Oral Formative Assessment as a Means to Increasing Total Learning and Engagement in an Engineering University Classroom

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Abstract

Oral assessments used in a university engineering classroom can be a valuable tool in increasing student motivation and total learning as well as aiding instructors in understanding the progress of their class and staying connected with their students. This paper explores the effects of implementing oral assessments in a junior level numerical methods course for engineers over two semesters. Changes in course structure are explained as well as observational and survey results. When biweekly written assessments were replaced with oral assessments, students were found to be more engaged, make better use of feedback to make progress, and perform better on a final written exam and overall in the class. Instructors were better able to follow the progress of their class, give more detailed and individualized feedback, and adjust content level based on the students in their course. Oral assessments proved to be an effective tool to aid students in developing exam preparation, active discourse, and self-evaluation.

Introduction

Significant challenges for instructors at the university level are found in assessing students' progress in a course, adapting the course to fit student learning pace and style, and providing adequate feedback that motivates students [1]. Grades and paper corrections of written assignments and exams are often delayed and underutilized by students. Written assessments imay not provide adequate direction to help students to reflect on their understanding of a subject and adapt their learning behaviors. The numerical scores given to these assignments and exams could distract, and sometimes discourage, students from actual learning. From the instructor's perspective, written exams may not give an accurate evaluation of their students' understanding as many different factors may interfere with a student's ability to answer written exam questions.

One alternative assessment instrument is oral assessment. Oral assessment can take a variety of forms as long as there is a verbal component. Project presentations, thesis defenses, clinical assessments, and mock trials are all examples of oral assessments. This paper focuses on oral assessments where students respond verbally to questions from the instructor. Using the six

dimensions of oral assessments identified by Joughin [2], the characteristics of the oral examinations considered in this paper are summarized in Table 1.

Table 1 Characteristics of the Oral Performance Assessments in this Study

Dimension	**Characteristics**
Primary Content	Assess knowledge and understanding.
Interaction	Dialogue: Instructors and students are engaged in highly interactive conversation about the content.
Authenticity	Decontextualized: Students' knowledge and understanding of the concepts and methods taught in the course are probed without a real-world problem-solving setting.
Structure	A set of core questions is employed; instructors and students are allowed to deviate from this set by asking follow-up questions. Students are encouraged to bring their questions to the oral assessments.
Examiners	Instructors.
Orality	Primarily oral: Students can illustrate their ideas on paper / white boards.

This study introduced oral examinations into a college-level engineering course in a state flagship public university in the United States. It should be noted that while the junior-level core course in question is an engineering course, it is rather fundamental and its content is primarily computational mathematics.

A few studies of oral examinations in college-level mathematics courses have all reported positive findings. Heid [3] highlighted that oral examinations allow instructors to have a deeper understanding of various aspects of students' mathematical understandings (especially how concepts relate to each other), and help instructors adjust course content and teaching methods. Students also reported that oral examinations are effective in gauging their true understandings [4][5]. Iannone and Simpson [6] further suggested that oral examinations have positive effects on students' learning prior to assessments; and the act of being assessed in this setting may also contribute to student learning. Taking a quantitative approach, Nelson [7] reported significant improvement of the final exam score of students who participated in oral examinations over those who did not. This effect was larger for at-risk students and had lasting impacts on this group in subsequent classes.

Outside of mathematics, while high-stakes oral examinations in medical fields have been criticized as unreliable and causing excessive anxiety [8], lower-stakes formative oral examinations are recognized as providing a number of benefits to both instructor and students (e.g., [2],[9]). The instructor is able to directly and progressively probe a student's level of understanding, and provide immediate guidance and clarification to a student who has any confusion on the course topics.

Questions in an oral exam may be adapted during the meeting to suit the student's level of understanding and uncover areas of weakness. Oral assessments thus allow the instructor to assess the class level throughout the semester and identify topics that may need further explanation, which can then be given immediately. In addition to these well-recognized benefits from the literature, oral examinations also allow the instructor to connect with each student on a personal level and make students feel valued, which can be a significant motivational tool. Finally, the oral exam promotes improvement in the "C" student by discouraging apathy and providing interactive feedback. The ultimate goal of the oral exam is not to divide students into separate letter groups, but to motivate all students to learn the necessary material to become proficient engineers, while still advancing the top students further.

This paper describes the implementation of an oral assessment over two semesters, together with lessons learned and observational and survey results, in Numerical Methods for Engineers for civil engineering students at a large public university. Taught in a traditional lecture style classroom environment five years ago, this course has transitioned to an active, recitation style classroom with written assessments, and finally to an interactive class with recitations and both oral and written assessments. This paper explores the effects of oral assessments on the learning environment, student motivation and engagement, student self-efficacy, and mastery of learning objectives. The benefits of this transition are examined through instructor observation, surveys, and a final written exam. During the two semesters of implementation, it was observed that students were more engaged in class, studied more outside of class, performed better on the final written exam, were more positive about learning, and felt that the instructor cared about their individual success. In the second semester, an assessment experience survey was developed and administered to measure the efficacy of the oral assessments in increasing total learning and engagement. Currently in the third semester of implementation, additional survey and behavior data is being collected to quantify these benefits.

Implementation

Course Overview

CEE384: Numerical Methods for Engineers is a core junior level mathematics course in civil engineering. Students must first complete differential equations and linear algebra and must at least be co-enrolled is calculus of multiple variables. It is a required course for all civil engineers at ASU and prepares students to apply various numerical methods through computational means to solve applied engineering problems. As it is a required class, typically one hundred students enroll each semester. The course is taught in both the fall and the spring, but by different instructors, the co-authors of this paper. While different in structure, both offerings have similar course outcomes and both instructors would like to increase student motivation and increase depth of understanding amongst their students.

The main objective of CEE384 is not only to teach typical numerical methods such as Taylor Series, Newton Raphson, and Runge-Kutta, but also to teach students to apply these methods through programming to solve engineering applications. As a required math course with a significant programming element, this course is often a challenge for students who have limited

formal programming education. In order to support students, the co-authors of this paper have implemented different active learning strategies.

The spring offerings of this course have been set up in the past with one lecture period and two recitations per week, which are supported both by instructors and undergraduate teaching assistants (UGTAs). A formal lecture is held once every two weeks that covers background theory. A written assessment takes place every other week during the remaining lecture periods. During the two recitations each week, students see example problems demonstrated and solve practice problems with the aid of their fellow students and UGTAs. Additional work includes weekly homework sets and bi-weekly application projects in which students extend a code written in recitation and apply it to solve a practical engineering problem.

For the fall offerings, the instructor adopts a blended-classroom approach [10][11]. Students are required to watch short videos, read relevant textbook chapters, and complete pre-class assignments before coming to class. During class, short lectures and demonstrations (5 – 20 minutes) are followed by hands-on problem solving (15 – 30 minutes) with the support from the instructor and UGTAs. This applies to both the mathematical and programming content. Homework is assigned weekly; programming projects are roughly assigned every two to three weeks. Similar to the spring offerings, a total of 6 written assessments (in addition to the final exam) are given throughout the semester roughly every 2 to 3 weeks.

The adjustment of this course from a typical lecture style classroom to one with a more active learning style has greatly increased student motivation and mastery. However, the course still faced a number of challenges. The greatest challenge being that nearly 30% of students received a D, E, or W (withdraw) grade in the spring of 2017. In the spring of 2018, the course had a 24% DEW rate. Similar grades were given in the Fall 2018 semester with a 34% DEW rate. The number of C grades was also quite high and more than fifty percent of the class received a grade of C, D, E, or W (withdraw) in the course (59 of 112 students) in the spring 2017. While a grade of C is considered passing, it does not demonstrate sufficient mastery of the course content in a critical area of student education. This was a consistent result from over the four previous years. The regular performance from year to year suggests that rather than the problem lying with student aptitude, this course did not sufficiently motivate students or provide them ample opportunity to increase their understanding.

Additional issues that may contribute to the average performance include low attendance and participation in lecture for the spring offerings, overburdened workload from lengthy homework assignments and application / programming projects, frequent written tests that did not clarify common misunderstandings, insufficient feedback on all assignments, but especially written assessments, and insufficient support to improve performance throughout the semester.

Oral Formative Assessment

Beginning in the spring 2019 semester, a significant change was made to the Numerical Methods course at ASU. The biweekly written assessments were changed into biweekly oral assessments. This change was made primarily to increase student motivation and provide significant and

ongoing feedback to students throughout the semester on both the material and their learning techniques.

Spring 2019

The format of the biweekly assessments were carefully considered and developed to promote student learning and motivation without causing undue anxiety for students and without disadvantaging groups of students based on their background.

In order to minimize apprehension from an oral assessment, the assessments were called "conferences" to indicate that the questioning during the meeting could be two-way rather than one-way. Students were encouraged to bring questions to the conferences to form a conversational meeting as opposed to an examination. This had the added benefit of encouraging students to perform research outside of the class, read their textbook, and bring in difficult and theoretical questions to discuss as well as giving students the opportunity to clear up any smaller confusions that they might have.

Another technique used to lessen student anxiety was that the conferences were held in small groups of two to three students. While each question was directed toward a particular student, other students in the conference were permitted to give aid and ask questions regarding the topic. Students were sorted into random groups of three, which changed each week.

Each conference began with inquiring whether the students had any questions about the material covered in the preceding two weeks. After all questions from the students were answered, the instructor then posed questions to the students, varying the content and format of the questions based on the students' apparent level of understanding. Questions were of both a theoretical and practical nature. Some questions were solved on the whiteboard, including programming and computational questions. Others asked the students to draw connections between the theory behind current topics and previously covered topics. In general, questions were initially drawn from a prewritten question bank, but were rapidly adapted as each conference progressed following the strengths and weaknesses of the students.

Conferences lasted between ten and fifteen minutes each. This amount of time is sufficient to receive and give feedback to each student, while meeting with about forty students each week. This requires a weekly time commitment from the instructor of about four hours, which replaced the two one hour lectures from two different sections. Students attended conference every other week, while the instructor sat in conference every week. During the week that students did not attend conference, they were given written practice final exam problems to be completed individually.

At the conclusion of the conference, each student was assigned a grade from zero to three. A grade of zero was awarded for students who were not present for their conference or did not contribute at all. A grade of one indicated that the student attended conference, but was ill-prepared or showed a serious lack of understanding. A grade of two indicated that the student contributed and was prepared. A significant portion of students received grades of two for all conferences. Grades

of three were reserved for students demonstrating significant insight and were rarely assigned. This simple grading scheme allowed the students to focus on the idea of the importance of understanding rather than being evaluated. A small numerical mistake that might derail a student during a written exam can be negated with the oral conference as the student will still undoubtedly fall into the category of "understanding." An additional minor benefit, though one that is important at a large university, is that a simple grading scheme with grades assigned immediately relieves pressure on graders and allows them to give higher quality feedback in other areas, such as on homework assignments.

Fall 2019

In the fall of 2019, a slightly different oral assessment format was implemented.

While the oral assessments were not branded as conferences, the nature of the assessments remained the same as in spring 2019. Students understood that they were encouraged to bring their questions to the oral assessments. The procedure and grading of the oral assessments were largely the same as well.

The main difference was that the oral assessments were held over two class periods (75 minutes each) for the entire class once every two to three weeks. The class periods used for oral assessments were hands-on programming sessions. Student groups of 5 to 6 were assigned 15-minute time slots for their oral assessments, and were still expected to participate in the planned hands-on programming activities during the rest of the class period. Students were self-sorted into study groups of four to six. While switching groups was allowed at several time points throughout the semester, most students remained in the initial group. The oral assessment groups largely aligned with the student study groups. But randomly selected groups were mixed and matched to control the number of oral assessment groups due to limited time.

Compared to the spring 2019 implementation, no additional time commitment was required from the instructor. However, with a larger group, 15 minutes were often not sufficient to allow for in-depth probing of the understanding of each individual student. The instructor made sure that each student had a chance to speak by sometimes directing questions to specific students, but students would occasionally speak over each other in pursuit of better grades. This was commented on by some students at the end of the semester.

On the other hand, many students commented on how having peers from their own study groups for each oral assessment had reduced their anxiety level.

Research Methodology

A student survey was developed and employed to explore students' experiences and perceptions of the oral assessments. The DEW rates and students' final exam grades were also examined. The research protocol was reviewed and approved by the ASU IRB board.

Oral Assessment Experience Survey

To gauge students' experiences with the oral examination, a survey instrument was developed based on research about assessment and feedback in the literature. Gibbs and Simpson [12] identified elven ways in which assessments affect learning. The eleven ways are grouped into five categories: 1) quantity and distribution of student effort, 2) quality and level of student effort, 3) quantity and timing of feedback, 4) quality of feedback, and 5) student response to feedback. Arguably, frequent and well-prepared oral examinations can lend themselves better to all of the five categories, when compared with written examinations and extremely low-stakes formative assessments (such as homework assignments and recitations). Only a limited number of survey instruments on assessment experiences are reported in the literature. Gibbs and Simpson [13] developed and tested an Assessment Experience Questionnaire (AEQ) that includes thirty-six questions, mostly following the five categories identified in [12]. It is worth noting that a separate section in the AEQ is devoted to questions that are related to how assessment / examination affects learning achieved during preparation as well as during the assessment itself. This was not identified as a separate category in [12]; but it is in line with the "assessment for learning" and "assessment as learning" arguments made in [6]. Gibbs and Simpson [13] also suggested possible improvements to the AEQ, among which two new categories focusing on "learning from the exam" and "approach to learning" are noteworthy. These suggested categories align well with our hypotheses that

- The highly interactive conversations during oral examinations themselves are another learning opportunity for students and can help them clear up misconceptions;
- The focus on articulation of understanding and reasoning requires students to take a deeper approach to learning; and
- The questions asked by the instructor (both scripted and follow-up) demonstrate how to approach a concept.

Other survey instruments reported in the literature are either based on the AEQ [5], or are relatively ad-hoc [3][4].

Based on the literature, it was decided to adapt the AEQ for this research. Appendix I shows the survey questionnaire used in this research. The survey includes three sections and seventeen questions. The three sections are "study effort and assessment environment", "learning from oral examination", and "approach to learning / exam". Among the seventeen questions, two are open-ended (asking students to provide additional comments). Students were asked to rate the other fifteen statements on a five-point Likert scale. Eight out of the fifteen Likert-scale questions are from the AEQ [13], with slight modification in language. Seven new questions are developed, designed specifically for the assessment environment (as anxiety is widely recognized as a possible drawback of oral assessments) and the three hypotheses mentioned above.

The survey was administered to the Fall 2019 class with a total of 47 students to gain initial insights. Note that due to the relatively small sample size in Fall 2019, the survey instrument has not been validated. Additional data is being collected to validate the instrument.

Course Performance Comparison

To further quantify the efficacy of oral assessments, the DEW rates and students' final exam grades were examined. The DEW rates can be viewed to represent total student motivation, efforts, and engagement. Additional individual student learning behavior data (such as course page views, number of attempts on homework problems, etc.) is currently being collected, which will shed more light on students' efforts and engagement. The final exam used each semester was determined to have the same relative difficulty, but with varying problems, consisting of computational, analytical, and theoretical questions. It is important that the questions change each semester so that students are not able to share questions from the previous year.

Findings

The overall results of the oral conferences were high attendance, confident and motivated students, and higher performance on the final written exam. One student commented, "The conferences every other week helped make sure you were staying on pace with the course, and there was always help from the instructor." Students also felt like they had sufficient individual support from the instructor as represented by another student comment, "this new method is better, since it gives the student an opportunity to get to know the professor better and not be afraid to ask questions."

Observational Results from Spring 2019

In the spring of 2019, few quantifiable results were gathered from the course to measure the efficacy of the oral conference. In the fall of 2019, a detailed survey was administered at the end of the semester and those results are discussed in the next section. Despite the lack of measureable results from the first semester, there were many observational results that encouraged the further investigation of this teaching method.

Attendance in lecture had been low in previous semesters and was only increased by taking regular attendance. Students who did attend were often seen to work on other assignments and eat lunch during the lecture period. Attendance in recitation typically hovered around eighty percent as students were required to submit an assignment at the end of each recitation period. In the new version of Numerical Methods in spring 2019 (with oral conferences), lecture periods were eliminated from the course and posted on the course website. Recitation periods followed a similar format with examples and class work, but the students were not required to submit their class work and neither was attendance taken. Despite easing the attendance and assignment requirements, attendance in recitation remained high, above ninety percent for the duration of the semester. Not only was attendance high, but students remained actively engaged throughout each recitation period. Many students would continue studying the topic if they finished the assigned problems early and ask questions on extended and advanced topics. One hypothesis explaining this behavior is that while a written exam typically confines itself to what the students should probably be able to achieve, an oral exam is fluid and the question level may be continually adjusted up or down during the exam. The instructor may ask complex questions to begin, knowing that a student's inability to answer the first question does not mean they must fail the exam since another question

may easily be substituted. The level of questions may also continually rise if the students demonstrate sufficient expertise.

In addition to changing behavior patterns in the classroom, the change in exam format also brought about a notable change in exam preparation. Written exams from previous semesters caused students to focus on equation memorization and neglect the theoretical understanding that was desired for them to gain. The dynamic and fluid atmosphere of the oral assessments changed the way students prepared for their assessment. Students recognized that they would not be able to just achieve a passing grade through numerical computation, but that they also must completely understand the algorithms. A similar change was viewed in the students' approach to programming. In previous semesters, students often viewed the assigned MATLAB codes as something to finish and forget. Handwritten codes did sometimes appear on exams, but memorization rather than understanding was typically the result. With the oral exam, instead of giving a question that is repetitive or a question that is very difficult, questions can be modified to assess the actual level that the students are at. This makes a big difference for students who are struggling and may come out of a difficult written exam with the mindset that they did not understand anything or students who are excelling and may finish a written exam with the idea that they understand everything. In one situation the student experiences resignation and in the other, the student experiences confidence that may lead to neglect of future studies. When the questions are adjusted during the exam, students learn to evaluate their own strengths and weaknesses, gain confidence at accomplishment, and still see the path to further improvement.

Another positive aspect of the oral assessment is that students who misunderstand the question due to language difficulties are given immediate aid without the need for those students to actively seek help. This is important for international students during the initial question period and throughout the exam as each statement in the oral exam may be clarified to make sure it is understood as intended.

Finally, a number of important benefits for large classes were incurred. Each previous semester, a number of academic integrity violations occurred. These typically took the form of students sharing MATLAB code on assignments or students using unauthorized aid on exams in a large lecture hall with seats that had tight spacing. With the oral assessments, there were zero academic integrity violations. Not only did students not have the opportunity in the exam to use unauthorized aid, students also realized that they would be asked to actively demonstrate their understanding directly to the instructor and thus learning the material rather than completing assignments became the most important goal. In a large class, it is also quite easy for a handful of students or more to go under noticed either through lack of attendance or simply an introverted personality. High attendance and biweekly meetings with the instructor ensured that the level of every student was accurately tracked and provided feedback to the instructor.

Results from Oral Assessment Experience Survey and Course Evaluation

Observational results from the Numerical Methods course in the spring of 2019 showed that oral assessments may be a valid tool in increasing student motivation and overall success in an engineering math class. Students also left many positive comments on the course evaluation. A sample of these comments are shown below,

- "The format of the conference exams may have helped alleviate stress from students"
- "The way it was set up was very student-friendly. The conferences every other week helped make sure you were staying on pace with the course, and there was always help from the instructor or TAs every class period."
- "The class setup was very well done, I enjoyed the small meetings instead of quizzes."
- "I never felt that I was behind because I had the chance to clarify any confusion I might have had."
- "I really enjoyed the conferences that were done bi-weekly that covered content learned in the course. The conferences are preferred over the assessments because students are not as pressured to complete the other assignments assigned in class. There is also more flexibility given to students to study and learn on their own."

Following this success, oral conferences were in the Numerical Methods course in the fall of 2019 with a different instructor (second author). To aid in measuring the efficacy of implementing oral assessments or conferences in Numerical Methods, a survey was given to students at the end of the Fall 2019 semester addressing a variety of different topics.

The final survey focused on measuring student perceptions of oral assessment after having participated in a class with this format, "learning from oral assessment", and their "approach to learning / exam".

The first section, regarding student perceptions of an oral assessment asked students if they perceived the oral assessment to be a source of anxiety. While 54.3% of students said they did look forward to exams (Figure 2, Likert ratings of 4 and 5), 45.7% said that they also were anxious about conferences (Figure 3, Likert ratings of 4 and 5). The average anticipation rating is 3.70; and the average anxiety rating is 3.37. The latter is consistent with the distribution of efforts (Figure 1).

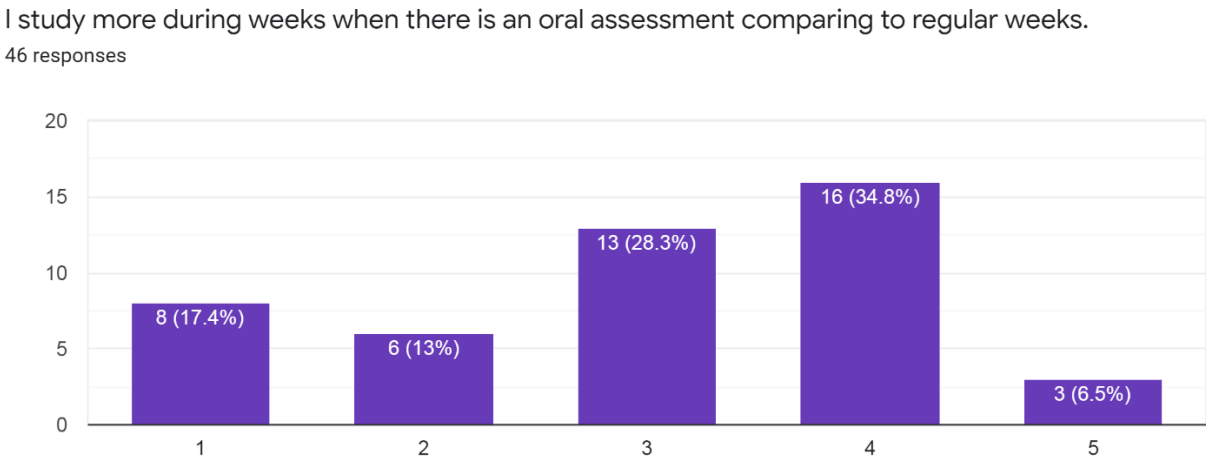

Figure 1 Study Efforts

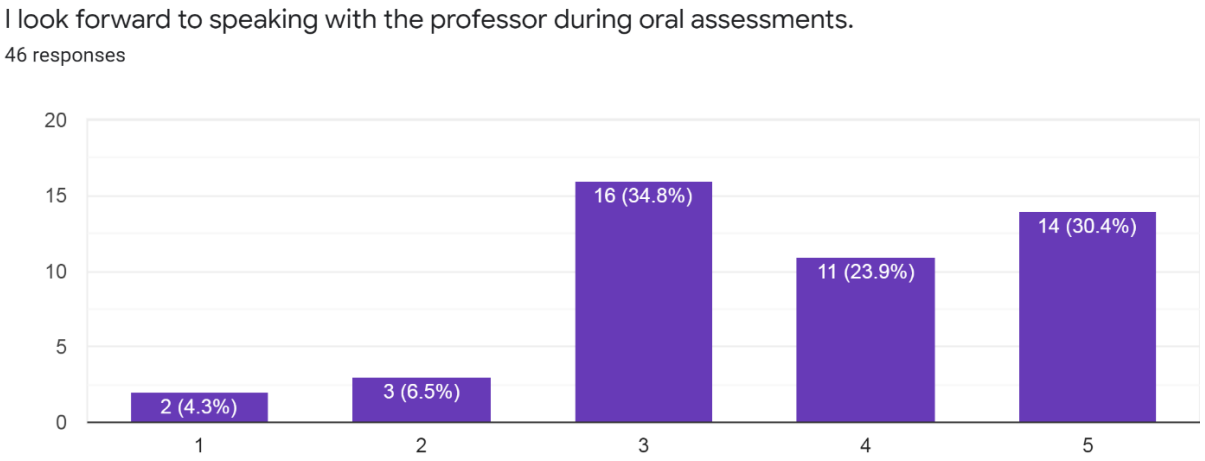

Figure 2 Anticipation

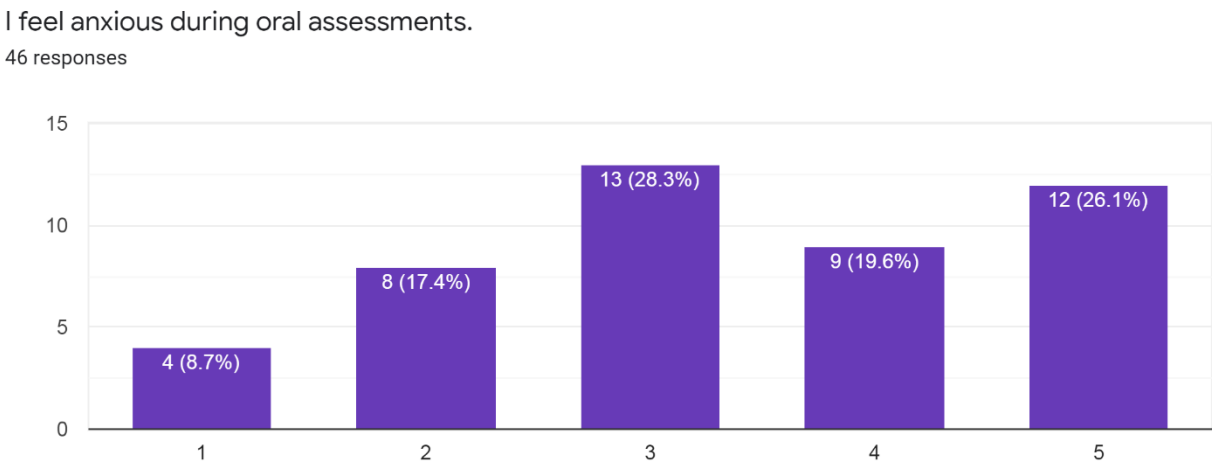

Figure 3 Anxiety

The second section focused on "learning from oral assessments". This section showed very promising results. Students seemed to agree that preparation for oral exams was a useful and purposeful process. 58.7% reported learning new things while preparing for the oral assessment (Figure 4). The process of taking the oral assessments itself was viewed as a valuable learning experience, with an overwhelming majority of students reporting "engaged in thinking" (87.9%, Figure 5) and "understand things better" (80.4%, Figure 6) as a result of oral assessments. More than 60% of the students also indicated that the oral assessments "brought things together" for them (Figure 7). One hypothesis is that the highly interactive two-way conversations and immediate feedback in the oral assessments are two major factors contributing to learning. This is supported by the finding that 71.8% of students agreed that oral feedback was more useful to them than the written feedback on their in-class hands-on work (Figure 8), despite the fact that the majority of students (67.4%) indicated they use the written feedback to improve their homework.

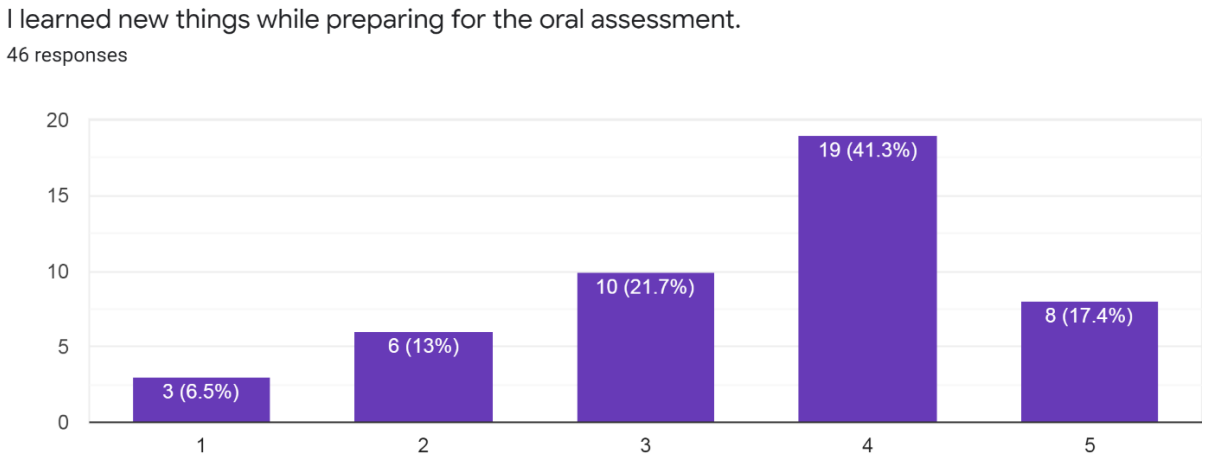

Figure 4 Learning during Preparation

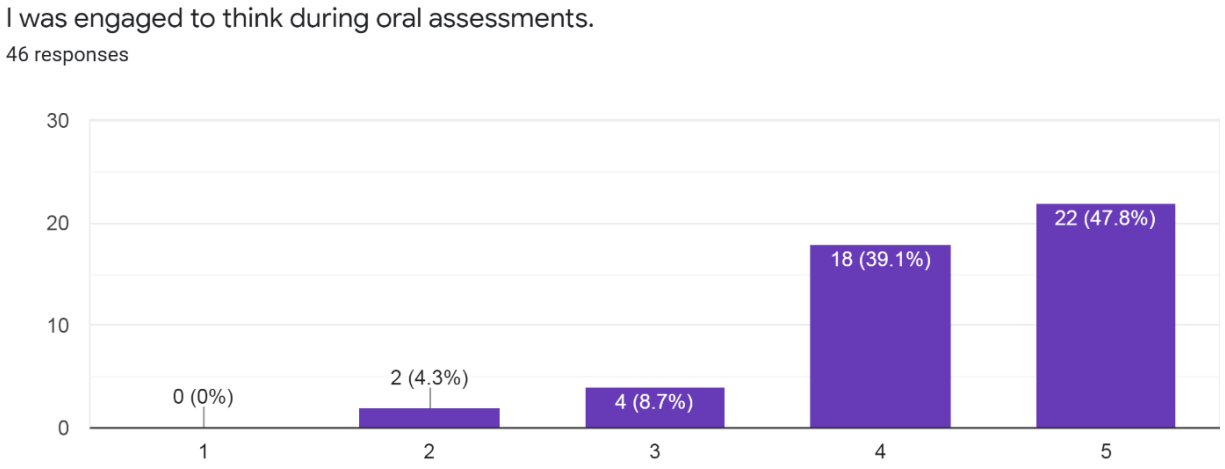

Figure 5 Thinking during Assessment

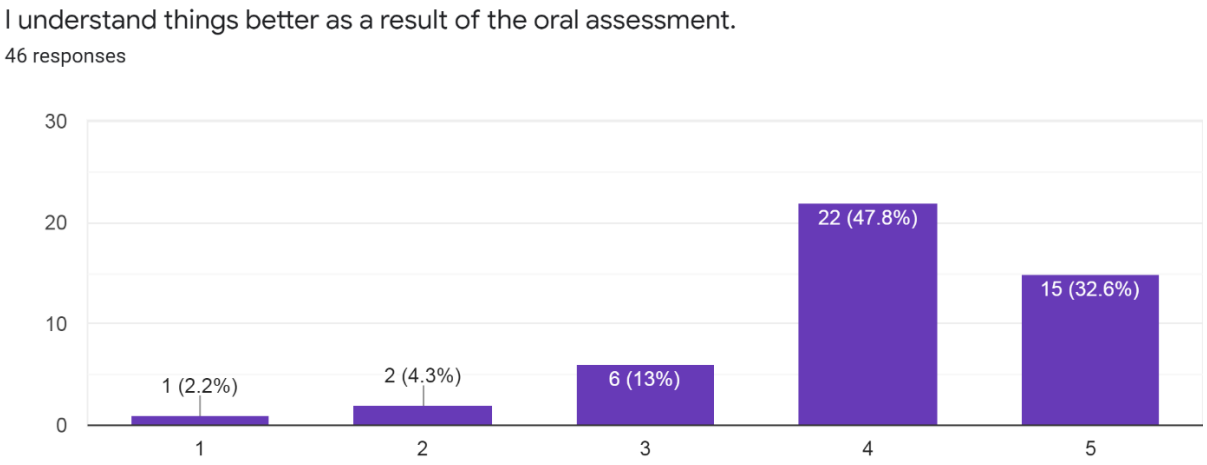

Figure 6 Improved Understanding

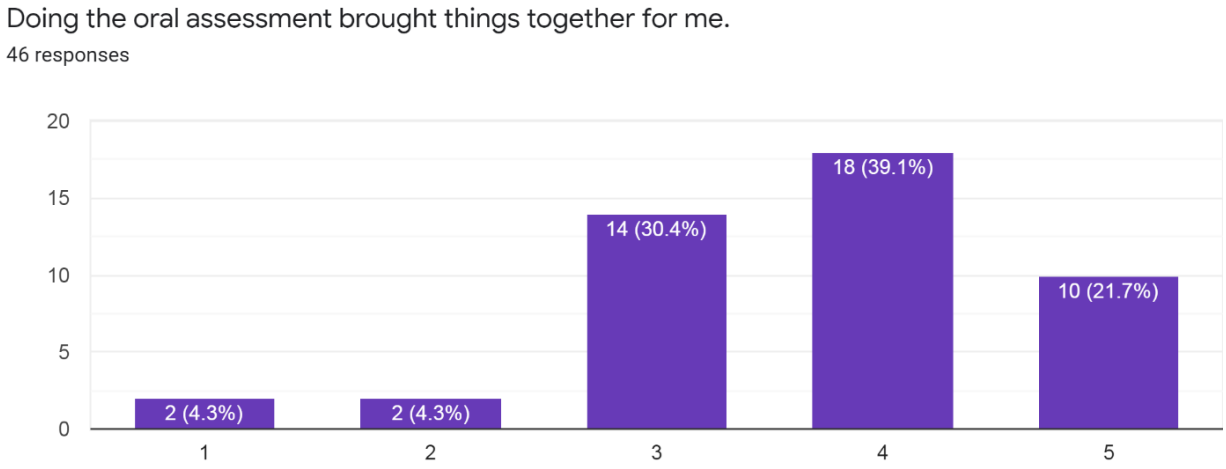

Figure 7 Improved Concept Map

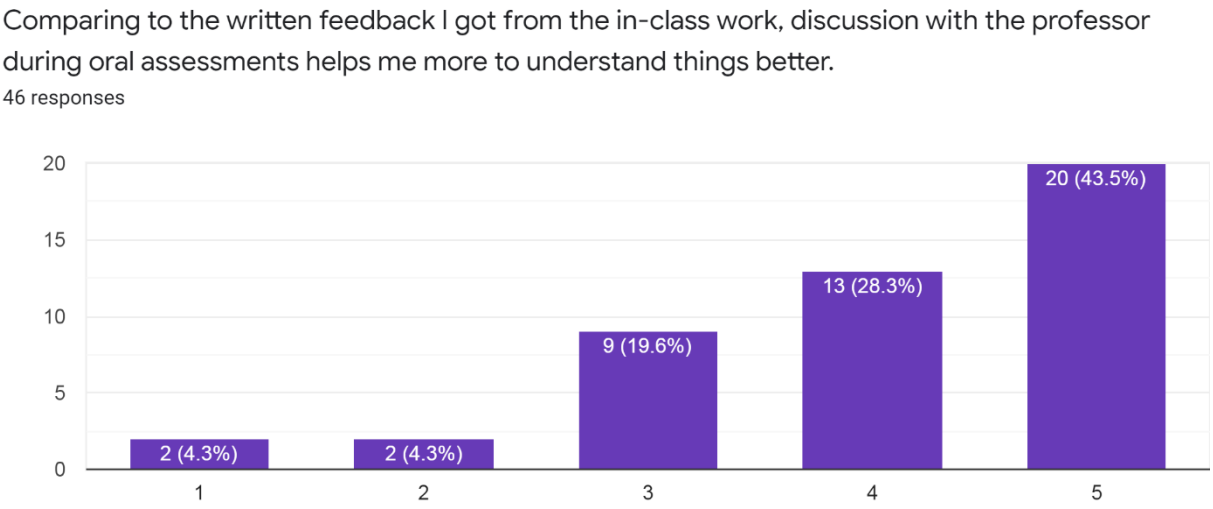

Figure 8 Oral versus Written Feedback

The third section of the survey probed whether students' approach to learning and preparing for assessment has changed as a result of the oral assessments. This section again showed very encouraging results (Table 2). Students realized that they need to understand the theories and algorithms to succeed in the course (questions 11 and 15), and as a result paid more attention to higher level learning objectives as a result of the oral assessments (question 14) instead of simple memorization (question 10). These findings are consistent with the observational results from Spring 2019. Additionally, a majority of students agreed that the oral assessments demonstrated higher theoretical concepts, as well as how to examine such concepts, to them in a new light (questions 12 and 13). As a result, 67.4% of the class reported better retention of knowledge after oral assessments comparing to written exams (question 16).

Table 2 Student Responses to Questions in Section 3 "Approach to Learning / Assessment"

Question Number and Statement		**Percentage of Each Response***					**Out of 5**	
		1	2	3	4	5	Avg.	Std.
10	Preparing for the oral assessment was mainly a matter of memorizing.	22.2	35.6	26.7	13.3	2.2	2.38	1.04
11	A deeper understanding of the topics (as opposed to just procedural) is crucial to succeed in this course.	2.2	0	11.1	35.6	51.1	4.33	0.84
12	The discussion in oral assessments often involves questions that I have not thought of.	4.4	4.4	22.2	28.9	40	3.96	1.09
13	The discussion in oral assessments showed me how to thoroughly examine a topic.	2.2	8.9	26.7	35.6	26.7	3.76	1.01
14	I pay more attention to the theories and reasons behind the procedures because of the oral assessments.	4.3	13	19.6	32.6	30.4	3.72	1.15
15	In the oral assessment you can "fake good" and get away with not understanding without the professor noticing.	39.1	39.1	15.2	2.2	4.3	1.93	1.01
16	I forget more of the information after an oral assessment comparing to a traditional written exam.	15.2	52.2	21.7	8.7	2.2	2.30	0.95

* 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

The positive findings from both Section 2 "learning from oral assessments" and Section 3 "approach to learning / assessment" of the oral assessment experience survey suggest that oral assessments may be an effective tool to support "assessment for learning" and "assessment as learning" [6].

It is worth noting though, in the open ended section of the questionnaire, a significant number of students requested that the oral assessments be longer in length. This is consistent with the instructor's observation that a 15-minute session is not sufficient to probe the understanding of each student with a group of 5 to 6. It is suspected that this was one of the main reasons for the nontrivial percentages of students who perceived that they may have gotten away with memorizing (question 3, Likert scale 3 and higher) and / or "faking good" (question 15, Likert scale 3 and higher) during oral assessments. While having a smaller group (or a longer session for a larger

group) is an ultimate goal, it is difficult to balance the time demand on the instructor while increasing interaction time with the students.

Course Performance

Over the previous four years, the DEW rate in the spring averaged around 30%, with some years being slightly higher or lower. In the spring of 2019, the DEW rate dropped to 14%, while using similar metrics and levels of evaluation. Scores on the written final increased by approximately 10%. Finally, the number of students receiving a grade of C, significantly declined with 73% of students received a grade of "B" or higher.

For the fall offerings, the DEW rate from previous blended classroom sessions have hovered around 30% for the past two years. In the fall of 2019, the DEW rate dropped to 19%. For the final exam, students from the Fall 2019 session scored an average of 62.14 out of 100, while the Fall 2018 and Fall 2017 sessions had class averages of 37.1 and 48.01 respectively. It should be noted that the Fall 2019 and Fall 2018 sessions are the most comparable, where students were asked to explain their answers to multiple choice questions. The multiple choice portion of the Fall 2017 final exam employed all-or-nothing grading. Statistical testing shows that the Fall 2019 final exam performance is significantly different from those in Fall 2018 and Fall 2017. We believe that requiring students to articulate during the oral assessments contributed substantially to the improved conceptual understanding reflected in students' explanation of the multiple-choice portion of the written final exam. The exact extent of this contribution is yet to be explored by accounting for variations in the cohorts' characteristics (such as academic standing, GPA of pre-requisite courses, etc.).

Recommendations for Future Exploration

This trial with oral assessments has exposed an underutilized tool in engineering education and leaves open many avenues for further exploration. Examination of group formulation may reveal whether it is better to have a group of balanced learners, or whether it is better to group stronger and weaker students together. Group size may also be interesting to vary. Having multiple contributors can be helpful, but there is certainly an optimal group size before students begin to feel neglected. Methods for reducing anxiety before oral assessments are also worth identifying. Evaluation techniques also need to be studied as assigning a grade from an oral conference can be quite challenging.

In addition to the setup and organizational tasks involved in oral assessments, ideal question types that range from practical to theoretical should be identified. The efficacy of oral assessments in programming should also be studied.

In conclusion, oral assessments have been demonstrated to be a useful factor in increasing student motivation and consequently total learning in Numerical Methods for Engineers and should be studied further.

References

[1] M. Price, K. Handley, J. Millar, and B. O'Donovan, "Feedback: All That Effort, but What is The Effect?" *Assessment & Evaluation in Higher Education*, 35(3), pp. 277 – 289, 2010.

[2] G. Joughin, "Dimensions of Oral Assessment", *Assessment & Evaluation in Higher Education*, 23(4), pp. 367 – 378, 1998.

[3] K. Heid, "In-Depth Interviews to Understand Student Understanding", in *Assessment Practices in Undergraduate Mathematics* (Gold, G., Kieth, S., and Marion W. ed), pp. 109 – 110, 1999.

[4] V. Odafe, "Oral Examination in College Mathematics: an Alternative Assessment Technique", *PRIMUS*, 16(3), pp. 243 – 256, 2006.

[5] P. Iannone, and A. Simpson "Oral Assessment in Mathematics: Implementation and Outcomes", *Teaching Mathematics and Its Applications: International Journal of the IMA*, 31(4), pp. 179 – 190, 2012.

[6] P. Iannone, P. and A. Simpson, "Students' Views of Oral Performance Assessment in Mathematics: Straddling the 'Assessment of' and 'Assessment for' Learning Divide", *Assessment & Evaluation in Higher Education*, 40(7), pp. 971 – 987, 2015.

[7] M. Nelson, "Oral Assessments: Improving Retention, Grades, and Understanding", *PRIMUS*, 21(1), pp. 47 – 61, 2011.

[8] M. Davis and I. Karunathilake, "The Place of the Oral Examination in Today's Assessment Systems", *Medical Teacher*, 27(4), pp. 294 – 297, 2005.

[9] M. Hexham, F. Campbell, and J. Westwood, "Oral versus Written Assessments: a Test of Student Performance and Attitudes", *Assessment & Evaluation in Higher Education*, 37(1), pp. 125 – 136, 2012.

[10] R. Clark, A. Kaw, Y. Lou, A. Scott, and M. Besterfield-Sacre, "Blended vs. Flipped Teaching: One Course – Three Engineering Schools." *2017 ASEE Annual Conference and Exposition*, Columbus, OH, June 2017

[11] R. Clark, A. Kaw, Y. Lou, A. Scott, and M. Besterfield-Sacre, "Evaluating blended and flipped instruction in numerical methods at multiple engineering schools." *International Journal for the Scholarship of Teaching and Learning.* Vol. 12: No. 1, Article 11, 2018.

[12] G. Gibbs and C. Simpson, "Does Your Assessment Support Your Students' Learning?", *Learning and Teaching in Higher Education*, 1(1), pp. 3 – 31,2004.

[13] G. Gibbs and C. Simpson, "Measuring the Response of Students to Assessment: the Assessment Experience Questionnaire", *The 11th Improving Student Learning Symposium,* Hinckley, Leicestershire, UK, September 2003.

Appendix I Survey Instrument

Rate the following statements on a five-point Likert scale
(1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

Section 1 Study effort and Assessment Environment

1. I study more during weeks when there is an oral assessment comparing to regular weeks.
2. I look forward to speaking with the professor during oral assessments.
3. I feel anxious during oral assessments.

Section 2 Learning from Oral Assessment

4. I learned new things while preparing for the oral assessment.
5. I was engaged to think during oral assessments.
6. I understand things better as a result of the oral assessment.
7. Doing the oral assessment brought things together for me.
8. Comparing to the written feedback I got from the in-class work, discussion with the professor during oral assessments helps me to understand things better.
9. *Please provide any additional comments on whether speaking to the professor during oral assessments has helped improve your understanding of the course or not. Why or why not?*

Section 3 Approach to Learning / Exam

10. Preparing for the oral assessment was mainly a matter of memorizing.
11. A deeper understanding of the topics (as opposed to just procedural) is crucial to succeed in this course.
12. The discussion in oral assessments often involves questions that I have not thought of.
13. The discussion in oral assessments showed me how to thoroughly examine a topic.
14. I pay more attention to the theories and reasons behind the procedures because of the oral assessments.
15. In the oral assessment you can "fake good" and get away with not understanding without the professor noticing.
16. I forget more of the information after an oral assessment comparing to a traditional written exam.
17. *Please provide any additional comments on whether oral assessments have changed the way you approach this course or not.*