appropriate level. Good reading-quiz questions should probe student understanding of a topic, not whether they memorized the bold-faced words in a chapter. Consequently, ideal reading-quiz questions would be relatively complex and present opportunities for exposing student misconceptions. However, these questions cannot be so difficult as to require students to have an in-depth understanding of the material. If students arrive in class with this level of understand-
The purpose of these questions is to help the teaching staff identify areas that are difficult for students well in advance so that they can be more efficiently addressed in class. Therefore, it is critical for you to demonstrate your thought process when posing questions about what you do and do not understand after reading. Please see the examples of how these grading criteria were applied in these examples.
Applied grading criteria.

When grading your reading questions, we will apply the grading criteria as demonstrated below:

Examples of high- and low-quality questions

Example 1:
When reading through Chapter 2, three different students might have the following types of questions, which would earn the following point values:
1 point—When do I use the Henderson-Hasselbalch equation?
2 points—The Henderson-Hasselbalch equation can be used when we are talking about buffers. Why do conjugate acid/base pairs make good buffers?
3 points—I can see on the titration curve in Figure 2–17 that the buffering region is around the flat spot on the graph for a conjugate acid and its base. I can also see algebraically how when the concentrations of acid and base are equal that the pH equals pKa. But I am having a tough time understanding conceptually why in the buffering region adding H+ or OH- will have less effect on pH than if they were added outside the region.

Example 2:
After reading Chapter 3, three different students couldn’t think of any questions. So, they went to the end-of-chapter questions to see if they could answer them. They all looked at question #7, and submitted the following questions as their reading question for the day:
1 point—I didn’t have a question for this chapter, so I looked at the end-of-chapter questions. Specifically I looked at #7, and the question I have is, “Why do the functional groups on alanine have different pKa values in the different molecules?”
2 points—Chapter 3 was pretty straightforward for me, but after looking at question 7 at the end of the chapter and reading the answer they gave in the back of the book, I wonder why distance between the two functional groups on an alanyl residue would make the pKa change?
3 points—I didn’t have any problems with Chapter 3, so I looked at the questions at the end. After reading question 7 and its answer in the back, I am confused. I understand that the local environment around an amino acid residue will certainly have an impact on the acidity of a functional group (its pKa). But why don’t the pKa values continue to change for chains with more than four alanyl residues on them?

In addition to reading the submissions and lecture, each member of the course staff was responsible for reading 20 to 25 questions submitted by one discussion section. After reading the questions, the instructor or TA identified common or thought-provoking questions or widespread misconceptions revealed in the student submissions. These questions and misconceptions were forwarded to the instructor in charge of the lecture for that day. The instructor used this information to tailor the lesson to the needs of students not only for that lecture, but also for remaining lectures on that topic.

In addition to reading the submissions, course staff also evaluated the quality of the reading questions using a rubric (Figure 2). The staff assigned points to each submission and provided individualized feedback to each student through the Desire2Learn interface. The intent of this feedback was to answer student questions, target misconceptions, and correct inappropriately applied scientific terminology. However, the level and amount of feedback varied among staff members. Some provided lengthy and detailed explanations to student inquiries, while others provided short explanations with references to textbooks or websites for further information. The staff did include their names in the feedback, so students knew the identities of their evaluators each week, thereby enabling them to ask additional questions or seek further clarification. In order to minimize grading bias and to give students an opportunity to interact with each of the instructors and TAs, the course staff rotated through the discussion sections throughout the semester, each staff member evaluating a section twice. Of the 82 students who responded to a midsemester evaluation of the course, 81% indicated that feedback received from the course staff was valuable to them.

Unexpected outcomes

As identified by Henderson and Rosenthal (2006), there are many possible positive outcomes of this instructional strategy. They described their experiences with reading questions in an introductory, calculus-based physics course of approximately 70 students. Although reading questions described here were implemented in an upper-level biochemistry course for majors with nearly twice as many students, similar advantages of reading questions to those described by Henderson and Rosenthal were identified: Students actually read a large portion of the text (85% of those who completed the midsemester evaluation), instructors gained increased knowledge of student understanding, the classroom environment and discussions were enhanced, more one-on-one interaction between student and instructor occurred, and reading questions were utilized to inform lecture development.

In addition, reading questions had the perhaps unexpected benefit of increasing students’ abilities to communicate scientifically. Students entering this course have completed two semesters each of general chemistry, organic chemistry, and biology, but they have rarely integrated the knowledge gained in these diverse courses. Biochemistry represents, by definition, the intersection of these disciplines and requires that students learn to communicate through the use of sophisticated and often technical language. At the beginning of the semester, students used incorrect or inaccurate terminology in their reading questions, sometimes making it difficult to pinpoint where they were having trouble.
instructors and TAs encountered this type of situation, they corrected the misused or incorrect terminology and provided feedback on how to pose clearer questions. As the semester progressed, the frequency with which it was necessary for the course staff to give this type of feedback decreased due to students’ increased sophistication and mastery of scientific vocabulary.

Students enrolled in the course were not the only ones to benefit from the reading questions. The graduate TAs gained valuable experience interacting with and responding to students. This is quite noteworthy because as graduate students in science, they are more likely to hold research assistantships rather than teaching assistantships and are typically assigned to the facilitation of labs rather than teaching whole course sections by themselves (Austin 2002). Furthermore, assignments of graduate students to TA positions are seldom made with the development of future professors in mind (Austin 2002). Not only were these graduate TAs involved in teaching discussion sections, but their one-on-one interactions via reading questions were a unique opportunity to witness first-hand the types and level of reasoning difficulties commonly experienced by undergraduate biochemistry students, a population with which they will surely interact if they pursue academic careers.

Limitations and suggestions
Despite the many benefits of reading questions, there are several logistical considerations an instructor should consider before adopting them in the classroom. Of these, time is by far the greatest limiting factor on the success of reading questions. With large class sizes, providing a thorough response to each reading question individually is not just time consuming, it can be completely time exhaustive. Even with six staff members, evaluating and responding to reading questions almost every week was prohibitively time intensive. Although the reading questions were useful in revealing basic points that students were missing and allowed students to pose probing questions to the instructors that they might not have been able to ask in class, the course staff felt that the cost of time out-weighed these benefits.

As suggested by Henderson and Rosenthal (2006), a portion of students’ final grade was based on the reading questions. Although this was a small percentage of total points (< 5%), students quickly became preoccupied with their performance in this aspect of the course. During a midsemester anonymous evaluation, the majority of students stated that they found the instructor feedback to their reading questions to be valuable (81%), but overall they did not like the reading questions because of perceived inconsistencies in the grading. Only 37% of students felt that the grading of reading questions was fair. Nonetheless, students admitted that they would be less likely to complete the reading-question assignments if not held accountable through grades. They recommended that the reading questions be worth less or count for extra credit, or that they should be graded more leniently. In response to this feedback, we adjusted the point value of reading questions. Students received one point automatically for submitting a reading question and could receive up to two more points as extra credit for particularly thoughtful questions. Still, only 10 out of the 11 reading questions counted toward their final grade. With this grading scheme, reading questions comprised only 10 points of the total 700 points in the course, but students could earn up to 20 points of extra credit if they took the assignment seriously.

Overcoming grading inconsistencies, especially when six individuals are involved in evaluating student performance, is a difficult task. Although the course staff discussed the grading criteria at the beginning of the semester and met shortly after submission of the first reading question to discuss assignment of point values, there were still differences in how individual instructors and TAs approached their grading. Moreover, the range of student reading questions was great, contributing to the difficulty of standardized evaluation. One suggestion for improving consistency is to dedicate a larger portion of time to calibrating the grading among instructors or TAs. Without actual examples of student work, it is difficult to prepare for the wide range of student responses, both in quality and in quantity, that will present themselves. It is therefore necessary for instructors and TAs to discuss grading and to refine grading rubrics in order to minimize
grading inconsistencies.

With large classes such as this one, implementation of reading questions might not be practical due to the amount of time required for evaluation and response. There might be ways to reduce the number of instructor hours necessary to use reading questions successfully in the classroom. One obvious strategy is to reduce the total number of reading questions required in a given semester. However, this strategy would obviate the incentive for each student to do all of the assigned readings. Another strategy would be to provide less individualized feedback to students. Instead of responding to each reading question, similar student questions could be grouped together and a single response written to address them. Alternatively, student reading questions could be posted to a discussion forum and students could answer each other’s questions, with the instructors moderating the discussion.

Another limitation was that students did not have access to other students’ questions, or see how instructors and TAs responded to those questions. To capitalize on the social nature of learning commonly reported in the literature (NRC 2000), students should have access to all questions and responses. Student questions could be stripped of names by the course delivery software. This added layer of anonymity could create a lower-stakes situation that might result in more candid and a greater range of questions. Alternatively, a discussion forum or web log might also be an effective way of accomplishing this while simultaneously fostering a community of learners.

The instructors of this course are considering a combination of these approaches for future semesters. By using the reading questions and responses from this trial semester, the number of instructor hours could be decreased. One idea with the goal of decreasing instructor hours is to group reading questions from the trial semester according to topic. A more concise question could be generated by an instructor or TA to represent all student questions on that topic. Then, a single detailed response could be written to address that general question. All the reworded questions and responses could then be posted on the course website. The course delivery software provides control of student access to different portions of the website.

In future semesters, once a student submits a reading question they would receive a set number of points, and would then gain immediate access to the entire list of reworded questions and detailed responses for that reading assignment. This would provide an opportunity for students to read and learn from questions based on topics originally generated by students. Because reading the questions submitted by students was not the time-limiting factor for our instructors and TAs, they would still be responsible for reading the 20 to 25 reading questions for an entire discussion section. If in reading these questions they were to find a new or particularly thought-provoking question, it could then be added to the list of questions and answers available to students. In this manner, reading questions could still be used to inform the development of lectures and in-class activities, but instructors and TAs would be freed from writing a large number of detailed responses to student reading questions. One drawback to this approach is that students would no longer be ensured a personalized response to each reading question, which a large number of students reported as being useful to their learning.

Conclusions
Recent research has provided insights into the effective teaching and learning of science (NRC 2000). Putting these research results into practice, however, can present a challenge. Particularly within large-lecture classrooms, a combination of instructional strategies must generally be employed to yield similar outcomes to those that can be obtained in a smaller class by implementing only one or two new strategies. Strategies such as reading questions can provide instructors with valuable information about their students, which can feed back into their teaching, creating a positive and productive learning environment.

Acknowledgment
The authors and this work were funded in part by a grant from the Howard Hughes Medical Institute (S2005889) to the University of Arizona.

References

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