Board 400: The impact of Oral Exams on Engineering Students' Learning

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The Impact of Oral Exams on Engineering Students' Learning

1. Introduction

Our project, entitled "Improving the Conceptual Mastery of Engineering Students in High Enrollment Engineering Courses through Oral Exams"**,** aims to advance the knowledge and understanding of the potential impact of oral exams on engineering students' learning and their learning experience. Prior research suggests that the adaptive dialogic nature of oral exams has potential benefits for both instructors and students, including deeper insight into students' reasoning and understanding, thus holding promise for improving both assessment of conceptual mastery and for providing feedback for students to adapt their learning attitudes and strategies accordingly. Considering the complexities of designing and implementing oral exams for various contexts, our multidisciplinary engineering instructor team developed oral exams for different engineering courses to explore various options for administering oral exams and to examine the impact that different designs have on student learning. We are particularly interested in understanding: associated stress levels before taking an oral exam; impact on students' comfort in reaching out to the instructional team; impact on students' motivation to learn; impact on learning and learning strategies; and assessor influence on students' experiences with taking oral exams.

These goals give rise to the three corresponding research questions of this project:

RQ1. Students' overall psychological experience with oral exams (stress and connection to the instructional team):

- Do oral exams cause excessive stress to students? Who is more likely to be stressed about oral exams? How is oral exam-related stress compared to written exam related stress?
- Does the oral exam experience make students more comfortable reaching out to the instructional team for help?
- How well did the assessor administer the oral exams? Is there a difference between the instructor and Teaching Assistants (TA)?

RQ2. Students' learning experience: do students find oral exams to play a positive role in their own learning?

- Do oral exams increase students' motivation to learn?
- Did oral exams increase students' understanding of the subject matter?
- Do oral exams change students' perceptions of changes to their learning strategies?

RQ3. How does the implementation of oral exams impact student's overall academic performance ?

Potential benefits of oral exams

Oral exams have the potential to provide a more authentic process for assessing students' conceptual knowledge, as well as an opportunity for instructors to identify students' gaps in learning and provide targeted feedback. Prior research has shown additional potential benefits such as increased student engagement and motivation toward learning, improved student learning

toward conceptual mastery, opportunities for students to develop communication skills about engineering concepts, and academic integrity.

When designed well, the dynamic and interactive nature of oral exams can have positive results in terms of higher student engagement and improved learning in STEM courses. Several studies of using oral exams as a teaching and assessment tool highlight the potential benefits such as encouraging in-depth conceptual learning [1]-[7], increasing professor-student interaction [8]-[10], enhancing oral communication skills in participating students [2], [6], [7], [11] and improving the efficacy of assessment in STEM education [1], [2], [9]. Despite the evidence of the potential learning benefits of oral exams, STEM educators used oral exams sporadically in their classes in the United States [8], [9], [11], [16], [17].

Multiple studies also suggest that oral exams contribute to maintaining the integrity of evaluation processes [13], [14], [18]. During the pandemic, a number of STEM educators implemented oral exams in their classes to enhance interaction with students, as well as to maintain the integrity of the classes during the sudden shift to remote instruction [12]-[15]. Oral exams have the potential to contribute to students' trust in the fairness of the evaluation process for everyone in the class. A number of studies report that while oral exams can contribute to academic integrity, more importantly, they can enhance students' confidence in their programs' accurate assessment of the class learning outcomes. [13], [19]-[22].

On the students' end, verbalizing one's flow of thought promotes generative processes for meaningful learning beyond rote memorization [23]-[25]. Often students adopt rote memorization as their short-term learning strategy for written exams, limiting their scope of cognitive processes to a passive receiver of information [23]. In contrast, students preparing for verbal explanations are promoted to engage in generative processes in learning [26]-[27], such as selecting and abstracting important information, organizing them into structure, and transferring it for problem solving in novel contexts [27]-[29]**.** Several studies have observed the long-term benefit of engaging in opportunities to verbalize one's thoughts with others (e.g., small group discussions [30]; tutor learning effect, [31]) and even just from being in the mindset to teach someone than not ([32]-[33]). Beyond these learning activities, oral exams benefit both the student and the instructor where the student engages in generative process of learning and the instructor is able to synchronously diagnose the student's thought processes to guide their teaching.

Potential challenges of oral exams

Concerns about scalability, reliability, and validity are also highlighted in this research, and are cited as barriers to more widespread adoption of oral exams. Increased student stress is another potential concern given the inherent dialogic nature of oral exams. Related stress could be a result of the requirement of having to process questions, verbalize answers, and explain one's thinking in the moment. Students may also experience increased stress due to a lack of experience and familiarity with taking oral exams.

Another potential challenge to administering oral exams is the possibility of implicit bias seeping into the process. To mitigate this possibility, those who administer oral exams must have an understanding of perceived or actual effects of bias in the exam based on gender, race, ethnicity,

fluency in English, or other characteristics that may not be related to the actual exam content; limitations in the scope and depth of an oral exam due to time constraints; and norming challenges associated with assigning grades to students based on personalized and customized exams. Checking one's assumptions when assigning grades can help minimize the effects of implicit bias in the oral exam process.

Logistically, oral exams can be challenging to implement, especially when attempting to administer them uniformly in high enrollment courses [7], [11]. Compared to traditional written exams, oral exams require a significantly different assessment design approach that considers a unique set of variables depending on the context of the course. Scheduling, grading criteria, feedback mechanisms, motivation structures for low-stakes oral exams, and instructional guidance on preparing for an oral exam for both examiners and examinees, need to be considered and carefully planned.

Our Study

The full project aims at developing oral exams that maximize their formative benefits to our students and addresses the design challenges associated with their scalability and adoption for high-enrollment classes. In this paper, we focus on understanding the full picture of oral exams: connecting students' psychological and learning experiences with their academic performances across several courses. We specifically aim at addressing three components of oral exams. First, we examine the overall psychological experience on the student's end in preparing for, during, and after the oral exam. Specifically, we asked students about their stress levels before and after the oral exams (vs. written exams), how they felt about the assessor administering the oral exams (e.g., instructor and/or teaching assistants), and whether they felt more comfortable approaching the instructional team after the oral exam. Secondly, we examined whether oral exams positively impacted students' learning. Specifically, we asked whether oral exams incentivized students to modify their learning strategy, increased their motivation to learn, or promoted a deeper conceptual understanding. Third, as a preliminary step to establishing the relationship between the oral exam experience and the overall academic performance, we report the outcomes of two courses that specifically administered oral exams at different timings during the class for comparisons. Altogether, we took a step further to examine how the student experiences with oral exams vary across different groups of students (e.g., underrepresented minority students, first-generation students, gender, etc). We discuss how we can better support specific needs of our students in creating an equitable environment for all students.

2. Methods

In this study, we sought to understand the impact of oral exams on students' learning and learning experiences. This research is performed at University of California San Diego (UCSD), a large R1 public research institution in the United States. The study was based on a collaborative study among faculty from Mechanical and Aerospace Engineering (MAE) and Electrical and Computing Engineering (ECE), and educational researchers from the Teaching + Learning Commons at UC San Diego. The study is based on data collected from Fall 2021 to Fall 2022. Over 5 quarters, a team of 7 faculty from MAE and ECE designed and implemented oral exams in 13 undergraduate engineering classes (9 unique courses):

- MAE 30A Statics and Introduction to Dynamics
- MAE 30B Dynamics and vibrations

- MAE 131A Solid Mechanics I
- MAE 131B Solid Mechanics II
- MAE 107 Computational Methods in Engineering
- MAE 8 MATLAB Programming for Engineering Analysis
- ECE 35 Introduction to Analog Design
- ECE 65 Components and Circuits Laboratory
- ECE 101 Linear Systems Fundamentals
- ECE 144 LabVIEW Programming: Design and Applications

Sample

A total of 1628 students took the oral exams during this period. The classes range from first-year to junior level, with class enrollment size from n=26 students to n=309 students. All students who took the oral exams were invited to take the surveys, and various response rates were received. There were 71.68% of students responded to the pre-survey, 60.5% of students responded to the post-exam survey, and 36.12% of students responded to the end-of-quarter survey. We took the entire survey respondent population as our sample for the study.

Study Design and Data Collection Instrument

To understand the impact of oral exams on students' learning, our study investigated both students' insights of oral exams and their implementation integrity and the potential impact of oral exams on their academic performance. To explore students' insight, the data used in this paper is mainly collected from online surveys. Student identities (IDs) were collected and de-identified by non-instructor research members and were then combined with demographic data and exam grades for analysis. To study the impact on student performance, students' performance data were collected as a natural part of the course instruction.

To study students' perception of the impact of oral exams on their learning experience, all students who took oral exams were sent a web-based survey including both Likert-scale questions and open-ended short-response questions. Online surveys were sent at the beginning of the quarter, after each oral exam, and at the end of the quarter. All students who participated in the oral exams were invited to self-select into the research. Likert -scale questions were used as indicators of the impact of oral exams on students' learning experiences, complimented with open-ended questions to explore students' thoughts behind their rating. The indicators are:

1. Stress caused by oral exams. Students were asked to predict, report and summarize their views about the stress associated with oral exams. In the pre-survey, students were asked " I expect oral exam stress to be excessive", and "I expect written exam stress to be excessive". After each oral exam, students were asked to rate their level of agreement on " I found oral exam stress excessive", and "I found written exam stress excessive". At the end of the quarter, students were asked to rate their level of agreement on "I found oral exam stress excessive", and " I found written exam stress excessive".
2. How much do the students believe oral exams made them feel more comfortable reaching out to their instructors and TAs for help? In the pre-survey, baseline data was established by asking students to rate their level of agreement on "I feel comfortable reaching out to the instructional team". At the end of the quarterly survey, students were asked to rate their level of agreement on "oral exam makes me feel more comfortable reaching out to the instructional team".

3. Students' perception of how much oral exams increased their understanding of the subject matter. At the end of the quarterly survey, students were asked to rate their agreement level on "Oral exam increased my understanding of the subject matter"
4. Students' perception of the impact the oral exam has on their learning strategy. Students were asked at the end of the quarterly survey to rate their level of agreement on "Oral exam changed my strategy in studying".
5. Students' perception of the impact oral exams had on their motivation to learn. During both post-exam and end-of-quarter surveys, students were asked to rate their level of agreement on " Interaction during exam oral increased my motivation to learn".
6. Oral exam administrator competency in both behavioral (tone, helpfulness, etc.) and technical aspects (questioning, accuracy of feedback, content knowledge, etc.).

The surveys aimed to elicit students' insight about the impact of oral exams on their learning experience, how they prepared for the oral exams, and what they felt were the main benefits and drawbacks of oral exams.To study the impact on academic performance within the class, a few classes conducted semi-experiments. There is no rigorous control group. The semi-experiment conducted is elaborated on in a later section.

Ethical Approval:

Ethical Approval was granted for the study by UC San Diego's Institutional Review Board. Participants were briefed on the study and provided consent when they completed the online surveys. To protect participant anonymity, survey responses were de-identified by non-instructor project research members.

Data Analysis

Student surveys included Likert scale responses with 5 levels of agreement: strongly disagree, disagree, neither agree nor disagree, agree and strongly agree. Descriptive statistics were conducted to understand the students' overall agreement with the outcomes. Correlational analyses were conducted to understand how the oral exam impacted different sub-groups (such as gender, first-generation college students, etc), and nonparametric Kruskal-Wallis tests were conducted for the ordinal survey Likert scale question results.

To analyze students' thoughts, thematic coding was used for the open-ended responses using the qualitative data management software, Atlas.ti.

To explore potential significant differences in perceptions among subgroups of students, the nonparametric Kruskal–Wallis H test was applied to the ordinal data collected from the surveys. Many aspects of the students' demographics were investigated, including gender, First-Generation status (FG), underrepresented minority status (URM), Grade Point Averages (GPA), and students with different levels of English speaking proficiency. After we find significant differences, bar charts are plotted based on the proportion of different groups' responses to study more details of the significant differences.

To study the impact of oral exams on students' learning, descriptive analysis and regression analysis were performed. More details are described in the results section.

3. Results and Discussion

3.1 Students' insights about oral exams

A. Do oral exams cause excessive stress to students? Who is more likely to be stressed about oral exams? How is oral exam-related stress compared to written exam related stress?

Concerns over students' stress are commonly cited as one of the factors deterring instructors to adopt oral exams for their courses. It is commonly suspected that oral exams cause more stress on students due to their verbal communication aspect, lack of experience taking oral exams, and other reasons. While stress is often a normal feeling that accompanies taking exams, high levels of stress can create a barrier to learning and performance, and is important to consider when designing assessments and other learning activities. Thus, we surveyed our students about their stress, in comparison to the written exam in both pre and end-of-quarter surveys.

Students' anticipation before taking oral exams

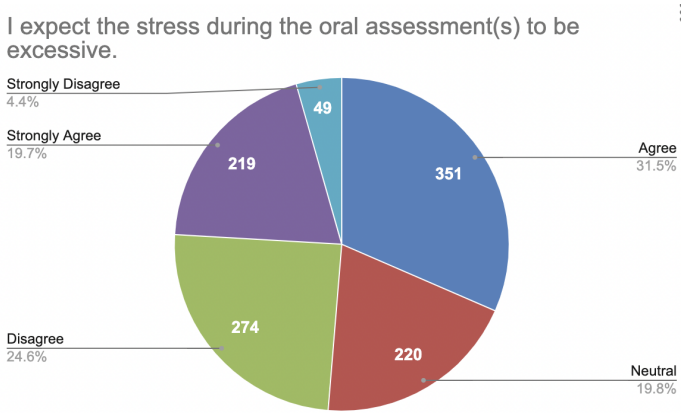

Figure 1. Students' anticipation about stress from oral exams

The pre-survey results show that more students tend to expect excessive stress during the oral assessments. There were 56.1% of the valid respondents who answered "agree/strongly agree" to the prompt, while nearly 19.8% answered neutral, and 24.1% answered, "disagree/strongly disagree". In addition, we found the following few sub-groups of students anticipate a higher level of stress toward oral exams. More female students anticipated higher stress compared to male students (p-value = 4.67e-08). A total of 64% of female students agreed or strongly agreed that they expected excessive stress, while only 46% of male students did so. More First-Generation (FG) students anticipated high stress compared to non-FG students (p-value = 1.33 e-07). Sixty percent of FG students agreed and strongly agreed they expected the stress from the oral exams would be high, while 46% of non-FG students claimed the same. Students with different cumulative GPAs also presented different attitudes toward oral exams. Based on the post-hoc analysis to compare the different GPA student groups pairwise, we found more middle-performance (B and C range GPA) students expected high stress from oral exams,

compared to high-performance (A-range GPA) and lower performance (below C GPA) students (p-value = 0.0005 for A and B students, and p-value = 5e-06 for A and C students). 52% of B-range GPA students and 64% students agreed or strongly agreed that the stress from oral exams would be excessive, compared with 43% A-range students.

Students' prior oral exams experience also impacts their expectations of stress. A pre-survey question asked the students how many times they have had oral exams before, with answers of " never", "yes but not for credits", "once/ twice", "several times", and "many times". Based on the post-hoc analysis to compare the different levels of prior experience of oral exams pairwise, we find that there is a strong significant difference between students who "never" took an oral exam with students who took oral exams "many times" (p-value = 0.007), as well as a less strong significant difference between students who "never" took oral exams and students who took oral exams "Several Times" (p-value = 0.04). Fifty-six percent of students had never taken oral exams, 46% who had taken oral exams, not for credits, 54% who had taken them once or twice, 45% of students who had taken them several times, and 36% of students who had taken oral exams many times. This seems to indicate that part of the students' stress towards oral exams comes from their lack of experience and/or familiarity with oral exams based on their previous academic experience.

The expected stress towards oral exams is also associated with students' English proficiency level. In the pre-survey, students were asked to self-report their spoken-English proficiency level, which varied from "no proficiency", "elementary proficiency", "limited working proficiency", "full professional proficiency", and "Native/bilingual proficiency". Very few students self-reported themselves with "no proficiency". Seventy-seven percent of students selected "limited working proficiency", 61% selected "professional working proficiency", and 49% self-reported as having "full professional proficiency". Forty-nine percent of "native/bilingual proficiency" students agreed or strongly agreed that they expected excessive stress from oral exams. It seems like lower English proficiency students are more likely to experience stress related to taking oral exams.

To better understand the reason behind stress caused by oral exams (the dialogic and interactive nature, lack of experience or familiarity, or other reasons), similar questions about written exams were also asked. Results showed that the following sub-groups of students self-reported statistically significantly higher anticipated stress towards written exams: female students, FG students, and middle-performance students (B and C- range GPA).

Thus, from the pre-survey, we can tell that female, first-generation, and mid-range GPA students usually experience higher exam-related stress, whether written or oral. Students' English proficiency is the unique factor that contributes to oral exam-related stress. Students who have lower English proficiency experience higher levels of stress than with written exams.

The implication for instructors is that as for oral exams, non-native speakers and students who do not have much oral exam experience higher levels of stress compared to other students. To mitigate this challenge, one thing instructors can do is provide detailed information about the oral exams, how it is graded, how to prepare for them, and potential sample oral exams. Instructors could also emphasize that oral exams give them an opportunity to practice their

communication skills, but their grade would be based on their understanding, not their language skills.

How was the stress level after the oral exams?

Students were also asked to report their stress level **after each oral exam and at the end of the quarter** (the number of oral exams varies from class to class–usually one to three oral exams). Differences were noticed based on gender, FG status, and cumulative GPA sub-groups of students and were consistent with the pre-survey results: More female students expressed stress toward the oral exams they took compared to male students (p-value = 0.009); more First-generation college students expressed stress towards the oral exam they took compared non-first-generation (p-value = 0.019). High-performing students (A range GPA), identified less stress compared to middle-performance students (B and C range GPA) (A & B students comparison p-value = 0.0008, A & C students comparison p-value = 0.0001). The significant difference of the anticipated stress level among those who identified different levels of English proficiency vanished when students had the experience of taking an oral exam.

Post exam data were also collected on students' experiences related to stress and written exams. The following group of students experienced statistically significantly more stress: Female students compared to male students, First generation compared to non-first generation, and students with middle-level GPAs. This trend is identical to the oral exam results. Thus, it seems that the higher stress among female students, FG students, and B and C-range GPA students are generally more stressed about exams, regardless of the format.

It is worth noting that, students who self-reported with "limited working proficiency" level English are slightly more stressed about the written exams compared to native speakers.

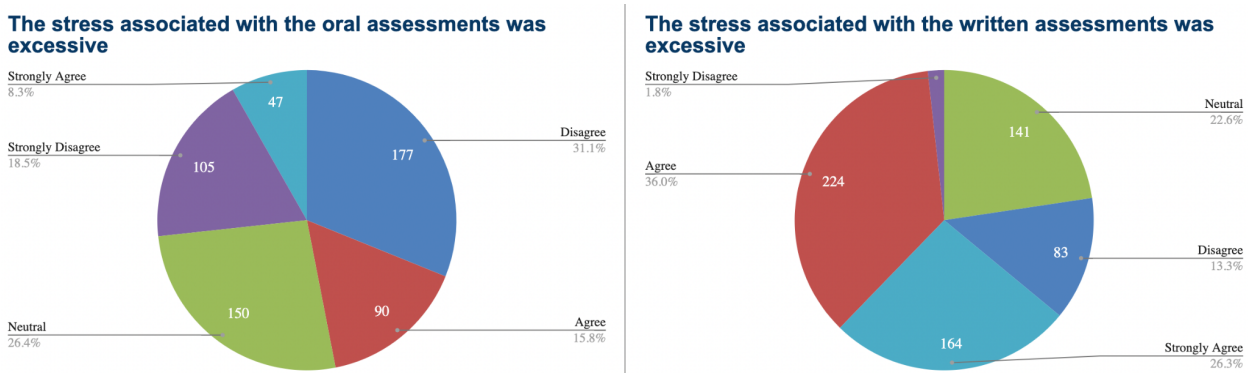

Figure 2. Post exam survey comparison between oral exam and written exams

From Figure 2, comparing oral exams and written exams, overall, more students feel written exams are more stressful than oral exams. 24.1% of students reported that oral exams caused excessive stress, and 62.3 % of students reported that written exams caused excessive stress.

B. Does the oral exam experience make students more comfortable reaching out to the instructional team for help?

We were interested in understanding whether the one-on-one conversation opportunity between students and the instructional team (instructor and Teaching Assistants) impacts their relationship, either strengthening or weakening. In particular, we were interested in exploring the impact of oral exams on students' comfort in reaching out to instructional team members for help.

In the **end-of-quarter survey**, students were asked whether oral exams made them feel more comfortable reaching out to the instructional team for help. Overall, more students identified that taking oral assessments made them more comfortable reaching out to the instructional team for help as seen in figure 3. While a relatively large percentage (36.1%) of the students answered "neutral" on the prompt, there is a great gap in percentage between students who answered, "agree/strongly agree" (50.3%) and students who answered, "disagree/strongly disagree" (13.6%).

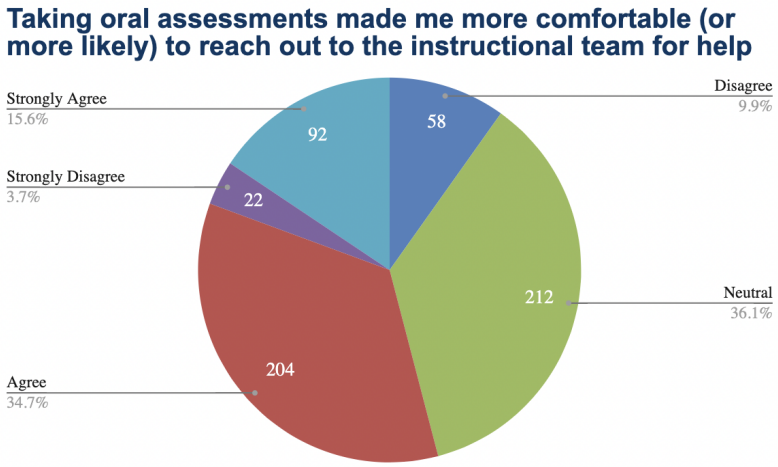

Figure 3. Students' perception of oral exam making them feel more comfortable to reach out the instructional team for help

There were also some differences between the URM & non-URM student groups, and FG & non-FG students. More URM students (58%) agreed or strongly agreed that oral exams made them feel more comfortable reaching out to the instructional team for help, compared to 48% of students who claimed so, with p-value = 0.03. More FG students (59%) agreed or strongly agreed that the oral exams made them feel more comfortable reaching out for help, compared to 45% of students.

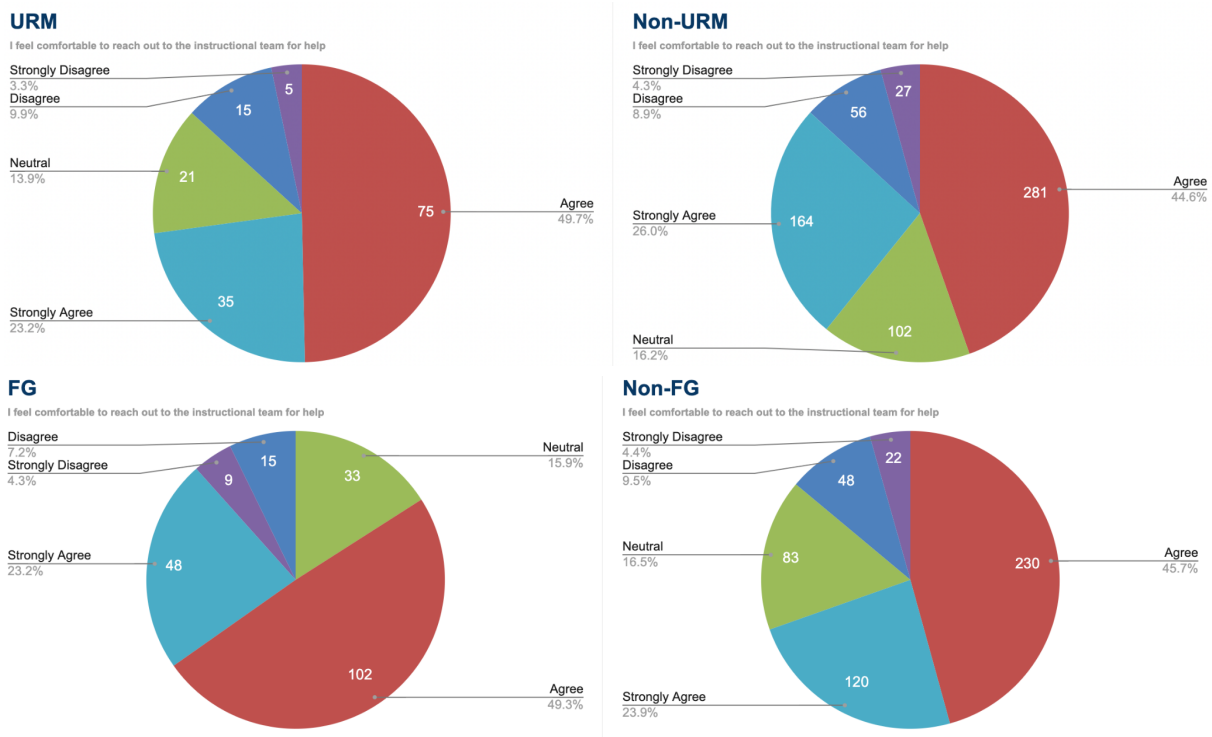

Figure 4. Students' perception at the beginning of the quarter regarding whether they feel comfortable reaching out for help

It is worth noting that from the pre-oral exam survey, there is very little difference between comfort levels in reaching out to the instructional team between the responses of URM students and Non-URM students. A similar trend is found between the responses of FG students and Non-FG students. Overall, more than 70% of the students agree or strongly agree that they felt comfortable reaching out to the instructional team for help at the beginning of the quarter. Participation in oral exams increased comfort levels.

In the **pre-survey**, students were asked to rate their agreement about their comfort in reaching out to the instructional team. Students who had more oral exam experiences agreed and strongly agreed that they felt comfortable reaching out to the teaching team for help. While more data is needed, this may indicate that oral exams have the potential to make students feel more comfortable reaching out to their professors or TAs for help.

Student responses to open-ended questions related to reasons students felt more comfortable reaching out for help gives due to oral exams were analyzed and coded. Many students' responses related to the realization of how much the instructional team cared about their learning, which made them more comfortable and more likely to reach out for help. Many students also commented on how the instructional team did not belittle them when they got something wrong, but instead helped them through it. This made students more comfortable with the instructional team because it showed them that the instructional team was not as intimidating as they may have previously believed.

C. Do oral exams increase students' motivation to learn?

This study also explored the impact of oral exams on students' motivation to learn. **After each oral exam and in the end-of-quarter survey s**tudents were asked whether they felt the interaction during the oral exams they took increased their motivation to learn. Overall, more students identified feeling motivated to learn by the interactions during the oral exams. 69.1% of the valid responses answered "agree/strongly agree" to the prompt, while nearly 23.9% answered neutral, and only 6.9% answered, "disagree/strongly disagree".

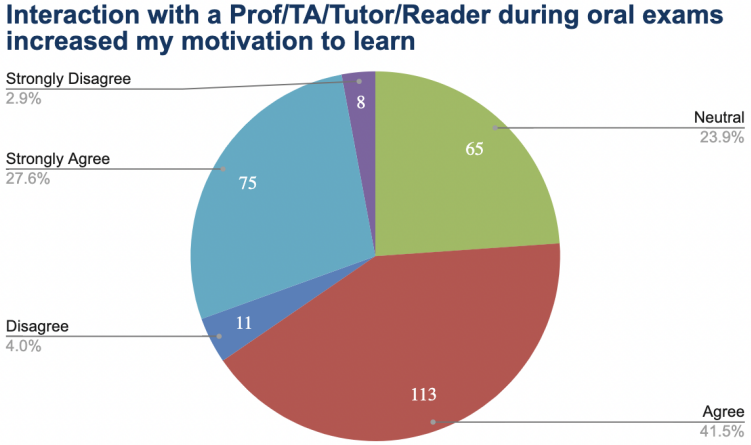

Figure 5. Students' perception of oral exam increasing their movation to learn

Student survey results showed a more significant impact on motivation to learn in First-Generation students and mid-range GPA (B and C) students. More FG students (80%) agreed or strongly agreed that the interaction during oral exams increased their motivation to learn, compared with 68% of non-FG students who reported so, with a p-value = 0.0017.

Based on the post-hoc analysis to compare pairwise the response from the different Cumulative GPAs, results showed a strongly significant difference between students in the "A range" and students in the "C range" (p-value = 0.002). Noting that although there is no significant difference between students from the "B range" and "C range", the difference is very close to being considered significant.The difference between FG and non-FG students suggests that oral exams can be a powerful tool to shorten the gap between FG and non-FG students.

Thematic coding and analysis of qualitative responses provided insight into potential reasons that oral exams contribute to student motivation. Students reported that oral exams revealed to them how much professors and other members of the instructional team care about their learning and well-being. Students found this increased their motivation to learn and increased their likelihood to reach out to the instructional team for help. In addition, in versions of the oral exams that were intended to give the students extra credit, students found that having a second chance to prove their knowledge increased their motivation to learn. This highlighted to them that the class was about increasing their knowledge rather than penalizing them for their mistakes.

D. Did oral exams increase students' understanding of the subject matter?

In the end-of-quarter survey, students were asked whether they believe the oral exams increased their understanding of the subject matter. Overall, the majority of students found the oral

assessment(s) increased their understanding of the subject matter. 72.1% of the valid responses answered "agree/strongly agree" to the prompt, while nearly 21.4% answered neutral, and only 6.4% answered, "disagree/strongly disagree".

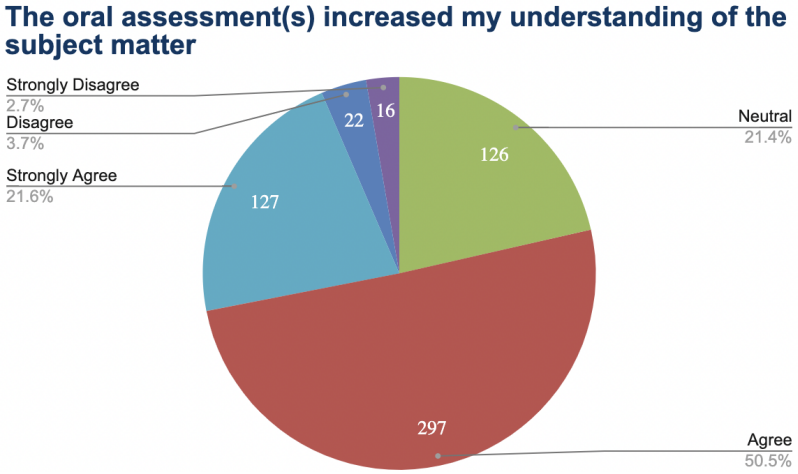

Figure 6. Students' perception of oral exam increasing their understadning of the subject matter

There is no statistically significant difference among any demographic sub-groups. However, results showed that whether students believe oral exams increased their understanding of the subject matter is positively related to their belief on "whether they found the course materials interesting and engaging", and "whether oral exams increased their motivation to learn". Based on the posthoc analysis to compare pairwise the responses from different levels of agreement on "Finding the Course Material Interesting and Engaging," results shos a strongly significant difference between the response of students who strongly agree that the course material is interesting and engaging and both those who agree (p-value = 0.00034). Results between students who strongly disagree that the course material is interesting and engaging and all other groups of students is not considered since the sample size ($n<5$) is too small for this subgroup, which can cause unrepresentative results.

Coding and analysis of qualitative responses provide insight into potential reasons that oral exams increase students' understanding of the subject matter. Some students reported that due to the way they prepared for the oral exam, their strengths and weaknesses were exposed and it helped highlight what they should focus on in their studying. In addition, it was also revealed to students while taking the exam when the assessor prompted them with a question or scenario they had been presented with before.

Students found the instantaneous feedback aspect of the oral exam to be the most beneficial to their learning. Many students came to view the oral exam as a place where they could ask questions or where they could get clarification on their approaches. Looking at the distribution of the proportion of the responses from different levels of agreement on "Finding the Course Material Interesting and Engaging" significant differences are found. Although overall, the trend appears to be more students find oral exams increased their understanding of the subject matter. Students who disagree that the course is interesting and engaging slightly more agreed on the current prompt. Nearly none of the students strongly agreed that the course material is interesting and engaging and found their understanding of the subject matter had not increased. This implies

students' perception of other course aspects mediates their view about the implementation of oral exams. Rarely any course element alone could work by itself without influence or get influenced by other course elements.

E. Do oral exams change students' perceptions of changes to their learning strategies?

Assessment has the power to steer students' learning behaviors. The adaptive nature of oral exams, and the opportunities to follow-up on students' decision-making process for their problem-solving, has the potential to guide students' learning towards a deeper and conceptual level. They can also serve as a more authentic assessment tool than traditional written exams. Thus, in the **end-of-quarter survey**, students were asked to reflect on whether the oral exams changed their learning strategies. Overall, results show a quite even distribution of students' agreement level on how they find interactions during the oral assessment(s) changed their learning strategies. 29.4% of students agreed/strongly agreed on the prompt, while 38.1% of students didn't have a preference, and 32.4% of the students disagreed/strongly disagreed.

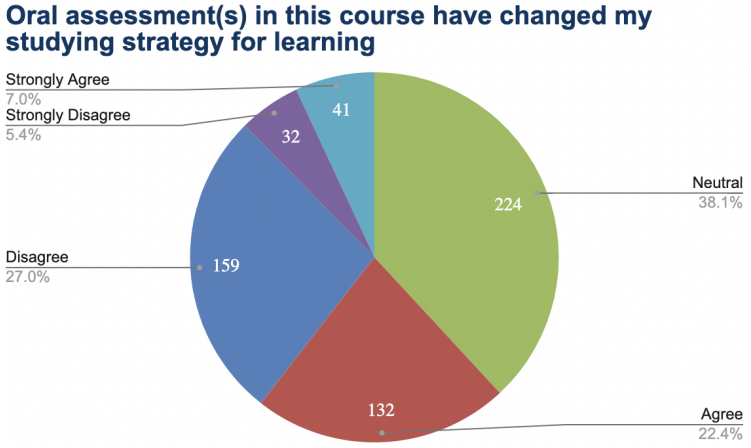

Figure 7. Students' perception of oral exam change their learning strategy

Results showed that more URM students, FG students, and students with lower GPAs (C and below C) reported oral exams caused a more significant change in their learning strategy compared to the non-URM students, non-FG students, and higher and middle GPA (A and B) students. Thirty-eight percent of URM students agreed or strongly agreed that oral exams changed their learning strategy more towards deep learning, compared with only 26% claiming the same, with P-value=0.021. 37% of FG students agreed or strongly agreed that oral exams changed their learning strategy, compared to 24% of non-FG students, with P-value=2.135e-05. There were 20% of A-range GPA students, 33% of B-range GPA students, and 37% C- range GPA students agreed or strongly agreed that oral exams have changed their learning strategy toward deeper and conceptual mastery. There is a significant difference between A and B-range GPA students, as well as between A and C-range GPA students. This suggests that oral exams have the potential to help students to evaluate their learning strategies and make corresponding changes. However, results also showed that compared to the question "whether oral exams increased students' understanding of the subject matter", the impact on students' learning strategy change is weaker. This could be due to a few reasons: First, not every student needs to change their learning strategies. Some high-performing students have been using effective

learning strategies, and thus do not need changes. This is different from whether students increased their understanding of the subject matter: even the students who have used the right learning strategies may still benefit from an oral exam on a particular concept that is still unclear to them. Secondly, the change of learning strategies may need a longer process and multiple types of interventions. Most of the courses in this study implemented oral exams once or twice on average for each student, which may not be enough to make dramatic changes in students' learning strategies. Literature ([34]-[35]) has also shown that it is difficult to change students' learning strategies as they have developed their strategies from their past experiences, and people, and in general, are more likely to continue to use the strategies they feel useful or comfortable. Thirdly, students may lack the metacognition, the science of learning knowledge to make changes, even if they noticed they might need to change. Lastly, most of the oral exams implemented in this pilot study were relatively low-stakes in the overall weight of their grades (ranging from extra credits, pass-or-no-pass criteria, or 5% to 15% of their total grades). The low-stakes exams may push students to think less about their learning strategies.

Thematic coding and analysis provided insight into how students' learning strategies have changed due to oral exams. Students find in preparing for their oral exams they spend more time focusing on their thought process or explanation skills than they would on a written exam in which they would focus on practice problems. Some students also report practicing their explanation aloud to ensure they could explain it. In addition, students highlighted focusing on concepts to be an important part of studying for oral exams rather than for the written exams it was more equation based.

F. How well did the assessor administer the oral exams? Is there a difference between the instructor and Teaching Assistants (TA)?

To make oral exams applicable to large-enrollment classes, effectively engaging TA is critical. In this study, the research team developed and implemented oral exam administration training for TAs, which included five videos and reflection exercises. After each oral exam, we asked the students to evaluate how well the oral exams were administered, including clarity of speech, being respectful, being fair (no bias), assessor's mastery of course content, whether the assessor provided sufficient time for the student to solve problem, whether the assessor provided useful hints when needed (if this is applicable to the oral exam design intent for the courses), whether the assessor provided useful feedback about students' performance. Each of these questions has five levels of options are "very low", "low", "neutral", "high" and "very high".

Overall, the majority of students evaluated extremely positively the various aspects of the assessor's oral exam administration as seen in figure. Results (figure 8) show that for the first four aspects (clarity of speech, being respectful, being fair (no bias), and assessor's mastery of course content), less than 2% of the students negatively evaluated the assessors.

Kruskal Wallis H tests were also applied to compare whether students' ratings for instructor and TA assessors vary, and if so, how much. Statistically significant differences were found on every aspect (except for "Provided sufficient time for me to solve problems on my own") of students' evaluation on different assessors (Professor/Instructor and a TA/Reader/Tutor). Clarity of speech

with P-value = 0.0146, Being respectful with P-value = 0.002, Being fair (no bias) with Kruskal Wallis P-value = 0.0272, Mastery of course content with P-value = 0.0002, Provided sufficient time for me to solve problems on my own with P-value = 0.017, Provided useful hints when needed with P-value = 0.0018, Provided useful feedback about my performance with P-value = 0.1866. Although both the TA and instructor were rated really high, it appears that students overall believe the instructors did slightly better than the TAs. This difference may be a result of many factors, such as the instructor's knowledge, communication skills when interacting with students, etc. While the training of TAs is considered to be successful, further research is needed to identify opportunities for improvement of the training.

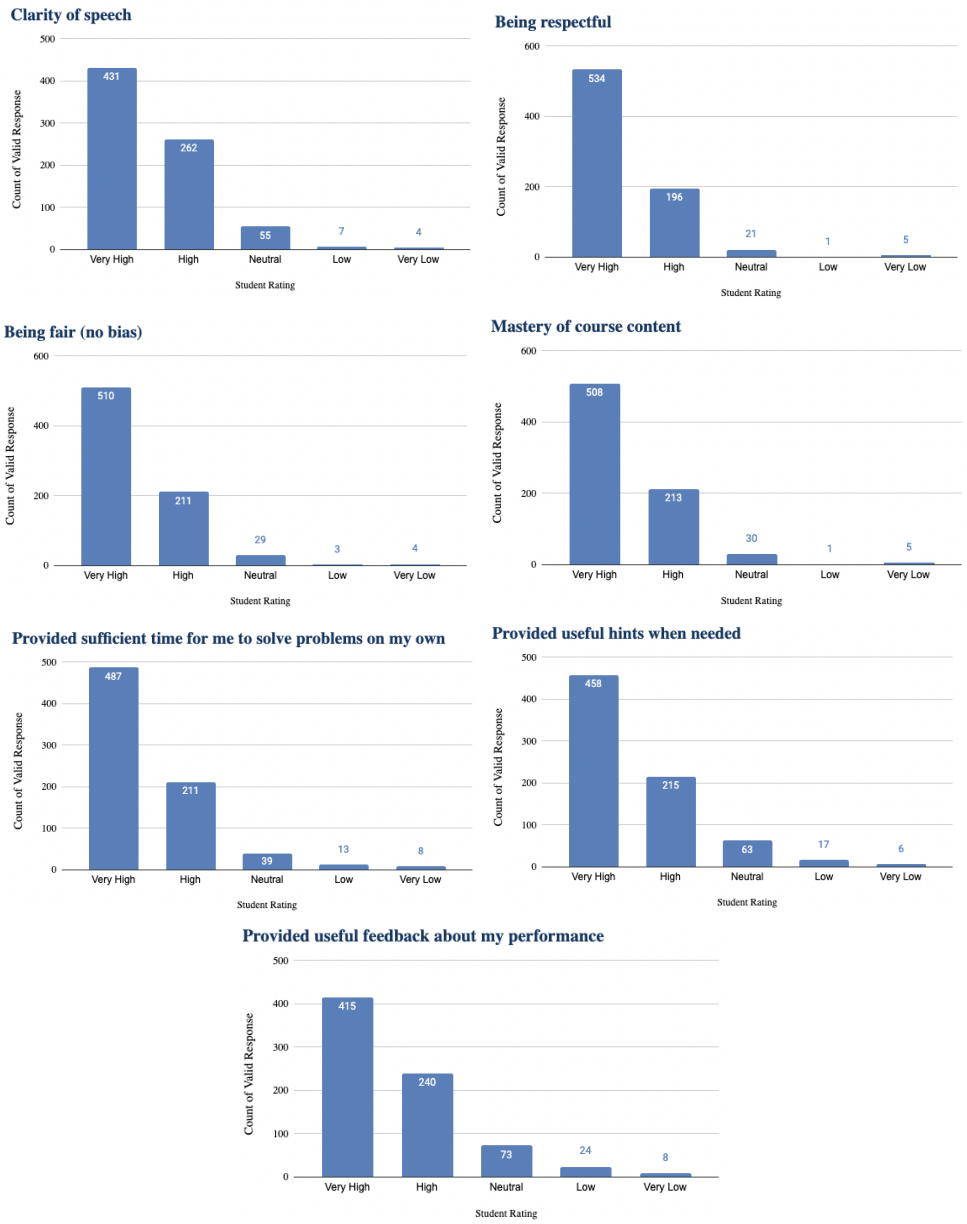

Figure 8. Students rating for assessor for oral exam

3.2 Impact of oral exams on students' academic performance

A few classes used semi-experimental methods to study the impact of oral exams on students' academic performance. Two cases are discussed in this paper.

1. **ECE 65 - Fall 2021**

In Fall 2021 offering of ECE 65, all students participated in a written midterm exam and a written final exam. In between these two exams, students who were randomly assigned to two groups took an oral assessment. One group, referred to as group 1 hereafter, took their oral assessment right after the midterm exam, and the second group, referred to as group 2 hereafter, took it at the end of the quarter, right before the final exam. The oral assessment questions were drawn from a question set that was given to students about one week before the start date of oral assessments. All students were required to prepare solutions to the questions in the question set and submit their written solutions, but only students in the corresponding groups participated in the oral assessment, explained their solutions, and answered extension questions. The written midterm and final exam grades were used to study the effect of oral assessments and the time of intervention on student learning. The results of our study show that the average final exam grade for students in group 1 was higher than that of students in group 2, although the difference was not statistically significant. Furthermore, the standard deviation of the grades for students in group 1 changed from 31% on the midterm exam to 21% on the final exam. This change was from 25% on the midterm exam to 20.5% on the final exam for students in group 2. This result suggests that the time of intervention could affect the effectiveness of the intervention and the earlier the students participate in oral assessments, the more effective these assessments might be on student learning.

2. **ECE 35 Fall 2021 and Fall 2022**

ECE 35 is an introduction to electronics course in the Electrical and Computer Engineering department. In Fall 2021, there were two sections: Section A with an enrollment of 176, and Section B with an enrollment of 158. The course's main assessments were four written 50-min quizzes and one written final exam of 3 hours. Each student was also offered one oral assessment of 20 minutes, worth 2.5% of the total grade, and scored on participation only. However, to serve as a formative assessment of class progress for the instructional team, students were assessed on a 2-point scale.

The main design parameter under study was the timing of the oral assessment: for Section A, this was after quiz 1 but before quiz 2; for Section B this was after quiz 2 and before quiz 3. The goal was to evaluate (1) whether quiz 2 performance would improve due to the oral assessment with Section B serving as a comparison/control group to Section A, (2) whether the complexity of topics had an impact on the oral assessment in terms of performance or student sentiment.

It was observed that there was no statistically significant impact on student performance, in either quiz 2 or the final exam. Also, the timing had no noticeable effect on student sentiment. It was observed that the participation-only grading yielded low stress, but also a lower focus on dedicated preparation. A key feature learned was that feedback during the assessment needed to be emphasized, as students reported that is particularly valuable. This was particularly the case for lower-achieving students.

In Fall 2022, ECE 35 was offered again as two sections, with a total combined enrollment of 309 students. Written exams now consisted of 3 quizzes and 1 final exam. However, oral assessments were rethought based on lessons learned from the prior year and the experiences of other researchers on the team. Instead of primarily considering the oral exam as an assessment method, it was recast as an early intervention strategy. In this setup, the goal was to offer it only to at-risk students and have it serve as a way to increase their self-efficacy and sense of belonging.

To this end, students who failed quiz 1 (76 students) were invited to participate in the oral assessment with extra credit serving as an incentive. The assessment was organized much the same way as an interrogation-style interaction, but with a focus on helping students self-assess where they struggled, providing learning opportunities, providing general encouragement, and inviting them for continued support during office/tutoring hours.

The students who participated reported increased motivation, feeling more comfortable in reaching out to the instructional team, and attending office/tutoring hours more frequently. While the extra credit was reported as playing a significant role in getting them to participate, the learning impacts were perceived by the students as equally important. Performance on the oral exam was also higher but failed to reach the level of statistical significance. The intervention was specifically designed to be more scalable, by targeting students who were most at-risk and would benefit the most. We believe it was successful at doing this, but also yielded a smaller intervention group for analysis.

4. Discussion

Results from this pilot study showed that oral exams increased students' motivation to learn, their comfort levels in reaching out to the instructional team for help, their understanding of the subject matter, and provided information about study strategies that can help promote deeper learning and conceptual mastery. These positive impacts are significantly higher in First-Generation students, URM students, and students with lower GPAs. The interactive nature of oral exams and the opportunity for holding a conversation between students and members of the instructional team provides a unique experience for students that benefits their learning.

Some instructors may hesitate to use oral exams due to concerns about causing excessive stress and thus negatively impacting students' mental health. Results from this study showed that most students who experience stress about oral exams do so because of a lack of experience with oral exams, or because of concerns about English-speaking proficiency. Regarding concerns of lack of oral exam experience, providing students sufficient guidance, including sample oral exams, could significantly reduce this concern. For English-speaking proficiency concerns, the oral exams in our study aim to minimize the impact of language on oral exam performance, which was reflected in the rubric development. The post-exam surveys show that after students have some experience with oral exams, the concerns about language proficiency decreased significantly.

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