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Preparing students for class: How to get 80% of students reading the textbook before class

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We discuss our implementation of targeted pre-reading assignments with an associated online quiz in two science classes, one physics and one biology. Our goal was to create a pre-class assignment that helped students recognize the benefits of reading before class. Students were asked to take part in a survey about how and why they completed the pre-reading assignments. We found that 80% of students read the textbook on a regular basis, which is much higher than reported in previous studies. Also nearly 3/4 of students reported using productive strategies for completing the reading assignment and cited reading prior to class as being helpful to their learning. Student self-reports were checked against electronic logs and were found to be highly accurate. Moreover, these results were nearly identical between the physics and biology courses.
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I. INTRODUCTION

Instructors often advise students to read the course textbook before coming to class in order to be better prepared to learn. Students can follow the material better,[1] ask deeper questions during class,[2] and perform better on exams[3–5] if they have already been introduced to the material before class. Students said that whether or not they have read before class was one of the most important factors in their decision to participate in class.[6] Yet studies show that 70%–80% of students do not read the textbook before class.[7–9] There have been a few ideas put forth as to why students are not reading. Cummings *et al.* propose that students have not figured out for themselves that reading is a potentially useful activity.[10] Podolefsky *et al.* hypothesize that students may see reading as helpful, but they may not see the link between reading the textbook and their learning, as measured by course grades and examinations.[8] Reading is thus considered a low-priority activity and students instead focus their time on activities they believe will have a more direct impact on their course grades.

These hypotheses imply that one way to encourage students to read before class is to make the connection between reading and grades more explicit, by administering a graded quiz on the reading. This can be done in class[11–14] or shortly before class using an online quiz. The latter approach saves precious classroom time and is easier to grade in courses with large enrollments. Online quizzes administered before class also provide information to the instructor as to student difficulties—information that can be helpful for the instructor in class preparation. The best-known example of testing in this way is the so-called "just in-time teaching" (JITT) method,[15] where students fill in open-ended questions online before class. However, even with JITT-implementation, Stelzer *et al.*[9] reported that, disappointingly, 70% of students still "never" or "rarely" read the textbook before class, with 69% claiming that the textbook was either "useless" or "not very useful."[9] Clearly grade incentives alone are insufficient to motivate most students to read before class, let alone to see the value in reading.

We wanted to investigate if students would be more likely to read and, more importantly, see the value in reading before class with a more targeted JITT-like reading and quiz. Initial implementations of this method lend support to this approach. To formally test this, we implemented two specific features: (1) the reading is very specific and closely linked to the material and activities to be covered in the upcoming class(es), and (2) the online quiz asks questions that explicitly refer to specific page numbers and figures in the textbook. This targeting of the assignment and quiz focuses student attention on particular topics, definitions, and/or examples that will be discussed in class that week. Similar to JITT, the pre-reading assignments include pedagogical aspects that are considered to increase learning, such as promoting practice with the material and immediate feedback about their reading comprehension and preparedness for class. Moreover, the feedback gathered through these online quizzes can also help instructors to use class time more effectively by focusing on topics that students find more challenging. Such pre-reading assignments can be used in conjunction with any classroom format. However, they may be particularly beneficial in classrooms where active learning methods are used, as peer discussions can be richer and more students will be able to participate if they come to class with the shared exposure and base knowledge this provides.

In this study, we introduced targeted pre-reading assignments in two large undergraduate science courses, one physics and one biology, both of which used active teaching methods. First, we investigated how often students reported reading the text and completing the online quiz, and if that differed between the two courses. This relied on student self-reports. Because questions have been raised about the accuracy of self-reporting,[16,17] we used electronic logs to check the accuracy of the students' self-reports. We also surveyed the students as to their strategies and motivations for completing assignments, to see if students were reading in a productive way and for the right reasons. Additionally, we looked to see if final exam performance was correlated with student self-reported motivation for reading or frequency of submitted pre-reading quizzes.

II. STUDY

A. Course description

This study was conducted in the Faculty of Science at the University of British Columbia in Vancouver, Canada.

The physics course, Physics 101, was an introductory calculus-based physics course intended for science majors that concentrates on energy and waves. This study focused on one section ($n = 215$) of a multi-section course, which met for three 50-minute sessions per week for 13 weeks. The course used the popular textbook by Knight.[18] In addition to lecturing, every class included active learning activities—specifically in-class worksheets and peer discussions, centered around 2–5 clicker questions. The course also had a 3 h lab component and a 2 h problem-solving session (led by TAs) that met on alternate weeks. Class composition was approximately 63% first-year students, 28% second-year, and 9% third-year and beyond.

The biology course, Biology 260, was an introductory physiology course, intended for second-year biology majors, that covers basic plant and animal physiology. Two sections of the course ($n = 248$ and $n = 181$) met twice weekly for 13 weeks. Both sections were team-taught by the same set of instructors and shared course materials, and were thus pooled for analysis ($n = 429$). Each class period was 90 min long and included a mix of lecture and active learning activities (e.g., clicker questions with peer discussion, multi-part group worksheets). The course textbook was the widely-used introductory biology textbook by Freeman *et al.*[19] Class composition was approximately 10% first-year students, 81% second-year, and 9% third-year and beyond.

B. Pre-reading assignments

Each of the targeted pre-reading assignments was planned to take students about one hour, with the quiz portion taking no more than 10–15 min of that time (see the online supplement to this article for an example from each class).[20] The readings were designed to be short with a clear connection to the material to be covered in immediately upcoming classes. Assignments had explicit guidance as to where students should direct their focus and which sections could be skipped because they were not crucial to the upcoming classes. The online reading quizzes were short (five to ten multiple choice questions) and were computer-graded; in Biology 260, an open-ended question was included where students could submit questions or comments to the instructor. Critically, some quiz questions forced students to open the textbook by directing students to look at specific figures and/or pages. For example, a quiz question from the assignment covering hydrostatic pressure read "looking at Figure 15.3, rank the forces on the water at the location of each hole." Generally, one or two of the quiz questions required students to consider aspects of specific figures, graphs, or equations, with the remaining questions probing reading comprehension, e.g., "what force is responsible for a suction cup being held on the ceiling?" As this is the students' first exposure to the material, question level was set at a much lower level than would be expected for post-instruction, e.g., homework questions, with 80–90% of the pre-reading quiz questions testing basic knowledge (e.g., definitions), or reading comprehension (e.g., interpretations); these questions compare to a Bloom's level 1 and 2, respectively.[21] One or two questions per quiz would require a Bloom's level 3 or 4 level of thinking, such as problem solving or analysis, as a challenge for the students.

Quizzes were scored immediately after submission by the computer, and students could see which questions they answered correctly. In Physics 101 students received additional feedback in the form of hints that lead to the correct answer and page number(s) for students to review; such feedback would appear regardless of how a student answered. In both courses quizzes were made available on Fridays. Physics 101 had one assigned reading and one online quiz due per week, with an online-submission closing time 1/2 hour before class on Mondays. Biology 260 had one assigned reading but two quizzes per week, each due in the morning before class.

The breakdown of how the course grade was determined for each course is shown in Table I. For both courses the pre-reading component was worth a small fraction of a student's final grade, slightly more in Biology 260. For both logistical reasons[22] and because this was the students' initial stage of learning, students were allowed to miss or answer incorrectly 10% of the questions and still receive full credit for the

Table I. Distribution of grading points in each course.

	Physics 101 (%)	Biology 260 (%)
Pre-reading assignments	2	5
Clickers	6 (4/2 participation/ correctness)	5 (participation)
Midterms (2)	15	40
Final Exam	47	40
In-Class activities	—	10 (participation)
Tutorial Quizzes	5	—
Mastering Physics Homework	5	—
Labs	20	—

Table II. Best practice suggestions for implementing pre-reading assignments.

1. ***Focus*** on what you plan to discuss in class, this creates a clear connection between the reading and the expectations of the students for lecture.
2. ***Explicitly explain*** the purpose of pre-readings and your expectations, and how the assignments are beneficial to the student—repeat a couple of times during term.
3. ***Guided reading*** with explicit prompts, e.g., figure numbers or questions to think about while reading.
4. ***Omit*** what is not necessary—and be realistic.
5. ***Graded quiz*** (if possible)—best to do online and not during class.
6. ***Reading*** quiz: The questions should be easy if one read and hard if one did not read, and avoid problems that require a numerical calculation.
7. ***Refer to*** things from their pre-reading—but ***do not re-teach*** them. (If you re-teach it all, the students will quickly stop reading.)

pre-reading component of their final course grade. In both courses, instructors took time throughout the term to explain and remind students that the purpose of the pre-readings was to prepare them for class. Instructors regularly referred to the pre-reading material during class, and spent time building upon the material, rather than re-teaching it. A summary of what we believe to be "best practices" for implementing the pre-reading, and what we followed, are listed in Table II.

C. Methods

To gather information on student behaviors and attitudes associated with the pre-reading assignments, students were asked to answer a series of five questions as part of a short (approximately 5–10 min) online survey. The survey was administered in the last week of classes, and answers were not available to instructors until after final grades were submitted. The questions addressed (1) how often students took the online quiz, (2) how often they read the textbook, (3) their strategy for doing the pre-reading assignments, (4) their motivation to complete a pre-reading assignment, and (5) how helpful they found the pre-reading assignments to be for their learning. Participation in the survey was voluntary and students were given the option of including their name on the survey. Only four students chose not to include their name; their data were thus not included in analyses that required matching student identity with survey responses. The survey response rate in Physics 101 was 80% (172 out of 215 students) and in Biology 261 it was 58% (249 out of 429 students).

We looked at two metrics to determine how well our survey sample represented the full distribution of students in each course. First, we used the distribution of students' final exam grades. In Physics 101, the mean final exam score for the survey respondents was 71.71 ± 1.04 standard error of the mean (SEM) as compared to a mean class final exam score of 71.07 ± 0.93 SEM. For Biology 260 the mean final exam score for the survey respondents was 68.77 ± 0.72 SEM, whereas the mean class final exam score was 66.68 ± 0.58 SEM. We also compared the fraction of reading quizzes done by students who took the survey to the fraction done by the class as a whole. In Physics 101, non-responders completed $76.57\% \pm 4.07$ of the pre-reading quizzes, while the class as a whole completed $87.73\% \pm 1.29$ SEM. For Biology 260 non-responders completed $83.18\% \pm 1.57$ SEM, whereas the class as a whole completed $90.20\% \pm 0.78$ SEM. This difference is in large part due to a small number of students (4 in physics and 7 in biology) who completed none or very few pre-reading quizzes. Based on these comparisons, we conclude that our sample is a fair representation of the full distribution of students, but does lack the input of a small subset of students who were not motivated to complete the assignments at all.

III. RESULTS AND DISCUSSION

A. Completing the online quiz

As shown in Fig. 1, in both courses over 98% of students reported completing the pre-reading quiz "every week" or "most weeks." To test the accuracy of these reports, each student's response is plotted with respect to his or her actual electronic record of quiz submissions in Fig. 2. The electronic log is for all students, and confirms that, indeed, 98.8% of physics students and 98.7% of biology students completed the online quiz on a regular basis. These numbers are quite high, and are rather striking considering the small portion of the course grade students received for the quiz.

Figure 2 also shows that the self-reporting is quite reliable, in contrast to what is stated by Porter.[16] To compare the electronic-log quantitative records with the qualitative answer options, we chose a range of electronic submissions that would correspond to each qualitative choice; the gray boxes in Fig. 2 mark these ranges. We chose not to make all boxes uniform in range because during consultation with colleagues it was suggested that not all options implied the same range of frequencies (e.g., the range of reasonable quiz submission frequencies was thought to be narrower for "EVERY week" than for "LESS THAN HALF of the time").

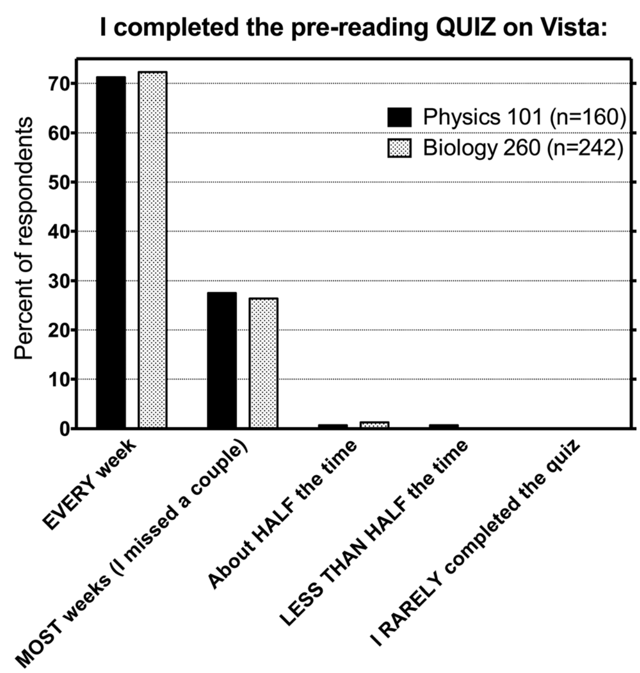

Fig. 1. Student reports of how often they completed the pre-reading quiz in Physics 101 (black) and Biology 260 (shaded). See text below for explanation of values of N shown.

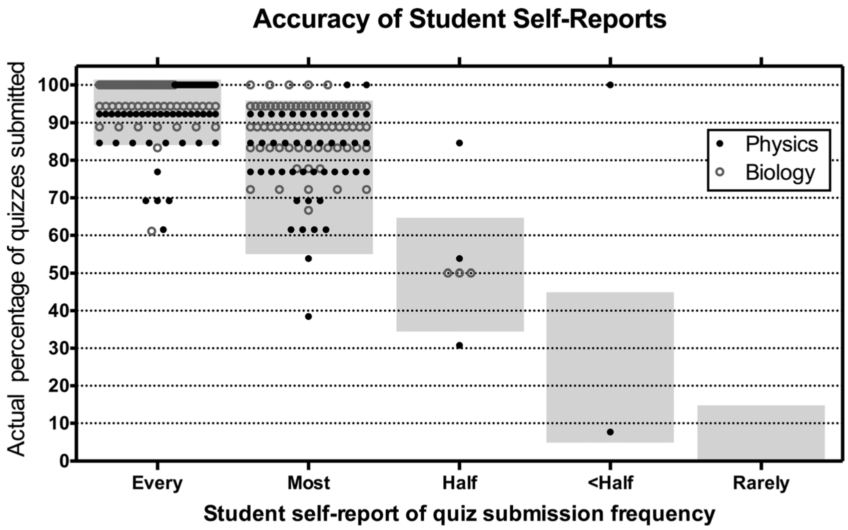

Fig. 2. Scatter-dot plot of student self-reports of reading frequency (horizontal axis) compared to actual percent of quizzes submitted (vertical axis). Gray boxes demarcate the criteria developed by the authors to quantify the qualitative survey answers. Each dot represents a single student.

Also, because students were allowed to miss 10% of the quiz questions and still receive full credit, we chose to include students who submitted more than 85% of the quizzes as consistent with the choice, "every week." We feel this scale allowed for some variation in interpretation of the survey selection choices, while still reasonably representing student behavior.

According to Fig. 2, Student responses fell within our developed criteria 92.9% and 97.2% of the time for Physics 101 and Biology 260 survey respondents, respectively. Of the 19 students who did not meet the criteria, ten over-reported and nine under-reported the frequency with which they took the pre-reading quizzes. These respondents were considered inaccurate and their survey data was not included in all subsequent analyses. We recognize that these categories are subjective; however, it is clear from Fig. 2 that minor adjustments to the criteria will not greatly affect the results of student self-reporting accuracy. Overall, these results suggest that student self-reports within our study are likely accurate.

B. Completing the pre-reading assignment

The second question asked the students how often they read the assigned pre-reading sections. The results were that 85.0% of Physics 101 students and 79.3% of Biology 260 students report reading the assigned sections every week or most weeks, as depicted in Fig. 3. These numbers are nearly double of those reported elsewhere.[8,9] Note that the word "read" was in capital letters to help the students recognize the difference between taking the quiz (Fig. 1) and actually reading the textbook (Fig. 3). We note that only students whose reports we deemed to be accurate representations of their behavior are included in Figs. 1 and 3.

It is interesting that the percentage of students reading is so similar between the two courses, despite the large difference in how the respective student populations would relate to each course. Biology 260 is largely comprised of biology majors, whereas Physics 101 is largely composed of non-physics majors (mostly "pre-med" biological majors and other science majors). Although there are many biology majors in the physics course, only eight of the students are in both courses.

One might expect the biology students to be more likely to read a biology textbook, as they have an expressed interest in the subject based on their choice of major. This is not the case.

Furthermore, physics textbooks and biology textbooks are generally written in very different styles. Although both texts include a considerable number of figures and graphs, physics textbooks tend to place a large emphasis on equations and derivations, and often break up the flow of the text with worked examples, whereas introductory biology textbooks often focus on overlying concepts with occasional equations that describe these concepts.

Thus, the high and nearly identical numbers in the two courses suggest that it is the implementation method—and

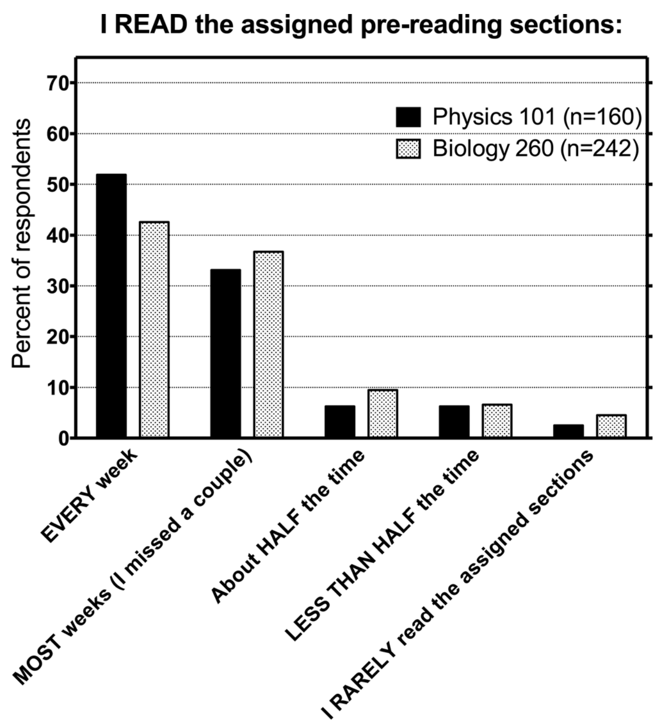

Fig. 3. Student reports of how often they read the assigned pre-reading sections in Physics 101 (black) and Biology 260 (shaded).

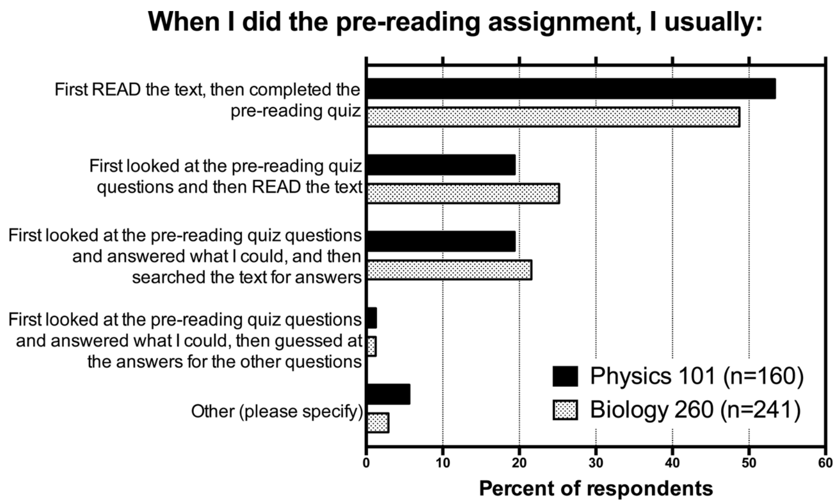

Fig. 4. Student reports of how they approached the pre-reading assignment.

not personal interest in content—that is the driving force behind students regularly reading before class.

C. Students' approach to pre-reading

The third question was aimed at finding out more about how the students approached the reading; that is, are they reading in an effective way or just "skimming" the text? Students were asked to complete the sentence "When I did the pre-reading assignment, I usually…" with four answer choices, plus a write-in option for "other," as described in Fig. 4. Looking at the first two answer choices in Fig. 4, 73.8% of Physics 101 students and 74.0% of Biology 260 students reported reading the assigned text either before or after looking at the quiz questions. We see either of these as desirable strategies, as the questions may help to direct their reading. A further 25.0% of Physics 101 students and 23.2% of Biology 260 students reported looking at the content of the textbook in some manner prior to attending class. These results include students who chose "other" that explicitly mentioned using the textbook in their comments; for example, one student reported, "if I don't have other assignments due, I read the text first then did the quiz, but sometimes, I looked at the quiz first then searched for the answers." Although these students do not read the textbook in what we consider to be the most desirable manner, they have at least looked at it. We conclude that the targeted reading assignments and quizzes that we have described here result in a large majority of the students reading the textbook in a desirable manner, with $> 95\%$ of the students at least looking at the content prior to class.

D. Student motivation to complete the pre-reading assignment

Students were asked to write about their motivation for completing a pre-reading assignment in a sentence or two. We chose to make this question open ended to allow students to express in their own words what they did or did not value in the assignments. All answers could be coded into 7 categories following methods similar to Welsh.[23] The detailed analysis and coding scheme we developed for classifying the comments is shown in Table III. A total of 576 comments were coded from the 379 students who responded; a single student's response often expressed multiple points. The comments were coded independently by each researcher, and then compared. The initial inter-rater reliability for the comments was high (mean within-category match of 93.4%, no category $< 89\%$). After consultation between the coders, the final round of coding yielded a mean within-category match of 96.7% with no category lower than 95%. Coders then discussed discrepancies until a 100% match was made across all categories. A few examples of student comments and coding are as follows:

- Student A: "They helped me understand the lectures and kept me up with the content." (lec prep, pace)
- Student B: "Mostly marks, but that taught me that doing so was really helpful in understanding the lectures." (grades/marks, lec prep)

Table III. Explanation of coding categories for survey question 4.

Category	Explanation
Grade incentive or "marks"	Student indicated he/she was motivated by grade incentive (or "marks"), or because it was "required".
General knowledge	Comments related to learning, gaining knowledge, checking his/her knowledge, and striving to do well academically.
Lecture preparation	Comments that specifically mentioned that the pre-reading prepared him/her for lecture, helped him/her understand the lecture, or be better equipped to answer/discuss questions during class time.
Helped keep pace	Comments that suggest the pre-reading was useful because it encouraged him/her to keep up with the course material. Includes comments that suggest the reading helps him/her stay focused.
Other (positive)	Comments that are positive in some way but did not fit into the above categories.
Other (negative)	Comments that are negative in any way.
Miscellaneous	Arbitrary comments that did not address the survey question.

- Student C: "It's for marks and… it helps me to distinguish what I know and what I have troubles with so I can be all ears in the parts where I am struggling with in class." (grades/marks, lec prep)
- Student D: "Wanting to learn the material; the marks." (gen know, grades/marks)

The results of this analysis are shown in Fig. 5(a). Although students cited grade incentive (or "marks") most often as their motivation, 64.7% of physics students and 83.9% of biology of students explicitly wrote about ways that the pre-readings had a positive effect in terms of their class preparation, their general learning, keeping up to date with the material, or other positive remarks. Only 16 students (12 from physics and four from biology) mentioned something negative about the pre-readings. Their reasons were: the pre-readings were not particularly helpful, readings and/or quizzes were difficult, or that reading is generally not effective for learning.

Looking at the student comments, one notices a trend: 20.8% of physics students and 27.0% of biology students mentioned *both* grade incentives and some positive effect on their learning. It is possible that some students, like Student B, may need the grade incentive at the beginning as a sort of extrinsic "carrot," but that after doing a few assignments they began to see them as a benefit to their learning. To look for indications of this, we analyzed the data in a different way: Fig. 5(b) shows the number of students who cited *only* grade incentives (or "marks") as a motivator versus those that cited some component of *learning* (limited to comments of "general knowledge" and "lecture prep"), irrespective of whether a student also mentioned grade incentives. This shows that even though most students recognize a benefit to learning before class, without the incentive of grades this may not translate into action (i.e., completing the assignment) in the same way across students. Thus, we suggest, when possible, assigning a small percentage of the final grade for completion of the online quizzes; Podolefsky *et al.*[8] also reported an increase in students reading before class in courses with a pre-class quiz.

In addition to the open-ended survey question, students were asked to rank on a 5-point Likert scale how helpful the pre-reading was for their learning of course material; the results are shown in Fig. 6. Students in Biology 260 were asked to separate the animal physiology from the plant physiology material for this question only. A total of 75.0% of physics students and 82.7% of biology students agreed or strongly agreed that pre-readings were helpful to their learning, despite the fact that many claim to have done them only for grade incentives [Fig. 5(b)]. Again, this is in stark contrast with the results of Stelzer *et al.*, where the reverse trend was reported despite also offering students grade incentives.[9]

E. Pre-reading and exam performance

In order to see if students' motivation levels correlated with their final exam scores, we divided the students' motivation levels into three groups: those that cited marks as their only motivator, those that cited only learning as their motivator, and those that cited both marks and learning as motivators to complete the pre-reading assignment. We then looked at the final exam scores for each group. Student standing was not a statistically significant predictor of motivation cited. A one-way analysis of variance (ANOVA) gave Physics: $F_{2,133} = 0.7248$, $p = 0.486$; and Biology: $F_{2,221} = 1.5863$, $p = 0.207$, where the F statistic represents the ratio of the "between-group variance" to the "within-group variance," and corresponds with a p-value that represents the probability of rejecting the null hypothesis (that there is no difference between groups) when it is true.[24] In other words, it is not, as often assumed, only the best students who recognize the benefits of reading before class; many students that were not top academic performers were motivated to do the pre-readings because they believed it was beneficial for learning. This conclusion matches with the results drawn by Podolefsky

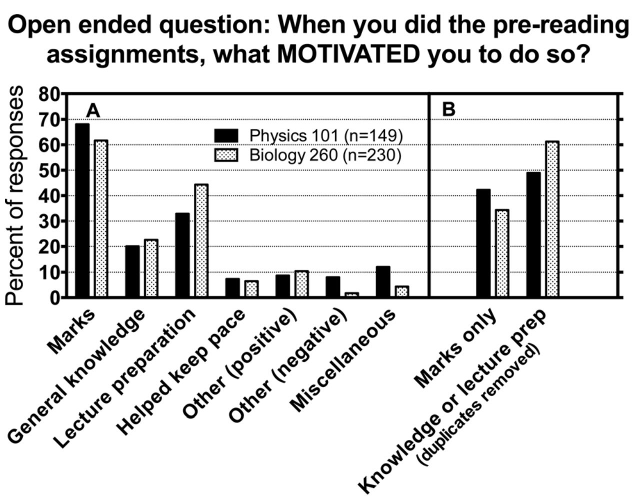

Fig. 5. Student comments on what motivated them to do the pre-reading assignments. (A) Data reported using the original seven categories determined by comment coders. The total number of responses adds up to more than 100% because some students expressed multiple motivators in their open-ended comments. (B) Taken from the same data as part (A), but reorganized to represent students who *only* cited marks as a motivator, and students who cited at least one aspect of *learning* (limited to general knowledge or lecture preparation) as a motivator.

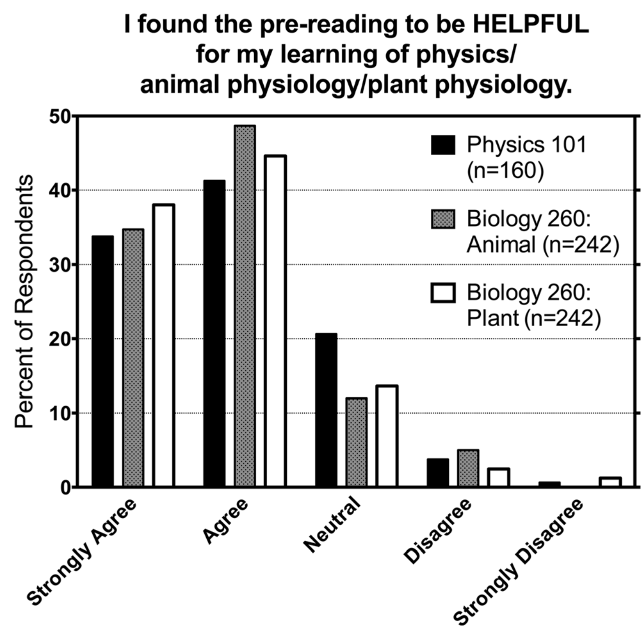

Fig. 6. Likert Scale representation of how helpful students felt the pre-reading assignments were for their learning of the course material. In Biology 260 students were asked to separate the animal physiology (dark shaded) from the plant physiology (white) material (for this question only).

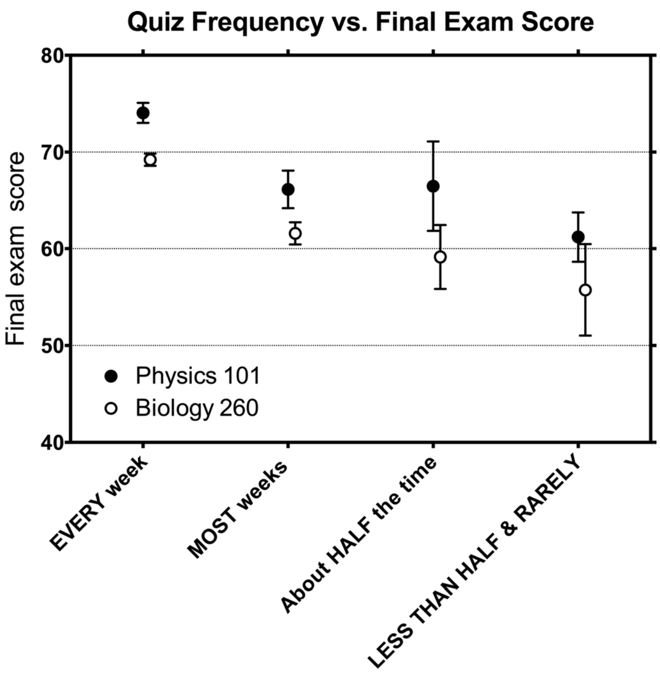

Fig. 7. Student performance on the final exam in relation to how often they completed the pre-reading quiz.

et al.,[8] which showed that whether a student uses the textbook in productive ways does not correlate with the student's academic standing.

Our study design does not allow us to determine whether pre-reading directly leads to an increase in student understanding and learning. Student final exam grades do, however, show a statistically significant positive correlation with how often they submitted the online pre-reading quiz (Fig. 7; Physics: one-way ANOVA $F_{3,206} = 7.6266$, $p < 0.0001$; Biology: one-way ANOVA $F_{3,419} = 15.8736$, $p < 0.0001$). The authors stress that this result does not indicate causality and as such must be interpreted with caution because a number of other factors could be confounding the analysis (e.g., increased time on task, motivation differences between those students that do the reading and those that do not, etc.). Further research is warranted to disentangle these factors, particularly because this result is in contrast to that reported by Podolefsky,[8] where no such correlation was seen for their calculus-based physics course.

IV. CONCLUSIONS

We have introduced a pre-class assignment consisting of a targeted reading and online quiz to encourage students to read the textbook before class, and thus be better prepared for lecture. This method has resulted in $>95\%$ of students reporting using the textbook in some manner before lectures, with $\sim 80\%$ of the students reading the textbook on a regular basis. Using electronic records, we found $>95\%$ of the students were able to make accurate self-reports, lending further support to the survey results presented here. We find these numbers to be nearly identical in both a physics and a biology course.

Arguably the most important finding is that students themselves recognize the benefits to their learning of reading before class and use productive reading strategies. Many students cite several positive effects of the pre-readings, such as preparing for class, gaining or checking their general knowledge, or keeping pace with the material. Although students do mention the relatively small grade incentive as at least part of their motivation for completing pre-reading assignments, $>75\%$ of students agreed that the pre-readings were helpful to their learning.

Using this method, we get students to read the textbook to prepare for class; however, we did not collect data about how exactly students read. It has been established that students learn more from reading texts when employing a metacognitive strategy that requires them to monitor and reflect upon their understanding while reading.[25,26] An interesting area for future research would be to determine the specific strategies[27] students employ when completing the pre-reading assignments. Another interesting aspect would be to investigate how different types of reading quizzes might affect students' critical reading skills. For example, would students analyze the text differently if, instead of asking students which concept is portrayed in a specific graph, we asked them to choose the graph that best proves a certain concept? This type of question gives students practice in picking out the key points themselves while still targeting certain areas within the text to focus students on before class. That could result in greater learning, but it is also possible this would be counterproductive, because in this first exposure to the material, such questions might be too challenging. Many such open questions remain on how to optimize learning from reading the textbook before class, but the work discussed here provides an essential first step for carrying out any such studies. It also provides a valuable aid to instruction.

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Plug-type Resistance Box

The plug-type resistance box, outmoded since ca. 1915, has the resistance coils connected to block of brass on the top cover. When the plug was out, the resistance between those two blocks was in the circuit. Putting in the plug shorted the resistance and gave an effective value of zero – how effective depended on how well the plug was seated and the cleanliness of the surfaces. Plugs tended to stray – this example, sold by the Chicago Apparatus Co. for $14.00 in the 1929 catalogue, has plugs from two different sources. Normally the plugs march in straight lines across the top of the box, but the designer of this series of boxes put the plugs in an arc. For $2.00 more you could get the box with glass sides so that you could see the coils. This example is in the Greenslade Collection. (Notes and photograph by Thomas B. Greenslade, Jr., Kenyon College)