Mathematica Militaris

Volume 24 | Issue 1 Article 5

June 2019

Motivating Class Preparation with Oral Quizzes

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***Abstract*—In this article we compare the effectiveness of oral quizzes and online homework (WebAssign) as means of preparing for class. We find that both assessment methods motivate students to prepare for a similar amount of time, but oral quizzes cause them to spend more of their time reading the textbook than does WebAssign. We found no significant difference between the performance of students using these two methods. We conclude that while oral quizzes do not dramatically increase the quantity of preparation, they seem to improve the quality. We believe that oral quizzes are a valuable technique for instructors to add to their repertoire.**

I. Introduction

A fundamental aspect of pedagogical research is how to increase the effectiveness of instruction in the classroom, and, closely related, the effectiveness of student preparation. Educators at every level are actively experimenting with approaches to improving student preparation ranging from the conservative, such as careful refinements to traditional approaches, to the revolutionary, such as upending the paradigms of "instruction" or "classroom" themselves.

We approach this research question in the context of instruction at the U.S. Military Academy (USMA), which creates two special opportunities. First, the small classrooms at USMA (at most 19 Cadets) allow for teaching techniques not feasible in a more typical large-enrollment university course. Second, the graduation outcome for every student ("Cadet") is to commission as an officer in the military, and as a result, the primary mission of the school is to create leaders of character. This has a marked effect on classroom culture: instructors have a heightened role as mentor, and there is increased emphasis on otherwise secondary goals like building student interdependence, interpersonal skills, and individual discipline.

In this paper, we propose applying an assessment technique called an "oral quiz," which we demonstrate is an effective tool for incentivizing student preparation. We begin by placing this technique in the context of pedagogical research such as the model of active learning. We present our methodology, both from a theoretical and practical point of view. We then present the results of using this technique in several sections of the same course, administered by two instructors, and compare the results to the standard technique in this course, namely daily online homework. We continue with some reflections on the technique, and end with a discussion of avenues for future work.

A. Background

Let us characterize the traditional college classroom as a sage professor, issuing an extended and minimally-interactive lecture to a large student audience over the course of a semester, punctuated by a high-stakes midterm and final exam. This venerable model is under increasing scrutiny as, among other problems, often in this environment "the information passes from the notes of the professor to the notes of the student without passing through the mind of either one." [3]

In this brief background section, we will discuss relevant current pedagogical research aimed at fixing this fragile model of learning, with a focus on the role of student preparation in learning.

1) Active learning: Active learning is a term defined broadly as "any instructional method that engages students in the learning process." [5] While this could technically include even a static, traditional lecture environment, in practice, active learning is intended to exclude any teacher-centric approach and instead focus on peer-assisted and problem-based approaches. [1]

A popular subset of active learning is the so-called flipped classroom. A simple definition of this model is that whereas in the traditional classroom, lectures take place inside class, and practice exercises and problem solving take place outside class, in the flipped classroom that pattern is reversed (with the lecture being replaced by book readings or more often, video lectures). [1] To guide the in-class activities we may draw on decades of psycho-educational research, for example, the concept of "constructivism" due to Piaget (1967) that a teacher's

role is to guide the student in constructing new knowledge from his or her previous knowledge. [1]

One category of this in-class activity is informal cooperative learning, where students "work together to achieve a joint learning goal in temporary groups" (e.g. formal cooperative learning, which is typically for longer periods and larger concepts.) As an example in this category close to our own proposal, "turn-to-your-partner" discussions have students receive a prompt, formulate an answer, discuss with a partner, and then are individually accountable for answering the question in a 30 second summary of their pairs discussion. This activity, in addition to learning the material, aims to build positive interdependence, interpersonal skills, individual accountability [3] — which we point out, is not unlike the aims of a USMA instructor for developing future leaders.

Outside of class, instruction that used to occur as lecture is now accessed at home (i.e. in the barracks), in advance of class. Often this model manifests as the teacher posting instructional videos or interactive lessons online. This idea is now pervasive as both a commercial and open-source venture: to list a few examples, MITs OpenCourseWare (OCW) and edX offerings, Cengages "Watch It" videos, Khan Academy, Udacity, Coursera. [1]

In our view, a principal aim of active learning and flipped classrooms is to attack the traditional lack of student preparation (completing homework, reading, etc.) and thereby improve student understanding and engagement. These models do so by placing the onus for learning back on the student. [6]

2) Thayer Method: Interestingly, the concept of a flipped classroom has long historical precedent at USMA under the moniker of the "Thayer Method." In 1817, Sylvanus Thayer standardized the education program at USMA in his role as the first superintendant. Most of the practices he introduced are still in effect today: classes were small, Cadets were expected to come to class prepared to recite on the topic of instruction for that day, including a literal recitation period of class where Cadets presented to the instructor what they had learned the night before at the chalkboard. (The first systematic use of chalkboards was at USMA.) [7]

These methods, then as now, were not popular with students. In fact, in 1821 the Cadets set fire to the mess hall as a diversion while they (attempted) to fire a cannon at Thayer's house. [7] But the method persisted. In the 1950s, the Department Head of the Mathematical Sciences summarized the instructors role: "the instructors objective is to cause . . . Cadets to participate *actively* in the development and clarification of concepts." (Emphasis ours.)

3) Assessments: Integral to any instructional model is the process of assessment. Assessments serve a wide-range of purposes: identification of special needs, feedback on student learning and instructional effectiveness, and assigning grades, to name a few. [4] The model of single-event, high-stakes testing (e.g. the final exam) has come under scrutiny for various reasons such as inefficacy and inaccuracy, and although it still continues to be the norm in contexts from primary to graduate level education, there is a diverse portfolio of alternative assessment techniques in common use in modern classrooms ranging from the traditional (quizzes, written homeworks) to the constructivist (oral presentations, open-ended group projects). [4]

A primary challenge with creating any assessment, whether in a traditional or "flipped" classroom, is to avoid the tendency to "teach to the test" and the resulting low-quality, uninspired teaching environment [2], and instead somehow balance a desire for ambitious and inquiry-oriented learning with the requirement for students to perform well on an assessment.

B. Contributions

Cadets at USMA have many demands on their time, and in our experience, class preparation is often perfunctory and strategic. Since we believe that proper preparation for class is an important part of the learning process, we want to employ a technique that would motivate Cadets to prepare with an eye toward understanding rather than completion.

Following the tradition of the Thayer method, oral quizzes are an attempt to synthesize the critical aspects of modern active learning and assessment research into a concise, effective in-class event that takes full advantage of the special opportunities afforded at USMA and honors our ultimate mission, producing leaders of character.

We believe that the interactivity of oral quizzes will inspire Cadets to prepare better for class, but we were concerned that the lack of daily assessment might reduce the overall time they spent preparing for our course. Our experiment demonstrates that absent any confounding factors, the preparation time difference between daily online homework and oral quizzes is not significant, although our intuition tells us and our experience seems to indicate that the quality of preparation is better.

II. Methodology

A. Course Context

The context of this project is MA103: Mathematical Modeling and Introduction to Calculus. According to its course description,

> MA103 is the first course of the mathematics core curriculum. It emphasizes applied mathematics through modeling. Students develop effective strategies to solve complex and often ill-defined problems. The course exercises a wide array of mathematical concepts while nurturing creativity, critical thinking, and learning through activities performed in disciplinary and interdisciplinary settings. The course introduces calculus using continuous and discrete mathematics while analyzing dynamic change in applied problems. Students employ a variety of technological tools to enhance the ability to visualize concepts, to explore ideas through experimentation and iteration, to complete complex and time-consuming computations, and to develop numerical, graphical, and analytical solutions that enhance understanding.

The majority of Cadets take MA103 in the first semester of their plebe (freshman) year. The most mathematically advanced Cadets instead take an honors course in differential equations, while the most mathematically deficient Cadets take a pre-calculus course followed by enrollment in MA103 in the spring. These two sources account for approximately the top 20% and the bottom 5% of the population, respectively. The students in the fall section of MA103, which is the context of our study, are first semester freshman Cadets who have demonstrated mathematical ability in their high school coursework and standardized test scores which is on par with the rest of their incoming class. The Cadets have not yet declared a major when they are enrolled in this course, but MA103 is a core course for all Cadets, so Cadets who take MA103 go on to major in every subject.

B. Daily Assessment Techniques

The current MA103 course standard for daily assessment is a pattern of daily homework assignments automated through the online homework system WebAssign. We compare this technique with "oral quizzes," a collaborative, verbal, in-class check on learning and preparation.

1) WebAssign: In sections using WebAssign as their form of daily assessment (the course standard), students complete two to five problems each night, covering the material in the sections of the book they are assigned to read. The material is discussed in class the following day. These problems are computational, and WebAssign grades the answers automatically. The students are given an unlimited number of attempts at each problem, and after each submission they are told whether their answer is correct. Although all students receive the same questions, WebAssign automatically varies the numerical values of each question between students to limit outright copying of answers. The students receive a homework grade based on their score on WebAssign homework, worth 150 points in a 2000 point course, or 7.5% of the grade.

2) Oral Quizzes: In sections using oral quizzes as their form of daily assessment, students still have access to the same WebAssign problems as their peers in WebAssign sections, but these problems are not worth a grade in the course. Instead the students are graded on three oral quizzes and three handwritten homework assignments over the course of the semester.

At the beginning of the semester, the instructor puts students into oral quiz pairs, and provides a list of possible oral quiz questions. The list is divided by section of the textbook, with each section containing all the WebAssign questions and one additional question from the textbook.

Each class begins with a one-question quiz. The question is either one of the WebAssign questions from the previous nights' suggested homework, or it is the textbook example for that day. When the students show up for class, the oral quiz question is posted for them to see. The students can begin working as soon as they arrive, and their solution must be ready to brief five minutes after class begins.

After the five minutes of preparation are complete, the instructor selects one group to present their solution. The selection is ostensibly at random, although in practice the instructor may select the pair strategically. This pair spends at most five minutes explaining their answer to the rest of the class, including some extension beyond the numerical answer. This mathematical depth could be straightforward, such as filling in the details of the solution, or insightful, such as demonstrating a connection to other material in the course.

The brief is followed by a short question and answer session in which the class and the instructor probe the extent of the briefers' understanding of the problem.

After a poor brief, these questions can be scaffolding to lead the group to the answer. After an excellent brief, they can be "stretch questions" that push the students to connect the problem with other course material.

The group that briefed their solution receives a grade based on the correctness of their answer, the depth of their understanding, and the effectiveness of their written and oral presentation; the other groups receive no grade that day. Each group is graded three times throughout the semester.

The three written homeworks also given to oral quiz sections were slightly longer problems selected to assess the students' understanding of the mathematical modeling process. Together the oral quizzes and homework are worth 150 points in a 2000 point course, or 7.5% of the grade, and oral quizzes account for 90 of these 150 points.

C. Instructor Background

Two of the authors, Dr. Steward and MAJ Lynch, conducted this comparison of methods in their classrooms, both in the context of MA103.

Dr. Steward taught two oral quiz sections and one WebAssign section in MA103, with previous experience using both WebAssign and oral quizzes in other courses (electives). MAJ Lynch, who taught one oral quiz section and two WebAssign sections in MA103, had previous experience using WebAssign but was trying oral quizzes for the first time. Additionally, one of MAJ Lynch's WebAssign sections was composed of Cadets who were considered "at risk," which we consider a potential biasing factor for the purposes of this comparison.

D. Expectations and Hypotheses

We believe an ideal outcome for daily homework is that students (1) spend time practicing mathematics and (2) spend time using their textbook. This amounts to an expectation on both the *amount* and the *type* of preparation, both of which are ideally done at a high quality. WebAssign promises to enable this vision, specifically: a student reads his or her textbook, carefully works problems on paper, submits his answers and receives instantaneous feedback, which he can then use to check his work.

Unfortunately, in our collective anecdotal experience with WebAssign, we have found that this vision is not reality. In our experience, students rarely open their textbook, turning first to the online homework. They are reticent to write anything on paper while working on the computer, and they frequently resort to guessing since their answers are checked immediately. On the other hand, WebAssign does typically inspire a high participation rate due to its weight in the course grade and the relative ease of a passing grade through minimal engagement, which at least ensures that the students are seeing mathematics each night.

Nevertheless, we hold steadfast to our convictions that practicing mathematics and reading mathematics textbooks are critical components to learning mathematics. To that end we sought a different means of motivating and assessing preparation.

We hypothesized that the oral quiz promised an effective replacement. Our rationale centered around two aspects. First, the public speaking and collaborative aspects of the oral quiz we hoped would incentivize preparation out of an intrinsic desire to avoid public embarrassment and be a good team player. Second, the mathematical depth portion of the quiz, as well as the knowledge that many of the questions were taken directly from the textbook, we hoped would incentivize use of the textbook.

We also note that we continued the practice of using course points to motivate our technique (i.e. the oral quizzes were graded), since we find that to an even greater degree than at other universities, students at USMA will not make time for assignments that do not have points attached.

E. Data Collection

In order to evaluate how much and what type of preparation students were doing for class, we collected the following data:

- how much time students spent preparing for class (daily survey)
- how students spent that class preparation time (daily survey)
- students' performance in the class (assessment scores)
- student satisfaction with WebAssign and oral quizzes (survey)
- student opinions on WebAssign and oral quizzes (personal interviews).

The daily survey of preparation time and use was conducted by having students report, on a piece of paper, how much time they spent preparing for that day's lesson the night before. This information was collected anonymously and supplied voluntarily.

All other surveys were also optional and anonymous. They were administered online through the learning management system at USMA.

III. Results

A. Amount of preparation

We first examined if the choice between oral quizzes and WebAssign has a significant impact on how much time students spent studying. In short, the answer is that it does not. From a macro perspective, in five of the six sections for which data was collected, the average cadet spent 30 ± 3 preparing for class each night, including three oral quiz sections and two WebAssign sections. The remaining section used WebAssign and the average cadet spent 54 minutes preparing for class. However, this was a special section targeted at Cadets with weaker math fundamentals. We believe that this is a more likely cause for their significantly greater preparation time, and we treat them separately throughout this paper.

We also viewed preparation through the lens of a lesson-by-lesson comparison. When all unusable data was filtered out and assessment days were discounted, we had 24 lesson days for which enough data was collected to compare sections. When you include all 6 sections of students, those using WebAssign spent more time preparing for class than their peers in 19 out of 24 lessons (79%) and students in oral quiz sections spent more time preparing than their peers 4 of the 24 lessons (17%). However, when the one section with weak fundamentals was discounted, students using WebAssign spent more time preparing than their peers 12 of 24 lessons (50%) while students given oral quizzes prepared more than their peers 7 out of 24 lessons (30%), and there was no difference in preparation between the groups for 5 out of 24 lessons (20%). This preliminary analysis indicates that when major differences in section populations are ignored, students dedicate the same amount of time to class preparation regardless of whether they use WebAssign for nightly homework or are given oral quizzes in class.

B. Type of preparation

We hypothesized that oral quizzes would incentivize reading the text because oral quizzes had a depth component and sometimes were taken from examples in the text. To provide evidence regarding this research question we analyzed the Cadets self-reported surveys. The results of the surveys for both groups of Cadets are depicted in Figure 1. Cadets in both the oral quiz group and the WebAssign group spent the majority of their time doing problems. We think this is a positive outcome. The oral quiz group decreased the percentage of time doing problems in order to read the text more, as hypothesized. All other study types were found to be generally unchanged between the two groups.

While we recognize the quality of preparation is similarly important to the quantity and distribution, it is much harder to evaluate. Though we believe that oral quizzes inspire Cadets to prepare better than WebAssign, we do not have data to support this hypothesis. Yet anecdotal evidence from our interviews with students seems to confirm this supposition.

C. Student satisfaction, preference, and qualitative feedback

One aspect to examine when looking at a pedagogical experiment is student satisfaction. Although never a sole indicator of success, it usually a good idea to consider how well received a new intervention is by the audience. To assess satisfaction, we used a 5 point Likert scale with 5 meaning their preparation tool was effective and 1 meaning it was ineffective. Students in the oral quiz group rated their experiences effectively equal. The oral quiz sections gave an average rating of 3.71 compared to the WebAssign groups' average rating of 3.68. We also asked which preparation method each group would prefer. This question is somewhat flawed because the WebAssign group had never experienced oral quizzes (although they were verbally explained), and the oral quiz group had experienced WebAssign, but only in previous courses. Perhaps in part due to this experience bias, Cadets greatly preferred the preparation tool that they experienced during the experiment as seen in Figure 2.

Cadets were also interviewed and asked about their experience using the different preparation tools. In general, Cadets found any form of preparation valuable, but they did offer various pros and cons of oral quizzes and WebAssign.

They stated that one advantage of oral quizzing was that it made them try to achieve a better understanding of the concepts as opposed to just memorizing a method. One Cadet stated, "Since you had to brief someone in an oral quiz, it required you to understand what you were talking about." Another Cadet stated, "Having WebAssigns [be] graded motivated people to complete the WebAssign but not learn the material." In particular we have observed that Cadets will quickly resort to random guessing on WebAssign until they get the correct answer. When confronted with this hypothesis, one Cadet

Fig. 1. A comparison of the percentage of time spend engaging in different study activities for Cadets in two different test groups

Fig. 2. A comparison of each test groups' preference for preparation tools.

in a WebAssign section responded: "Yes. After a while if I'm not understanding the problem or the numbers don't seem to be working, I'll just be like: 1 through 10."

One negative aspect of oral quizzes that Cadets noted is that some students were tempted to "play the odds" and hope that they would not be chosen to brief. One Cadet noted, "A lot of kids definitely slacked off, (because) it's like a 1 in 9 or 10 shot [...] that [they'll] actually get called on." Another said "If it was just based on briefings, I might take the chance on a couple days. I can't do math homework tonight. But WebAssign kept me regular with math."

When students in oral quiz sections were preparing, the survey data indicates they read the textbook much more than students in WebAssign sections. One Cadet in the WebAssign section stated, "A lot of times I found myself just going on WebAssign and not looking at the [textbook]" while their peers in the oral quiz section noted, "If you know that part of [the oral quiz] might be from the book, you kind of have to read that part from the book." The Cadets even observed that a mixture of reading and homework problems helped them learn: "It helps to read the part from the book and do WebAssign because then you get the material a lot better."

One last positive element of oral quizzes that the Cadets talked about in the interviews was the briefings themselves. Although the primary target of an oral quiz is the briefer, the observers also benefited from the brief. "It helps in both ways, both for the presenter and the person watching the presentation." Furthermore, oral quizzes helped instructors shape the direction, speed, and difficulty level of the day's lesson, "You would do examples in class based on how well we understood the

question we were doing for the oral quiz. So that was really helpful."

The interviewees all agreed that Cadets have different motivation levels; they will prepare well if they are motivated and will not get much out of their preparation if they are not, regardless of preparation technique. For the typical Cadet, WebAssign motivates consistent preparation but little understanding. Oral quizzes inspire deeper thought but allow Cadets to skip some lessons entirely. One Cadet summarized the differences between the two methods by saying, "If you don't grade the WebAssign, nobody's going to do it, but a briefing is nice because you can hear someone else explain how they broke down the problem."

D. Course performance

Although the primary purpose of this experiment was not to determine if one preparation method produced better grades, it is always to examine if one is correlated with better student performance. Unsurprisingly, grades were not significantly different for the two test groups. Cadets that were in the oral quiz group had an average course grade of 77.7% as compared to Cadets in the WebAssign group who had an average course grade of 76.7%. However, when the section with identified weak fundamentals is omitted, the WebAssign group had an average course grade of 77.4%, essentially the same as the oral quiz group.

E. Summary

We found that in most ways the data does not indicate any significant difference between sections graded on nightly online homework and sections graded on oral quizzes. If we accept that a section with weak fundamentals is a biasing factor, these groups showed effectively no difference in amount of time preparing for class, satisfaction with their evaluation technique, and performance. The only quantitative difference we found was that oral quiz sections spent more time reading the book and less time working on problems than their WebAssign peers.

Our qualitative metrics indicate that oral quizzes caused students to think more about how and why solutions worked. Further, the briefs themselves seemed to drive learning for some Cadets. We believe that this demonstrates that oral quizzes, while not a panacea for poor preparation, are a useful weapon to add to an instructor's arsenal.

IV. Instructor Reflections

After using oral quizzes in the classroom for over a year, we collectively found them to be a useful tool that can enhance classroom learning. We saw both good and bad outcomes, but in our experience, the positives outweighed the negatives.

The first positive outcome we observed was the immediate engagement of students in the classroom. In a normal class, students show up and look at their phones, or chat with classmates, or check email until it is time to start the class hour. One benefit of the oral quiz is that students start thinking about math as soon as they arrive. We also saw that students spent more time reading and thinking than their peers who didn't have oral quizzes. This impression was reinforced by the analysis of our survey results and our interviews with Cadets. Oral quizzes also allowed us to adjust our lessons on the fly. We could check our students' understanding right away, which let us gloss over topics they had mastered and focus our class time on ideas that challenged them.

The only significant negative outcome that we observed when using oral quizzes was that students more often spent no time at all in preparation. Students in general, and Cadets specifically, are motivated by points. Having nightly graded homework usually ensures that most people engage with the material in some way every night, even if they do it inefficiently or ineffectively. However there is a temptation for students to not prepare at all for class if they know they will only be graded on preparation a few times a semester. One of the authors has also used oral quizzes in a more advanced class in the computer science major, and he did not observe this drawback in that context [8].

As we consider the contexts in which we have used oral quizzes, we find that they are most effective for evaluating procedural techniques that can be performed in a short time. Oral quizzes proved useful in freshman level classes, but should perhaps be supplemented by nightly homework to sustain engagement. In sophomore and junior level courses, we believe such a supplement is unnecessary. We observe that senior level courses often cover material which cannot be tested in five minutes, and so oral quizzes might prove less effective.

In total, after looking at the positive outcomes and negative outcomes, we feel that oral quizzes are effective to promote student learning in different ways than online homework. We would not recommend abandoning nightly graded homework, especially in required classes. Using oral quizzes in tandem with nightly homework

may in fact yield better results than either method in isolation. In the future we will look to keep the graded requirement component of nightly homework while incorporating oral quizzes to promote student reading and thinking.

V. Conclusions

When interpreting the results, we found that oral quizzes are a useful tool for instructors and should be considered based on the instructor's style and teaching philosophy. No evidence suggests that oral quizzes are significantly better than WebAssign, but no evidence suggest that they are worse. They therefore should be considered as part of a menu of options to get students to prepare for classes.

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