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Reflection on Oral Quizzes

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Abstract—In this article we reflect on an instructional technique piloted in our discrete mathematics course this past semester. Motivated by a desire for students to better prepare for class and for them to receive adaptive feedback, we introduced oral quizzes as a check on preparation. We observed oral quizzes to be a good inspiration for out of class reading and practice, they forced students to practice oral and written communication of mathematics, and allowed us to tailor feedback to be appropriate for each student. We will discuss our motivation in more depth and detail oral quizzes as we implemented them. Finally we reflect on the instructional method and consider how oral quizzes can be improved and modified for other classes. We found oral quizzes to be very successful, and we believe they can be adapted to suit nearly any college math class.

I. INTRODUCTION

MA372 Introduction to Discrete Mathematics is a one semester course designed for students of mathematics and computer science. The purpose of this course is to introduce topics in Discrete Mathematics, providing a foundation for further study and application. The topics covered are useful to both the applied mathematician and the computer scientist. They include propositional logic, elements of set theory, combinatorics, relations, functions, partitions, methods of proof, induction and recursion, digraphs, trees, finite state machines, and algebraic systems. Specific applications to computer science are presented.

This course is ideally taken after the completion of the Core Math sequence of MA103 Math Modeling, MA104 Single Variable Calculus, and MA206 Probability and Statistics. In the Core Math Program, we utilize mathematical training wheels, to teach cadets good habits through repetition. This course is one in their majors, but it is also a first course in proof writing for many of the cadets. So we are trying to take the training wheels off, but still walk along behind them with our hands ready to catch them if they start to fall over.

At USMA, we employ the Thayer Method: the practice of having cadets prepare on their own before a lesson, doing the reading and practice problems, and then coming to class with questions. Historically the Thayer Method was extremely harsh, wherein cadets would be tested on the day's lesson upon coming to math class; if they passed, they could leave to prepare for the next lesson; if they failed, they had to stay until they could pass. Our intent with the design of oral quizzes was to serve as a bridge for cadets, and make doing homework over the next lesson less brutal, and have a payoff. In its modern

incarnation, the Thayer Method is very similar to a “flipped” class.

This course is taken by all Computer Science majors in spring of sophomore year; it is an elective for Math and Operations Research majors. In 18-2, of 73 students: 63 are Computer Science majors; 3 are Math/CS double majors; 3 are Operations Research majors; 2 are Math majors; 1 is a Systems Engineering major; 1 is an Information Technology major. So, this course serves as both a service course for the Computer Science department, and an introduction to writing mathematical proofs.

Prior to the beginning of the semester, the Course Director sent a memo to all students enrolled in the course. It is similar in its intent to a Syllabus at civilian institutions. As stated in the Course Director Memo to Students, MA372 Introduction to Discrete Mathematics has two key goals. A successful student will:

- 1) Have the confidence and ability to think mathematically and effectively use discrete mathematics to solve new and/or interdisciplinary problems.
- 2) Have the ability to effectively communicate (in both oral and written form) the results of their mathematical work.

In our course design, we wanted to have students do several things:

- Prepare for each lesson (read the book, take notes, do practice problems)
- Communicate (written and oral)
- Work effectively in groups

Our solution to incorporating all these things: oral quizzes. Oral quizzes are daily checks on cadet preparation for class that also serve to introduce the day's new material. A pair of cadets presents (as a chalkboard brief) a solution to an exercise from the textbook and demonstrates some mathematical depth beyond the book's solution.

II. METHODOLOGY

In order to achieve the above-stated goals, careful consideration was given to the structure of the oral quizzes.

In the Course Director Memo to Students, oral quizzes are described as quizzes on the daily preparation exercises. The intention is to encourage cadets to work together before and at the start of class, to aid in developing an understanding of the material, and to communicate that understanding. Students

are put into formal groups and have some time to prepare a specified example/problem/proof. Students are then chosen at random to brief their solutions, and evaluated on mathematical correctness and depth, communication, and brief style.

III. STRUCTURE

The cadets are split into pairs at the beginning of the semester to work on oral quizzes together. Within each pair, one cadet is the writer, and the other is the briefer. The pairs stay constant through the course. Once the pair is graded for the first time, the cadets switch roles. After they have been graded for the second time, they are free to change roles at their preference.

For each class, the cadets are assigned reading from the textbook. They are given a list of approximately ten suggested exercises to prepare for class. The oral quiz question is selected from these suggested exercises. All of the suggested exercises are odd-numbered, and answers are available in the textbook. This list of assigned reading and suggested exercises is placed on the course website at the start of the semester. Cadets know the oral quiz question will be chosen from the suggested exercises, or examples from the reading.

In class, the oral quiz question is displayed on the board as the cadets come in. They break into their predetermined pairs immediately and prepare their answer to the oral quiz question. Classrooms are outfitted with chalkboards along the perimeter of the room, generally with one chalkboard per cadet. Each pair works on a pair of chalkboards; the writer is in charge of preparing the board for the briefer to brief. The writer copies the problem from the textbook and records the pair's solution, including any diagrams and tables they wish to use. Five minutes into class, work stops, and one group is selected to brief their solution. The briefer presents the solution to the class, including some extension beyond the book's answer. This mathematical depth can be as simple as filling in details of the solution, or it can be as complicated as explaining the general technique at play in the problem. If cadets have worked on the suggested exercises and examples from the reading, then this is plenty of time to assemble a brief; if this is the first time they are thinking about the problem, then they are crunched for time.

Once the brief is concluded, the floor is open for the class to ask questions. If the class asks relevant and intelligent questions, this concludes the oral quiz. Otherwise, the instructor probes the group's knowledge with their own questions. These questions can be scaled to the level of understanding demonstrated in the brief. Poor briefs can be clarified with scaffolding. Excellent briefs can be extended with stretch questions that inspire the class to push the boundaries of their knowledge.

If the cadets briefing are poorly prepared, the instructor can ask leading questions to encourage the cadets to figure out the problem in real time. For example, an oral quiz question during our block on Number Theory asked cadets to find a solution to a system of congruences. The group chosen to brief had written "Chinese Remainder Theorem" on the board, left some

blank space, and correctly transcribed the answer from the back of the book. The instructor asked the group to describe what they knew about the Chinese Remainder Theorem, locate it in the book, summarize it in their own words, and see if they could get the set up started from an example that looks similar. After being led in this way, when the cadets appeared to have a more solid grasp on the problem, they briefed another board with the correct solution.

We chose to grade the oral quizzes on a 30 point scale (in a 1000 point course) with 15 points available for mathematical correctness. Ten points are assigned for the quality of communication in the brief. For the briefer this comprises speaking clearly and confidently, reading mathematical symbols correctly, having good posture, etc. For the writer this comprises writing clearly and large enough, using the board well, and writing enough that the briefer can present smoothly. Finally, 5 points are given for mathematical depth. This means demonstrating that the pair actively engaged in the problem, rather than simply parroting the provided answer.

An oral quiz takes between 8 and 12 minutes of class time, depending on the complexity of the problem and the number of questions posed by the class. However, this time is dedicated to thinking about and solving a problem relevant to the material for the day.

IV. REFLECTIONS

As an alternative to reading quizzes to encourage cadets to read the book before coming to class, oral quizzes are interactive and allow the instructor to scaffold difficult problems, or push harder on easy ones. They are also procedural in nature, rather than propositional. However, oral quizzes cover fewer topics than a reading quiz could. Cadets are also better able to "fake it" by doing the problem live. Over-reliance on other group member(s) is a concern, but this can be mitigated by making it known that both the briefer and the writer can be asked questions at the end of a brief.

Oral quizzes have several advantages over nightly homework. First and foremost, there is much less grading with oral quizzes, hence the instructor burden outside of class is minimized. Rather than just "drill" problems, there's the opportunity for more interesting problems, because cadets can work in groups, and have (albeit limited) access to the instructor for a few minutes while preparing. The idea of oral quizzes encourages the "Thayer Method" more than homework over the previous lesson.

On the other hand, compared with nightly homework, oral quizzes again cover fewer problems and topics. Because of the group work aspect, it is more difficult to assess individual understanding of a given problem, and only two students per class get feedback each time.

As with any pilot, we noticed some aspects of our original plan that could be improved. Students are sometimes reluctant to ask each other questions, thinking that they are making the job of briefing harder. We found it valuable to tell the cadets that there would always be questions for the briefers and to point out that our questions were often more difficult than the

ones they came up with. In this way we tried to communicate that cadet questions often result in an easier brief.

Attendance issues interrupted the random selection of briefers which led one instructor to try other methods of choosing who would present. Random selection of the presenting pair was not a vital aspect of the technique, and we do not believe choosing groups in some other way, say based on the quality of their answers, will greatly alter the activity or its effectiveness.

We are very pleased with oral quizzes as a means of encouraging out of class preparation, and we highly recommend trying them in other courses. They seem effective at accomplishing our goals, and they kick start class each day. It is always exciting to see students walk into class and start working on math before the class hour even begins.

V. THOUGHTS FROM CADETS

From the instructor viewpoint, it appears as though the implementation of these oral quizzes caused cadets to read and prepare more for class. Some anecdotal evidence that led us to draw this conclusion: reports from cadets, replies of “it’s working” when we explained our intentions to them, and higher level of questions from the assigned reading than expected.

We surveyed the cadets, in class, anonymously, asking the following questions:

- 1) Do you think oral quizzes helped you learn?
- 2) Did you prepare more for class due to oral quizzes than you would have without them?
- 3) What thoughts would you like to share about oral quizzes?

On the first question, of the 65 cadets surveyed, 49 responded “Yes”; 11 responded “No”; 5 responded with some variant of “Maybe”. For those that responded with more than one word answers, they mentioned that oral quizzes helped clarify questions or confusions from reading.

When it came to how oral quizzes affects cadet preparation for class, 42 responded they prepared more for class because of the oral quizzes; 21 did not change their preparation because of oral quizzes; 2 said they sometimes changed their level of preparation for class.

The interesting feedback came from the last question, where cadets could really let us know what they think of oral quizzes. Some thought they were great, and wished they could have them in other classes; some thought they took time away from doing practice problems in class; some had suggestions for future semesters’ use of oral quizzes. Below is a sample of feedback.

- I think the oral quizzes showed us how other people solved the problem as well as forcing us to study.
- Scary idea at first but actually engaging and helpful.
- They were an easy introduction to the lesson every day.
- I usually underprepare for math classes, but oral quizzes made me open the book to not let my teammate down.
- The follow-on questions were the most helpful part of the quiz. Driving an understanding of the concept is much

more beneficial than knowing how to solve a specific problem.

- Knowing that we would be quizzed on the material helped provide motivation to prepare, until it became habit.
- They helped clarify topics in the reading and allowed me to have a deeper understanding of material by attempting to teach it.
- Oral quizzes helped elucidate the main objective of each class and remind cadets about their readings.
- It forced me to look at material at put the class at a higher priority to other classes which also have readings.
- The expectation that we further the idea or connect it to other ideas confused me. I never really knew what was expected with that.
- I feel that the oral quizzes not only give us practice problems for the concepts we are addressing in class but also allow us to practice our delivery of mathematical concepts through words.
- Allow people to improve their quiz grade/1 or 2 bonus points for volunteering for the brief after their mandatory 2 briefs to motivate continued reading.
- The possibility for random quizzes kept me on my toes. Made me prepare for class in a way where I was expecting a quiz. This could be stressful when the concepts for the lesson are difficult and being quizzed on it before learning in class in unhelpful.
- They’re pretty cool. I wish I could have oral assignments in other classes (besides language classes) because IMO its easier to orally demonstrate you understand something. It’s also easier to prove that you dont understand.
- Thayer method is a killer. Sometimes it is not easy to grasp material a night before on our own to present it to the class. I was penalized for it and I did not enjoy it.
- I think they took too much time from questions/practice. Maybe have people bring in questions rather than doing quizzes.
- Oral quizzes did not help me learn. It accomplished the goal of making me read, but only to a level of browsing what questions I might be asked.

From this selection of responses, many are positive; overall we saw that about 42 respondents had positive things to say about oral quizzes; 12 had negative thoughts to share; and 14 had recommendations on how to change oral quizzes. Some of these recommendations were thoughtful and kept in mind the intent of the quizzes; others simply stated they would rather have a quiz after learning the material in class, to prepare for the WPR (Written Partial Review, i.e. Midterm).

VI. STRAY THOUGHTS

Especially keeping the cadet feedback in mind, we have some thoughts about oral quizzes that do not fit well into a specific category, but are a little bit about implementation, a little about evaluation, a little about motivation to cadets, etc.

This activity could also work as an ungraded assessment, but those feel like they have a spotty track record at USMA. Cadet time is so regimented, and in general even cadets with

excellent time management have too many tasks in a given day to give them all the attention they are due. So assigning a total of 60 points (out of 1000 in the course) rewarded cadets in a tangible way (their grade) for doing something good for their learning. On the whole, it's a pretty small piece of the grade, but each individual quiz feels like a big enough deal that the cadets still prepare. It probably feels worse to punt on one thirty point assignment than it does to punt on six five point ones.

A concern we had about the structure of quizzes was that we would see some drop off in preparedness once everyone has been graded twice, but we have not noticed that. In some sections, cadets are able to volunteer to brief for the chance to replace a lower graded brief from earlier in the semester. For motivated cadets who want to improve their grade, they continue putting effort into oral quizzes.

Success in getting students to prepare has been mixed. For one instructor, things have gone quite well, but the other instructor's cadets didn't buy in as much. Though this may have something to do with the fact that the first oral quiz of the semester fell on the day of the government shutdown, so one instructor's classes were covered by a military instructor who is not teaching the course this semester. While the structure and goals of the oral quizzes were outlined to them before the furlough began, it probably didn't get completely conveyed to the cadets.

We've never regretted taking the time for oral quizzes. Unlike reading quizzes, which feel like administrative time, oral quizzes feature active participation in problem solving from the cadets, which is what we want them to do with their class time anyway. If they were not doing the oral quiz, they would be solving problems at boards for that time.

VII. APPLICATIONS TO OTHER COURSES/FUTURE CHANGES

Oral quizzes seem to work well for beginning courses in a major. We think they can be adjusted to suit Core courses (at USMA, the Core Mathematics Program consists of MA103 Math Modeling, MA104 Single Variable Calculus, and MA206 Probability and Statistics) and advanced courses in the major as well. In our intermediate level course, we were able to choose some computational questions, some proofs, and some conceptual questions. We used these different problems to motivate different parts of the course. When we were first learning proof techniques, the oral quiz question was a proof, but we either chose a straightforward proof that followed the structure of an example problem from the reading, or gave the cadets some guiding questions while they were working on the boards.

At the start of a new topic, we chose a question that forced cadets to use and explain much of the new vocabulary. If they didn't volunteer the correct terminology in the brief, we were able to prompt them to do so. This also allowed other cadets to have some of their questions answered without having to specifically ask them.

In a Core math course oral quizzes could focus on questions from the reading that would force cadets to become familiar with the basic vocabulary and canonical examples. This might be better accomplished by focusing on worked examples from the reading as opposed to exercises from the end of the section.

In an advanced course in a Mathematical Sciences or Operations Research major, you could focus on more conceptual or proof-based questions. Here, the answer is maybe easy (or it's an odd-numbered problem with the answer in the back of the book) but the challenge lies in communicating the idea behind the answer, citing relevant theorems, etc.

One advantage we had in implementing this idea was a small pool of instructors. In order to achieve consistency across a large group of instructors with more varied backgrounds and perspectives it would help to plan goals and outcomes for each oral quiz question. This would enable instructors to provoke similar discussions across sections. The particular scaffolding and stretch questions used by the instructors need not be pre-planned, but having a common goal would help guide instructors as they implement this teaching method.

VIII. LOOKING FORWARD

Cadets have indicated a preference for immediate feedback, even if it means it's in front of the entire class. When that was done this semester, it was followed by a brief period of the instructor then writing this feedback down to hand back to the cadet team at the end of class or the next class period. Instead, it may better serve the flow of the lesson to give the cadets the rubric, give them comments, and let them write the comments down. This way, no extra class time is used for the instructor to write comments while the cadets begin the work for the day after the oral quiz.

We find that asking questions reactively in response to the oral quizzes is a powerful teaching tool, but it is also demanding for the instructor. We plan to think more about reliable methods for asking questions that provoke thought and generate class discussion and about ways the instructor can prepare for oral quizzes.

Some point incentive for questions asked at the end of a brief could encourage critical thinking and reinforce peer assessment that cadets do in their military training.