Student Perceptions Regarding the Effectiveness of Daily Quizzes in Collegiate Level Calculus

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This paper was completed and submitted in partial fulfillment of the Master Teacher Program, a 2-year faculty professional development program conducted by the Center for Teaching Excellence, United States Military Academy, West Point, NY, 2011.

ABSTRACT

Current research indicates that student performance improves with an increase in the frequency of testing. While there is a limit to this technique as a means of advancing retention, to what extent do the students themselves perceive the effectiveness of daily quizzing as a means of preparing for exams? In this paper, the link between short quizzes administered at the start of each class period and the students’ perceptions of how well quizzes prepared them is examined. The paper also examines perceived effectiveness of competition and the preferred material for daily quiz coverage. This analysis found that there is a slightly positive relationship perceived between daily quizzing and exam performance. The study also revealed that the majority of students do not want any sort of competition interjected into the exercise. The study concludes that quizzing over the previous day’s material is the most preferred option for enhancing retention.

INTRODUCTION

There are numerous benefits attributed to the use of daily quizzes as a learning mechanism. A 1974 study by Rieth, et. al. found that children learning spelling words had a greater retention when the list of words was broken down into several smaller lists and tested with daily quizzes as opposed to being provided with the overall list [1]. The researchers found that giving all of the words up front was inferior to other methods of distributed practice. This echoes earlier work by Spitzer who found that frequent testing was a useful technique toward helping in the retention of knowledge, and who encouraged an increase in the use of testing [2]. Spitzer also suggested that since testing can help to correct misunderstandings, corrections should always be returned to the student. He assumes that the quizzes are graded by the instructor and returned.

It is not just the impact on test scores that potentially benefit though. Taking into account student perception of quizzes, work by Byrd, Coleman, and Werneth [3] examined the impact of quizzes in an introductory college astronomy course. They found that a control course which emphasized daily quizzes resulted in a more positive student response to the course though there was no difference with the evaluation which was given to the instructors. Interestingly, their quizzes were cooperative quizzes with a scoring mechanism which could only help a student’s grade. The motivation for this technique was the desire for a methodology to keep students engaged in learning throughout the course’s three hour class periods.

In an article by David Glenn, the effects of frequent testing are presented, along with several arguments for conducting such research. [4] One of the largest problems they identify is the sheer time commitment which is necessary in order to provide effective feedback. The workload required to grade a
large amount of homework in a timely manner would quickly consume an instructor, the opportunity to
give feedback is simply not practical. [5]

Feedback is essential in that it prompts focus on critical problem areas. Hagedorn, Sagher, and
Siadat found that examining the quizzes allowed the identification of concepts which needed to have
additional instruction [5]. Another researcher found that frequent quizzing was important when teaching
remedial mathematics to students with weak mathematical abilities. [6]

The timing of the quiz might also have some impact on its effectiveness. Poljicanin, et. al.
conducted a daily quiz procedure as part of an anatomy course, though they decided to quiz at the end of
class.[7] They found that the introduction of daily quizzes conveyed to their students that testing is a fact
of life. In addition, the students found that their study habits improved and were better able to identify the
key-learning issues in addition to receiving frequent feedback on their performance. Their motivation
with quizzes was to stimulate thinking and not merely practice for exams or strive for “reward points.”
They found that daily quizzes enhanced success for students. This is similar to the methodology by Byrd,
Coleman, and Werneth [3] who also administered non-punitive quizzes. With regards to assigning some
sort of points to the exercise of daily quizzing, Komaki found that when additional points can be earned
through quizzing activities, performance was typically better than when no additional grade improvement
was possible.[8] She also found that students greatly preferred quizzing options which helped to boost
their grades with the least amount of additional effort possible. Other possibilities included dropping low
scores, waiving a final, or extra credit work.

A desired result of frequent testing is that students will not cram in anticipation of exams.
Mawhinney, et al. found evidence that large amounts of time between testing events do not encourage
consistent study behavior with students. [9] They found that testing every week or every three weeks
resulted in greater amounts of preparation time for a graded event as the time drew closer. With regards
to the effectiveness of repeated testing, the question naturally arises of the limitations of this technique. A
meta-analysis performed by Bangert-Drowns, Kulik and Kulik found that gains in test scores were
“incrementally smaller with each test added to the course”. [10] They also found that a larger number of
shorter tests resulted in better performance than fewer tests which were longer. They concluded that
teachers should engage in testing more often to improve the outcome of students. Abbott and Falstrom
found that frequent testing was critical to Personalized Systems of Instruction, which relies on extensive
testing and tailoring of courses, and has been found to be superior to traditional methods of lecture. [11]

Hagedorn, Sagher, and Siadat conjecture that teaching how to learn something may be as
important as trying to convey the lesson material. They also speculate that since mathematics as a subject
builds on previous concepts, cumulative testing may require students to review basic material and may be
particularly appropriate for the subject. [5]

Research conducted by Kling et al. [12] in 2005 found that shorter more frequent quizzes led to
better results than less frequent larger exams. Kuo and Simon hypothesize that lower achieving students
benefit more from increased test frequency than do higher performing students. Feedback and
remediation was found to be crucial for lower performing students to benefit from frequent testing. [13]
The subjects for this study are students of Integral Calculus. This is one of the core mathematics courses in the program of study at West Point and is typically taken during the second year of study. The course is a semester long and covers foundational principles, applications of calculus, and differential equations. There are four major graded events spaced evenly throughout the course, and two projects designed to provide real world application to classroom concepts. There are also two Fundamental Calculus Exams which are designed to provide additional testing of fundamental skills and the student’s algebra and modeling skills from previous courses. The program of study is used to prepare students for technical and engineering classes. The subjects of this study are from five class sections of students ranging in size from fifteen and eighteen students. Three sections took the class during the fall semester, while two sections took the course during an “off-cycle”, meaning that these students are behind their peers in the core math program for various reasons.

The prerequisite for Integral Calculus is Differential Calculus. The prerequisite makes widespread use of the “daily derivative”, which is a different problem that is worked at the boards by each individual student at the start of every class. Students and their instructor then evaluate their work. The results are tracked from day to day, with an overall score being assigned. The problems make use of the basic rules of taking derivatives and are designed to keep the material fresh in the minds of students as they make their way through the course. Though there is not much variation in the problems, they all involve testing over the basic rules of taking derivatives. During the time of the study of this paper, there was no course-wide analog of the “daily derivative” in the Integral Calculus course.

**APPROACH AND METHODOLOGY**

There were two methods of doing non-punitive quizzes: working publicly on blackboards, or working silently at desks. Public work at blackboards has the benefits of being able to see other people’s work, and it allows the instructor to see where students are having problems. Additionally, the researcher finds that working at blackboards is generally more productive since it fosters conversation between neighboring boards. Individuals who finish quickly are able to then help provide guidance to others, and students are generally kept working until everyone’s boards have the same answer. This provides students with the opportunity of continuing to struggle through their difficulties and reach their own conclusion, even if it takes some additional coaching from fellow students. This approach achieves a much more efficient use of time. When the researcher is satisfied that all work has been done on the boards, one of the students will be called on to brief their work, or the instructor covers the solution to the correct answer if pressed for time. This is usually a good time to clarify points in the problem-solving process, and it allows the students time to copy down an approved solution in their notes.

Working at desks on additional paper has the benefit of students being able to take their work with them, but it does not allow for additional help to be received from others and it typically requires some sort of time limit to be placed on the event. After completing the quiz at a student’s desk, the researcher has them either grade their own paper, or exchange with another student. This has the benefit of allowing them to see and critique others’ work, as well as get feedback from someone else.

There are several potential benefits to this method. First of all, it provides a daily test of knowledge; the students know that they will be quizzed so it provides incentive to learn the material. Second, it helps to prevent students from falling too far behind in the course since the daily quiz provides instant feedback with regards to how well they are assimilating the instruction. When collected, the
instructor gets a good evaluation of individual student performance and can identify trends with individuals. With small class sizes, actual collection of the quizzes may not be necessary as the instructor can walk about and spot check on student performance to gauge how many of the students are grasping the concepts. This echoes the findings of Poljančin, et al. [7]. In that respect, it forms a feedback tool for the instructor as well. Finally, it provides an incentive to prepare for class. Also, if a student’s peers will be grading their work it provides incentive for neatness of work and correct technique.

If quizzes are effective as the literature indicates, then there remains the question of how a quiz should be constructed. Typically they consist of one problem, similar to one that they have recently worked. Sometimes there might be one overarching problems with numerous sub-concepts which can be addressed quickly. When starting a new block of material for which there has been no previous material covered in the course, it may be appropriate to use a problem which is similar to one that is covered by the day’s reading in the textbook or to pull from other mathematical concepts which will support the day’s lesson. This has the added benefit of not having to sidebar a review technique in class. By utilizing a concept as quiz material, it then becomes possible to engage in the refresher discussion prior to entering the material for the day’s lesson, and one can proceed unimpeded or without worry of becoming sidetracked.

If the material builds on previous days, as most classes do (which is in line with previous observations from Hagedorn, Sagher and Siadat [5]), then material from the previous day is a good way to start. Often in the course of conducting class, a problem will be referred to verification or for a piece of the answer. Providing that piece during the quiz has the benefit of not needing to take additional time to derive it in class, but we can simply refer back to the quiz. This has the added advantage of setting things up for class; for example, a quiz might provide an answer to a question which we will develop certain techniques for discovery using a different method. For some students, reviewing the previous day’s work is a necessary component of learning and serves to warm up their mental acuity. This echoes work by Cunningham which stressed conceptual learning in mathematics classes [6]. Material which is considered crucial to the course can be quizzed any time. Every course has a set of core concepts which are considered foundational knowledge.

The quiz has an additional function; it highlights the importance of review and which concepts can be considered foundational to the course. In that sense, it helps to provide focus to the students. Just as important as administering the quiz is going over the answers in class. The researcher typically has the students swap papers for grading, though sometimes the researcher has them grade their own work. It is important to highlight where the concept was discussed in the notes or the section of the book which concerns the material for the quiz. This also allows the key ideas behind the problem to be highlighted. The researcher then works through the problem in class and explain each of the steps and at the conclusion they are given rough rubric indicating how many points to assign for each step. Since the scale is from 0 to 10, this keeps the addition easy. Occasionally, the instructor will allow the students to award points for neatness and logical follow-on of steps since these are crucial to problem solving and the researcher wants the students to understand that.

In making public the rubric, this allows the instructor to highlight several things. First of all, it helps to provide a baseline of grades since there is the potential for a wide variety of scores. Additionally, each student can look at their grade and understand what their shortcomings were and how serious various
errors are. Furthermore, the means of grading helps the students themselves realize which ideas are considered most important to solving the problem. This also provides insight into how test materials are graded on the exams which are administered throughout the semester.

This concept for improving calculus skills is as follows: give a one question quiz at the start of each class that takes no more than 3-4 minutes to complete and can be effectively graded in the same amount of time. The procedure for conducting daily quizzes is to begin each class period with the exercise. Work is done either on the blackboards which panel the room (enough for one per student), or by working individually at a desk. The problem to be solved is projected at the front of the classroom and is not visible prior to the start period. The problems are of one of three possible types: a problem from the previous day’s material, a problem taken from the reading which is to be done prior to the current day’s class, or a problem which involves some fundamental algebra skill or problem area which has been previously identified as problematic.

At the conclusion of the allotted time, the students trade papers and either the instructor works through a solution on the main board or a complete solution is briefed by the students. Then common errors and how to grade these are discussed. A grade is then assessed based on classroom discussion. The quizzes are then returned to the person who completed it for further study. Occasionally, the instructor gathers the quizzes for additional review following class.

SURVEY PROCEDURE AND DISCUSSION

After conducting daily quizzes for half a semester, the researcher surveyed the class with three different questions:

1. On a scale of 1 (Strongly disagree) to 5 (Strongly agree), how much do you feel the daily quiz helps to prepare you for the WPR (an exam)?
2. Should some sort of contest be incorporated into the daily quiz?
3. What material should the daily quiz cover? The material from the previous day, material from the reading for today’s lesson, or fundamental concepts?

The survey was administered by writing the questions on the blackboard, with responses being recorded individually on cards which were collected by a student at the conclusion of class. All responses were anonymous. A total of 73 individual responses were collected.

The response to question 1 had an average of 3.172 across all sections (min = 2.73 and max = 3.53) indicating a slightly positive belief in effectiveness of quizzing for exam preparation. The histogram is depicted in Figure 1. When compared to the section averages, there was no statistical significance between the section average and response of perceived effectiveness of daily quizzing.
The next question concerned incorporation of a contest into the daily quiz. Two thirds of the students surveyed did not want a contest. As expected, those who did want a contest rated a 3.30 in perceived effectiveness compared to 3.06 for those who did not want a contest. Examining the proportions of those who agreed and those who disagreed with the statement though, indicates that amongst those who gave a rating of 1 or 2 to the effectiveness (disagreement with the statement), the overwhelming majority of those students did not want to participate in any form of competition. It is unclear why they had this response; the researcher hypothesizes that they are either emotionally removed from the activity, or they do not feel confident enough in their abilities to compete against others. Another reason that the researcher finds this interesting is because daily testing and competition is a fundamental part of the prerequisite course. Figure 2 provides the distribution of responses regarding competition as a function of daily quiz preparation for exams.
The third survey question involved the type of material which should be covered. Several individuals indicated multiple areas of material which they preferred to be quizzed over. The overwhelming preference for quiz material was the previous day’s lesson. This option dominated both of the others with 63% of students preferring quizzes over previously covered material. The next option in popularity was fundamental concepts which was favored by 22% of the students and followed by quizzes over the current day’s lesson with 18%. An interesting observation is that fundamental concepts are preferred as desirable for coverage if the perceived effectiveness is between 1 and 4 and the current day’s material is selected by those who rated the effectiveness between 2 and 5. A histogram is provided below in Figure 3.

![Desired Content of Daily Quiz and Perceived Effectiveness](image)

**FIGURE 3: Desired Content of Daily Quizzes**

In addition to the anonymous survey detailed above, an anonymous online survey was also provided to gather feedback regarding various aspects of the testing procedure. When asked if students preferred to work at their desks or the boards, 36% of respondents indicated that they preferred to work at their seats, 13% preferred to work at the boards, while 41% wanted a mixture of both. The remainder did not have a preference.

Students who wanted to work at their seats cited the ability to take work with them as the primary reason for doing so. One typical comment was: “I want to be able to keep that work as notes when I am done. (rather than having to erase it and not gain any benefit from doing the problem other than practicing the concept.)” Even though the students usually copy down an approved solution while it is being covered in class, discussion in class revealed that they often feel rushed and unable to fully absorb what was just covered. Perhaps one way to accommodate this is to provide a greater amount of time for individuals to copy the solution down. Those who wanted to work at the blackboard cited help from the instructor and ability to see others’ work as reasons for this type of work. Since no grade was assigned to any of the quizzes, many individuals felt that it was beneficial to run into difficulties and then work through them by either getting hints from other students, or directed questions from the instructor. Those that wanted variety in terms of working location stressed that certain problems lend themselves better to being worked on the boards (typically the more complex problems).
Some of the other feedback included a suggestion that the quiz be administered at the end of class so that problem areas can be cleared up. Many students suggested that the quiz should only be worth a point or two of the overall grade. A lot of the students simply enjoyed the fact that it was a check on learning and helped them to gauge where they are in the course.

CONCLUSIONS

Overall, the researcher found that administering daily quizzes was a worthwhile exercise, though the students believed that the exercise only slightly beneficial in performance on tests. Depending on the problem type, working at the desk or on blackboards around the room is beneficial. For more complex problems involving multiple steps, work at the blackboard may be more appropriate, whereas work involving mathematical rules or a special manipulation may be more beneficial if done at the desk. Finally, the students have an overwhelming preference to cover material from the previous class and unstructured feedback indicates that it is a good means of determining one’s progress in the course.

REFERENCES:


