AC 2011-1146: DAILY REVIEW QUIZZES A HINDRANCE OR A HELP?

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Daily Review Quizzes – a Hindrance or a Help?

Abstract

This paper reports on a study of the costs and benefits of conducting frequent in-class review quizzes in undergraduate engineering mechanics courses at West Point. The study attempts to determine if the teaching technique increases conceptual understanding of foundational engineering topics and therefore increases the performance on the conceptual portion of exams in four separate courses (n = 131). It also examines the effect of such frequent testing on the attitudes of the students through the use of surveys. In sum, no conclusion could be made about the method’s ability to raise exam scores, but it did not negatively impact student attitudes about the classes. The motivation behind using the technique is reviewed along with relevant literature, and administrative guidance is also provided for those who wish to try the technique themselves at both small and large schools.

Introduction

In a limited amount of contact time with their students, teachers must accomplish various goals in order to facilitate student learning and meet their course objectives. Toward that end, most instructors expend significant energy creating and executing various learning activities within the classroom. However, there is considerable debate over which learning activities are the most effective in enhancing the ability of students to remember and apply the concepts learned in class. In particular, the use of frequent in-class quizzes is a source of debate between educators. Some studies suggest that testing improves learning more than simply studying. However, other literature indicates that frequent quizzes can increase student anxiety and hinder the development of teacher-student rapport.

Additionally, many instructors in engineering disciplines find that their students can often move through a problem satisfactorily, but are unable to articulate the conceptual understanding of material that is just as important as solving problems. The review quizzes described in this paper are designed to treat this problem by emphasizing concepts through the quizzes themselves, and then helping students reinforce their understanding of concepts through consistent quizzes. The two hypotheses that will be addressed are a) does frequent quizzing increase student conceptual understanding of the material, and b) does frequent quizzing hurt class morale and student motivation? The first research question is tested via exam scores and the second is tested using student surveys. The paper will start with a short description of how the review quizzes were administered, then it will proceed with a review of the pertinent literature, discuss the method of gathering and analyzing the test and survey data taken, and conclude with recommendations for further research.

Review Quizzes: Technique and Delivery
The concept-focused review quizzes were utilized in nine different sections of four separate courses in the Department of Civil and Mechanical Engineering at West Point. The experimental group for this study consisted of 131 students.

The quiz was typically given immediately at the start of class. Students then swapped papers and graded each others’ work as the instructor reviewed the answers prior to beginning the day’s material. By the second week into the term, the students knew exactly what to expect and it served as a good way to begin class. The instructor usually asked for student responses while going over the answers, and this also served to “break the ice” and help to generate student-teacher interaction that is sometime hard to jump-start at the beginning of class. Very often, going over the answers took less than two minutes; however, it occasionally generated a more lengthy discussion. Additionally, the instructors tailored their quizzes to cover material pertinent to the following class topic. By having the students grade each others’ work, the instructor accomplished two goals. It gave students immediate feedback and allowed them to correct misconceptions that they might have had. Additionally, it significantly reduced the grading burden on the instructor, who simply had to enter scores into his or her gradebook after each class. The cumulative score at the end of the semester was treated as an instructor grade, which is usually 100 points in a course that has 2000 possible points (or 5% of the final grade).

As will be discussed shortly, the average scores on most quizzes were somewhat low. In order to increase the student’s motivation in the face of such consistently poor performance, each instructor asked upwards of 140 points worth of questions, so that a student who did achieve only a 50% would receive a 70/100 for his or her instructor grade at the end of the semester. Of course, some students were able to earn more than 100 or less points.

Literature Review

Many different types of studies relate to the practice of frequent in-class quizzes. Most of the work undertaken in the past attempted to encourage students to complete out of class reading assignments since most courses cover far more material than can adequately be covered during class time. Research in this vein that pertains directly to giving reading quizzes will be covered, although the goal of both is the same—to encourage students to engage with conceptual material not covered on homework sets outside class. Additionally, several studies have addressed the effect of more frequent testing over widely interspersed testing. Finally, some support for frequent quizzes based on discoveries in the neurosciences will be summarized.

Literature Review: Preparation for class

A significant amount of literature pertaining to regular in-class quizzing is focused on the goal of improving student preparation for class. To that end, Liebler 1 outlines a low-impact, in terms of instructor workload, method of instituting regular in-class testing. His method employs quizzes based on daily homework problems and an instructor-led solution to one of the quiz problems during the lecture period. This technique emphasizes student completion of study
problems before coming to class. It also ensures that students do spend more time preparing for class, as 90% of students in his courses over a six year period reported that the quizzes forced them to study more than they normally would. Liebler also notes that this technique does increase the amount of time that the instructor spends conducting additional instruction during office hours, which aids student learning and can improve student-instructor rapport.

Similarly, Mahwhinny, et al.\textsuperscript{2} studied the effect of testing frequency on student studying behavior. This work showed that daily and weekly testing schedules are effective means to force consistent class preparation. This study also showed that variability in class preparation increased as the interval between tests increased. However, this work did not provide any data regarding the effect of testing intervals on student comprehension.

There are also several studies that attempt to force student to complete reading assignments prior to class. Carney et al.\textsuperscript{3} examined student motivation to complete assigned readings and tested different methods to include random quizzes (where administration of a reading quiz was determined by the roll of dice), non-random quizzes, and a learning log similar to a take-home quiz where the quiz questions were asked and answered as a growing document or log of learning. Across all three methods, students agreed each method motivated them to complete the readings on time. With the exception of the random technique, the students also agreed their ability to contribute to discussion was enhanced. It was noted that the students’ dissatisfaction with respect to the random quiz technique may have decreased that method’s effectiveness by stifling the professor-student relationship.

In a similar effort, Sappington et al.\textsuperscript{4} examined two different systems designed to track student effort level outside of class; the first method relied on student self-reporting for completion of their reading assignments, and the second used surprise quizzes. The second method was somewhat more reliable in enforcing reading, but at the expense of the negative connotation of surprise quizzes in the minds of both the student and the teacher. However, Sappington also pointed out benefits of such quizzes to identify at-risk students and highlights the need to hold students responsible for preparations for class despite potential student displeasure. Clearly, frequent quizzes are effective in generating more out of class effort by the students, however, it is important to combat the negative attitudes associated with such quizzes.

Literature Review: Engagement and Repetition

Kugel\textsuperscript{5} strongly advocates the use of consistent in-class quizzing as a way to enable students to actively engage with the material, improve understanding of how sections of material relate to one another, and "debug" their understanding of material presented in class. Ultimately, his goal is to use the quizzes to stimulate dialogue with the students. Lastly, Kugel stresses that instructors should convey the attitude that mistakes on the quizzes are opportunities to learn or clarify the material.
In a related study on a self-paced course, Wesp found that students obtained higher course grades when they took daily quizzes, and that these benefits did not stem simply from an increase in the number of tests taken. Although the courses in the current study were not self-paced, at a certain level, all courses are self-paced because students determine their level of involvement with the material. Typically, this involvement increases when homework sets are due or an exam is approaching. By forcing the student to have sustained contact with the material, the daily quizzes can reduce the “wait and surge” method of involvement that most students adopt, particularly in courses that do not hold their interest.

Karpicke and Roediger’s important study of the learning of foreign language, “The Critical Importance of Retrieval for Learning,” served as the primary motivation for the current work. It suggested that merely studying material after it was learned produced almost no increase in delayed recall (on exams), but repeated testing after material was learned significantly increased exam performance. Thus, it isn’t simply exposure to the material repeatedly that increases retention; rather, it is the act of retrieval (during small short quizzes), that more deeply encodes the material into students’ memory. The quizzes themselves, therefore, are key learning events, not just the studying that the students do in preparation for the quizzes.

Finally, Connor-Greene notes that students develop study patterns in response to the demands of their classes, which suggest that instructors can shape more consistent study habits through the design of their course. She also mentions that quizzes are comprehensive, continually requiring students to make connections between new and old material. She also uses quiz questions as a means to begin discussion on the day’s topic. Students in Connor-Green’s classes reported that they studied more consistently and came to class better-prepared, “Students appear to articulate their ideas more readily and clearly after writing their quiz responses, which raises the level of class discussion.” However, Connor-Green did not realize any increase in the grades of students who took scheduled quizzes.

Literature Review: Other considerations

On the other hand, Lowman argues against frequent in-class quizzes because they can increase anxiety about coming to class and can decrease the amount of learning that occurs in class following the quiz. “…too frequent testing is costly in class time and in teacher time spent on grading; it also leads to an overemphasis on external motivators at the expense of internal student motivation.” Lowman further discourages frequent testing in saying, “At the other extreme of the structure are instructors who have daily quizzes—or unannounced “pop” quizzes—on assigned reading or who grade homework problems only on the basis of right and wrong answers. Although these procedures are likely to produce more short-term compliance among students than are unstructured methods, they also often create student anxiety and an adversary relationship with instructors that color the orientation students bring to their learning.”
While teaching and initial learning is important, helping students to remember what was taught may be equally important. Neuroscientist John Medina\textsuperscript{10} describes the four stages of memory as encoding, storage, retrieval, and forgetting. He goes on to show that properly spaced repetition is critical to encoding information into long term memory. Once the information is in long term memory, the student needs to be able to retrieve the information correctly before it is forgotten. Each time a memory is retrieved, it re-enters working (short-term) memory, enhancing the student’s ability to retrieve it in the future, and decreasing the chance that it will be forgotten.

However, assisting students in forming more lasting memories of course material is only one problem. Some students confidently remember material incorrectly. MacDonald\textsuperscript{11} describes research that demonstrated how simply asking questions over a relatively long period of time strongly reinforces memories, even false ones. The review quizzes do exactly that, although with the intention of correcting false memories rather than implanting them.

In summary, the literature seems to provide a solid theoretical framework for how frequent quizzing would improve student learning. Additionally, it is clear that frequent quizzes increase the students’ preparation for class. The goals of this study, however, are to improve test scores with frequent testing and to do so without hurting class morale and student motivation. In this regard, the only study that reported on test scores did not see an improvement in exam scores, and Lowman’s classic work advises against the practice.

Experimental Procedure.

The goals of this study were to determine if review quizzes would enhance conceptual understanding and to determine the effect of the review quizzes on students’ motivation in the classroom. In order to determine if conceptual understanding was enhanced, the scores on the conceptual portion of course exams of each experimental group was compared to the scores of the control group using a t-test of independent groups, an assumed difference of zero, and a probability of a Type I error of 5%. The experimental groups were simply formed by those instructors who were interested in trying review quizzes in their sections, and the control group was the rest of the course (Table 1).

<table>
<thead>
<tr>
<th>Course</th>
<th>Experimental Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE300, <em>Fundamentals of Engineering Mechanics and Design</em></td>
<td>52 students in 3 sections, AY11-1</td>
<td>132 students in 8 sections, AY11-1</td>
</tr>
<tr>
<td>ME311, <em>Thermal-Fluid Systems I</em></td>
<td>18 Students in 1 section, AY11-1</td>
<td>173 Students in 10 sections, AY11-1</td>
</tr>
<tr>
<td>ME387, <em>Aerodynamics</em></td>
<td>31 students in 2 sections, AY10-2</td>
<td>86 students in 7 sections, last three years</td>
</tr>
<tr>
<td>ME350, <em>Thermal-Fluid Systems</em> (for non-engineering students)</td>
<td>30 students in 2 sections, AY11-1</td>
<td>84 students in 6 sections, last three years</td>
</tr>
</tbody>
</table>
Confounding Variables

There are numerous variables that must be controlled or addressed when determining if a teaching technique is able to increase learning. In order to determine if conceptual understanding was enhanced by the review quizzes, the performance of each experimental group on the conceptual portions of the exams was compared to the performance of each control group. Although not perfect, exam scores are the best measure of learning readily available without making significant course alterations.

When looking at exam performance, one of the most significant variables is student ability. One would expect smarter students to do better on exams. In order to control this variable, the grades in each section were normalized with respect to the sectional incoming average. This normalization was an important step, because in two courses in particular, it appeared that the review quizzes “worked,” however, after normalizing the scores with respect to the average ability of the section, the data did not demonstrate any better performance by the experimental group.

In addition to student ability, teacher ability is an important variable since the experimental group always had a different teacher than the control group. Although there are certainly variations in experience and personal touch, the teaching within the department is standardized to a fairly high degree. In retrospect, a better way to control the teaching variable would be to recruit more teachers, and have each of them conduct review quizzes in only one of their sections.

The impact of the many other potentially confounding variables is small. These include class size (they are all 14-18 students), difference in test instruments (the tests are very similar across the sections), student age (students are all between 20-23 years old), and the fact that the students taking the quizzes were not necessarily told that they were part of a study, although they were told why the instructors thought that frequent quizzing would be helpful to them.

Results and Discussion

Exam Performance

Figure 1 compares the performance of the experimental versus the control group on the conceptual portions of fourteen graded events in four different classes that were pertinent to this study. These results are also summarized in Table 2 including the probability of a Type I error (concluding that the quizzes improve learning and test scores when they actually do not). As can be seen, in eight of the fourteen trials, the experimental group outperformed the control group; however, only four of these have \( \alpha < 5\% \) required for statistical significance. Looking closer, one will see that of the six times that the experimental group performed worse than the control group, its p-value was less than 5\%, indicating statistical significance. It is worth asking whether the review quizzes might have hurt exam performance, and it is certainly possible that in several
cases, it did. The most likely reason that this could be the case is that students felt over-confident about their conceptual understanding such that they didn’t study the material as closely prior to the exam. Instructors using review quizzes should warn their students not to neglect appropriate study discipline simply because they have been quizzed in class. Thus, no conclusions can be drawn at this point about whether or not the practice of conducting review quizzes increases student performance on exams and therefore increases learning.

Figure 1. Normalized Performance on Conceptual Exam Questions

Student Motivation.

Two types of surveys were administered throughout the term within each course that utilized the review quizzes. First, students were asked to identify three strengths and three areas for improvement (open-ended questions) for the course in general. Additionally, students were asked specific questions about the review quizzes using a Likert Scale (Table 3). The goal of these surveys was to determine student attitudes about the quizzes in general, and to determine if the attitudes changed over time. In particular, there was interest in seeing if the quizzes increased students’ anxiety about coming to class and if it detracted from the students’ ability to focus on the lecture that followed the quiz each day.

The Likert Scale survey was administered nine times during the four courses that used the review quizzes. Figures 2-6 contains the results of the surveys, grouped by course, and Table 3 details the questions that were asked. The survey utilized a five-point Likert scale, where 5 corresponds with “strongly agree” and 1 denotes “strongly disagree.” The data presented are the
mean of all responses to each question. Although not technically rigorous, this method of presentation was chosen as the clearest way to present the data concisely. In general, the students had a favorable response to the review quizzes. Specifically, the students thought the quizzes were a good way to reinforce the material (average of 4.1 out of 5), they voted to continue the practice (3.9 out of 5), their anxiety about class did not increase (1.96 out of 5), and they preferred going over the answers together in class (4.1 out of 5).

Table 2. Normalized Performance on Conceptual Exam Questions

<table>
<thead>
<tr>
<th></th>
<th>Exper. Group</th>
<th>Control Group</th>
<th>difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME350 Exam1</td>
<td>74.2%</td>
<td>84.3%</td>
<td>-0.10</td>
<td>0.009</td>
</tr>
<tr>
<td>ME350 Exam2</td>
<td>88.3%</td>
<td>82.6%</td>
<td>0.06</td>
<td>0.183</td>
</tr>
<tr>
<td>ME350 Exam3</td>
<td>81.8%</td>
<td>77.7%</td>
<td>0.04</td>
<td>0.095</td>
</tr>
<tr>
<td>ME350 Final</td>
<td>72.0%</td>
<td>81.5%</td>
<td>-0.09</td>
<td>0.007</td>
</tr>
<tr>
<td>CE300 Exam1</td>
<td>82.2%</td>
<td>87.5%</td>
<td>-0.05</td>
<td>0.016</td>
</tr>
<tr>
<td>CE300 Exam2</td>
<td>85.8%</td>
<td>87.3%</td>
<td>-0.01</td>
<td>0.365</td>
</tr>
<tr>
<td>CE300 Exam3</td>
<td>82.9%</td>
<td>87.9%</td>
<td>-0.05</td>
<td>0.004</td>
</tr>
<tr>
<td>CE300 Final</td>
<td>70.7%</td>
<td>69.5%</td>
<td>0.01</td>
<td>0.628</td>
</tr>
<tr>
<td>ME387 Exam1</td>
<td>80.3%</td>
<td>73.1%</td>
<td>0.07</td>
<td>0.063</td>
</tr>
<tr>
<td>ME387 Exam2</td>
<td>76.8%</td>
<td>86.9%</td>
<td>-0.10</td>
<td>0.001</td>
</tr>
<tr>
<td>ME387 Final</td>
<td>87.3%</td>
<td>79.6%</td>
<td>0.08</td>
<td>0.005</td>
</tr>
<tr>
<td>ME311 Exam1</td>
<td>93.7%</td>
<td>85.0%</td>
<td>0.09</td>
<td>0.086</td>
</tr>
<tr>
<td>ME311 Exam2</td>
<td>98.2%</td>
<td>87.0%</td>
<td>0.11</td>
<td>0.013</td>
</tr>
<tr>
<td>ME311 Exam3</td>
<td>99.7%</td>
<td>94.8%</td>
<td>0.05</td>
<td>0.029</td>
</tr>
</tbody>
</table>

Table 3. Survey Questions

| Q1  | The review quizzes are an effective way to help me review and reinforce topics that I need to know. |
| Q2  | If I could vote, I would vote to keep doing the daily quizzes. |
| Q3  | The daily review quizzes increase my anxiety about coming to class. |
| Q4  | The review quizzes detract from my ability to learn the material presented during the rest of the class hour. |
| Q5  | I prefer to cover the answers to the review quizzes before starting class. |

Figure 2 demonstrates that student agreement that the quizzes were a good way to reinforce material that they should know. Additionally, it appears that in all but one course, their opinion about the value of reviewing via quizzes not only started high, but ended slightly higher.
To take it one step further, the students were then asked whether they would vote to continue to practice. Interestingly, although the responses were still positive, they were slightly less positive, and in two of the three courses where the surveys were administered, they were more prone to vote to continue the practice toward the end of the term. Thus students’ attitudes about the benefits of the quizzes were high in general and improved throughout the term.

This trend can also be seen when the responses to the free-text questions are considered. Although the open-ended questions yielded a wide variety of responses, most of which are not pertinent to this paper, Table 4 contains the number of times that the open ended response included a favorable or unfavorable comment about the review quizzes. If a student spoke favorably or unfavorably about the quizzes, their response was cataloged in the appropriate column. In each class, the ratio of positive to negative comments increased over the course of the semester. Anecdotal feedback also indicated that the students valued the opportunity to review, they appreciated the focus on concepts, and they also appreciated the attempt to improve their educational experience.

![Figure 2. Responses to “The review quizzes are an effective way to help me review and reinforce topics that I need to know.”](image)

Although students apparently see the value in the quiz as a means of reviewing material, it is also important to ascertain if the practice has deleterious effects on other aspects of their classroom experience. Figure 4 and 5 depict indicate whether students’ anxiety was increased due to the quizzes, and whether the quizzes detracted from the rest of the lesson. Although their responses were generally negative (that quizzes did not increase anxiety or detract from the lesson), it is interesting that in each of the three courses surveyed, students reported they were more likely to feel anxiety about the quizzes at the end of the term than mid-way through the
semester. Furthermore, two of the three courses felt that the quizzes detracted from the lesson more at the end of the course than at the mid-point. At first blush, this is surprising, especially since the students seemed to value the review more over time. One possible explanation is that as each course progressed, the variety of topics that could be covered on the review quiz increased, and therefore students would be less sure of what might be asked. The quiz scores themselves, however, did not decrease at the end of the course indicating that if this was the reason for the students’ increase in anxiety, it was unfounded. The last consideration to mention concerning student anxiety, is really to pose a question—is increasing student anxiety about class (at least a little bit) a bad thing? Although not addressed in the current work, the stress-performance model articulated by Yerkes and Dodson\textsuperscript{12} suggests that performance increases, at least initially, as arousal due to stress increases. It might not be such a bad thing if the added pressure to perform, based on anticipation of a quiz, results in greater effort to prepare for class.

![Figure 3. Responses to “If I could vote, I would vote to keep doing the daily quizzes.”](image)

Table 4. Open-ended Responses

<table>
<thead>
<tr>
<th></th>
<th>Positive comments about review quizzes</th>
<th>Negative comments about review quizzes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ME350</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lesson 8</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Lesson 40</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td><strong>ME387</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lesson 6</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Lesson 22</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td><strong>CE300</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lesson 11</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Lesson 33</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>
Although students apparently see the value in the quiz as a means of reviewing material, it is also important to ascertain if the practice has deleterious effects on other aspects of their classroom experience. Figure 4 and 5 depict indicate whether students’ anxiety was increased due to the quizzes, and whether the quizzes detracted from the rest of the lesson. Although their responses were generally negative (that quizzes did not increase anxiety or detract from the lesson), it is interesting that in each of the three courses surveyed, students reported they were more likely to feel anxiety about the quizzes at the end of the term than mid-way through the semester. Furthermore, two of the three courses felt that the quizzes detracted from the lesson more at the end of the course than at the mid-point. At first blush, this is surprising, especially since the students seemed to value the review more over time. One possible explanation is that as each course progressed, the variety of topics that could be covered on the review quiz increased, and therefore students would be less sure of what might be asked. The quiz scores themselves, however, did not decrease at the end of the course indicating that if this was the reason for the students’ increase in anxiety, it was unfounded. The last consideration to mention concerning student anxiety, is really to pose a question—is increasing student anxiety about class (at least a little bit) a bad thing? Although not addressed in the current work, the stress-performance model articulated by Yerkes and Dodson suggests that performance increases, at least initially, as arousal due to stress increases. It might not be such a bad thing if the added pressure to perform, based on anticipation of a quiz, results in greater effort to prepare for class.

Figure 4. Responses to “The daily review quizzes increase my anxiety about coming to class.”

The last question on the survey addressed whether the students thought it was worth the time in class to go over the answers. Once again, we see that the students generally preferred to go over the answers together with the instructor in class. This is most likely because the students want to see how well they did. Hopefully they are also interested in discovering the answers to questions they are unsure of. In either case, with their curiosity aroused, whatever they learn
should be better remembered in the future. Additionally, it is advantageous for instructors to have the students grade their own work. First, it significantly relieves the grading burden. Secondly, it is a great way to generate discussion. Finally, all teachers should relish the opportunity to expose gaps in their students’ knowledge and then rapidly fill them with sound, timely insights.

Figure 5. Responses to “The review quizzes detract from my ability to learn the material presented during the rest of the class hour.”

Figure 6. Responses to “I prefer to cover the answers to the review quizzes before starting class.”
Further Discussion

While the statistical benefits, in terms of grade improvement, of review quizzes are debatable – particularly in light of the relatively small sampling populations seen in this study – a lot can be said for anything that positively impacts student confidence in a technical course. Review quizzes offer two ways in which they can directly improve student confidence. First, the quizzes offer the opportunity for students to affirm that they understand when to apply the various analytical tools in a given course or the core concepts present in a given technical field. Additionally, the process of reviewing quiz answers gives an instructor the chance to open up discussion pertaining to the subject matter. An example of this, from ME311, *Thermal Fluid Systems I*, involves review quizzes that require students to write the correct equation to analyze pipe flow and make appropriate simplifications of the equation given a specific pipe network configuration. Reviewing the answer with students becomes a prime opportunity to discuss appropriate assumptions for this analysis and can give students a low-threat environment in which to discuss and ask questions regarding the reasoning behind the answers, the analysis, and the physical phenomena seen in pipe flow. This discussion can help break through student apprehension that comes from the fear of giving a wrong answer and appearing to be intellectually inferior in front of peers. This is especially true if instructors are able to frame a student’s answer in the light of being a hypothesis and treat the act of wrestling with concepts in order to master them as a necessary and good step in learning technical subject matter.

For instructors, the quizzes can serve as a continuous assessment of their teaching and of the students’ learning. Thus, future lessons can be tailored to accommodate the reality of where the students really are in terms of their learning. It is worth noting that these quizzes usually only cover “lower” levels of Bloom’s Taxonomy. Although most instructors aim to elevate both classroom discussion and later evaluations to the other levels of Bloom’s taxonomy, ensuring that basic facts are properly understood by students after they are taught is often simply assumed or overlooked by many instructors. However, proper understanding of these concepts is important in accurately integrating a body of knowledge as a whole. If daily review quizzes are performed, mistakes can be identified by each student, and corrected almost immediately, especially if the answers to the quizzes are covered right after the quiz is completed. Moreover, as the semester proceeds and an instructor wishes to use longer, more challenging conceptual problems during such a review quiz, assigning the quiz in pairs or small groups can also achieve the goals of meaningful review, but with an added, collaborative element.

In very large classes, a few slight modifications would need to be made. Reliance on teaching assistants would probably be necessary to help with managing grades. The quizzes could also be given if the course utilized the smaller recitation sessions with teaching assistants. If dishonest grading was a concern, teachers could simply have students swap papers prior to the grading. And if the benefit of these quizzes escapes a class, the teacher can simply begin a quiz one day by asking who wants this to be a graded quiz and who just wants to go over the answers. Since the majority of students will probably not fully understand that the more points they
accumulate through daily quizzing, the better, they will probably vote not to grade the quizzes. This moment provides an opportunity to explain that they just discarded five points, and it helps them clarify the grading arrangement that was described in an earlier section.

How well the students receive the practice is strongly predicated on how the instructor presents it to the students, both initially, and throughout the course. This is a pertinent concern for teachers of very large classes and of “core” classes where many of the students would prefer not to be taking the class. If a little time is taken to explain the teachers’ firm belief that the quizzes will help the students learn, and that the frequency of the quizzes will only help their grade, most students will grow to accept and even appreciate the practice. In the data presented, most of the students taking CE300, *Fundamentals of Engineering Mechanics and Design*, all of the students in ME350, *Thermal Fluid Systems*, were not engineering majors and were “forced” to take the course to fill general education requirements.

Despite potentially discouraging grades results and statistical significance with respect to the study’s goals, there are still several good reasons for faculty to consider implementing a daily quiz technique. These include increased student engagement at the beginning of class, a perceived increase in student motivation to review regularly versus the night before the exam and a better sense of the class’ grasp of concepts, which could prompt further review to ensure mastery. All these benefits occurred without any of the feared detrimental effects of more testing like increased grading load or degraded rapport. While students are not going to ask for more graded assignments, a majority recognized the value of a routine review using the vehicle of a daily quiz.

Conclusions

In summary, there appear to be many good reasons to review material at the beginning of each class via short, in-class quizzes. Additionally, the practice of giving in-class quizzes was not shown to erode student morale. On the contrary, when given the opportunity to vote, students voted to keep the review quizzes. However, a statistical analysis of test scores does not provide evidence that the practice increases student performance on the conceptual portions of exams. This agrees with the results reported by Connor-Green. Considering the apparent theoretical support for frequent quizzes, this result suggests that more research is necessary to understand why and to better control the variables that might affect the results of the study, such as the controlled environment that Karpicke and Roediger enjoyed in their study. If any single conclusion can be drawn from this study, it is that the frequent review quizzes do not hurt student morale or their attitude about attending class, as long as the practice is properly mediated. In fact, it may actually improve students’ attitudes about class if they understand that the intent is to elevate their learning and give them more meaningful opportunities for review. Ironically, it also seems to enhance student-teacher rapport, and can even jump-start class participation. This stands in contrast to the Lowman’s assertions, and is almost certainly the result of the care taken to explain the purpose behind the frequent quizzes. Although requiring an initial investment in
time and effort, these quizzes can be used semester after semester with only minimal resource commitment, and yet, the instructor can reap whatever benefits come with the practice.


