

Insights from the First Year of Project # 2044472 “Improving the Conceptual Mastery of Engineering Students in High Enrollment Engineering Courses through Oral Exams”

1. Introduction and Project Overview

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 impact of oral exams on engineering students’ learning. Prior work has shown that the adaptive dialogic nature of oral exams has the potential to provide instructors with more detailed insight into students’ reasoning and understanding, thus holding promise for improving both assessment of conceptual mastery and for providing incentives for students to adapt their learning attitudes and strategies accordingly. However, the same work has also shown that potential concerns of reliability, validity, and scalability have yet to be fully addressed, and are currently impediments to more widespread adoption of oral exams. As with any assessment format, careful design is needed to maximize the benefits of oral exams to student learning and minimize the potential concerns. 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. For example, there are logistical considerations such as scheduling, which can be challenging when the exams occur outside of regularly-scheduled class time, and particularly challenging in high enrollment courses. Grading criteria, feedback mechanisms, and incentive structures for low-stakes oral exams also need to be considered and carefully planned. Finally, because of the likelihood of a lack of familiarity with the oral exam modality, both on the part of the examiner and examinee, student preparation and training is needed for the instructional team. Our project aims to address these design challenges while focusing on scalability for high enrollment classes. To accomplish this, our approach is centered around the involvement of the entire instructional team, including both instructors and instructional assistants (IA). In addition to the exploration of various oral exam designs and processes, another key contribution of our work is the development of a complementary training approach for both faculty and teaching assistants involved in oral assessment, including strategies that promote equity and minimize the potential for bias.

In summary, the two overarching goals of the project are to: 1) determine which oral exam configurations most benefit student learning, which will be accomplished through a process of designing and testing various approaches in a variety of disparate engineering courses; and 2) develop and implement training modules for members of the instructional team, including faculty, graduate instructional assistants and undergraduate tutors, who take part in the oral exam process. These two goals give rise to the two corresponding research questions of our project:

RQ1. What is the impact of oral exams on student learning?

RQ2. How well has the instructor and instructional assistants training program prepared them to successfully deploy oral exams in their engineering courses?

These research questions in turn give rise to four major components of our research program: 1) Design and implement oral exams in various engineering courses; 2) develop and implement instructional assistant training; 3) develop evaluation instruments to measure the project outcomes; and 4) disseminate project findings to the engineering education community. More details of the project components are elaborated below.

Design and Implement Oral Exams

One of our major goals is to develop oral exam structures and approaches that create the most benefit for student learning using a systematic and continuous improvement design process whereby we implement oral exams in various engineering courses throughout the three years of the project, *evaluate* the impact of the various configurations, and based on the outcome of our evaluation of each iteration, *redesign* our approaches. Taking into consideration the complexities of designing and implementing oral exams for various contexts, our multidisciplinary engineering instructor team designed oral exam structures 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 which oral exam design parameters and configurations maximize potential benefits and minimize potential challenges/risks. The potential benefits of oral exams include improved student learning toward conceptual mastery, increased student engagement and motivation toward learning, opportunities for students to develop communication skills about engineering concepts, a more authentic process for assessing students' conceptual knowledge, opportunities for instructors to diagnose students' gaps in learning, and improved academic integrity. The potential challenges/risks of oral exams related to students include increased student stress due to the inherent dialogic nature of face-to-face exams that require students to process questions, verbalize their answers, and explain their thinking in the moment, or to non-inherent reasons such as lack of experience and familiarity with the format of oral exams. Challenges and risks related to administering oral exams include 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. Thus, our study will focus on the various design configurations and related interventions with a goal toward learning how we can encourage students' learning toward conceptual understanding, effectively assess students' conceptual understanding, effectively reduce students' concerns, such as undue stress (compared to other types of assessments) related to taking oral exams; and help students prepare for the oral exams. The oral exam design space is

categorized into three different categories of parameters: 1) Oral exam questions, 2) grading criteria and structure; and 3) oral exam administration logistics.

Develop and Implement Instructional Assistant Trainings

A critical component of this project is to develop IA training materials and an onboarding process to prepare them for oral exam administration, as well as ongoing feedback and mentorship. This ties in with a broader impact of this project, which is to better prepare the next generation of engineering educators from the training we develop and implement. Some of the IAs who participate in this project have a strong interest in engineering education careers, and the IA training they receive from this project will better prepare them as engineering educators. Oral exams are also excellent opportunities for technical conversations, similar to those seen in industry interviews or in authentic team collaborations. IA training for this project, thus, translates beyond academic careers and can be of value to IAs focused on industry careers.

Develop Evaluation Instruments

The project team takes a systematic design approach—implement, evaluate, redesign—for both oral exam design configurations and IA training programs. Our evaluation plan, the third major project component, includes the development of multi-faceted evaluation instruments including surveys, focus groups, performance data, etc., to measure the outcomes of the various oral exam designs, implementation, and IA training. We will also take an iterative approach to designing our evaluation instruments, to ensure the survey questions address the research questions and project objectives, and that the other components of the evaluation instrument are similarly refined.

Disseminate Project Findings

The project team will disseminate the knowledge gained to the engineering education community and gather peers' feedback.

2. Literature Review

Oral Exams and Student Learning

The interactive approach and dynamic nature of oral exams have equipped their academic users with effective tools to achieve higher student engagement and learning levels in STEM classes. While several educational studies have investigated different methods of implementing oral exams and their benefits for student learning outcomes in higher education, STEM educators historically used oral exams sporadically in their classes [1] - [5]. Multiple pedagogical articles underlined the advantages of oral exams in encouraging in-depth conceptual learning [7] - [13], increasing professor-student interaction [2], [4], [6], enhancing oral communication skills in participating students [3], [8], [12], [13], and improving the efficacy of assessment in STEM education [4], [7], [8].

Furthermore, the interest in oral exams has been revived during the pandemic-driven transition to online learning. A number of STEM educators have implemented oral exams in their classes to enhance interaction with students and maintain the integrity of the classes in the remote learning setups. [14] - [17]. Although oral exams' benefits are broadly acknowledged and investigated, their implementation in engineering programs often involves multiple unique challenges. A key obstacle is the issue of scalability and administering the oral tests uniformly in large classes [3], [13].

Oral Exams as an Academic Integrity Tool

Another advantage of oral exams is their usefulness in maintaining the academic integrity of online classes. The forced transition of classes to remote learning has led to several concerns about the integrity of online exams, where proctoring exams is by nature complex and, in some cases, impossible. Although the primary goals of oral exams are enhancing the conceptual understanding of the STEM topics and increasing professor-student interaction, multiple studies report their effectiveness in maintaining the integrity of evaluation processes [15], [16], [18]. A key theme here is leveraging oral exams to boost students' trust in the fairness of the evaluation process for everyone in the class. A number of studies report that while oral exams can deter possible attempts at academic dishonesty, their more important benefit is enhancing students' confidence in their programs' accurate assessment of the class learning outcomes. [15], [19] - [22].

Teaching Assistant Training and Development

Research suggests that teaching assistants can play an important role in student learning, engagement, and retention in STEM [23] - [25]. The widespread use of teaching assistants, particularly in large introductory STEM courses, has led researchers to note a need for the development and study of training programs that can orient teaching assistants to effective instructional practices, including active learning techniques and student-centered teaching [26] - [28]. While much of the initial research in this area has focused on graduate student instructors, more recently, attention has also turned to the potential for undergraduate teaching assistants to support student-centered instruction with appropriate training and preparation [25], [27], [29] - [31]. Training is especially essential when adopting novel instructional approaches that may be unfamiliar to both students and teaching assistants [28], [32]. In the case of oral exams specifically, teaching assistant support in administering oral exams is critical in scaling this resource-intensive instructional strategy for large courses, necessitating a thoughtful approach to training that respects constraints on teaching assistant time while providing sufficient training to administer oral exams consistently and effectively [33].

Several common features are recommended in the literature to conduct effective TA training. In addition to reviewing content knowledge, it has been recommended that training programs cultivate transparency around instructional approaches and expectations, encourage reflectiveness around teaching practices and experiences, and provide support with interpreting

grading standards and/or rubric implementation [27], [28], [34]. The opportunity to observe and discuss teaching interactions conducted by a more experienced instructor or TA (either through live or videotaped demonstrations or class observations) also appears to be particularly helpful as a training tool [28], [34], [35]. Additionally, direct and ongoing faculty mentorship in teaching has been found to have a significant impact on the development of TAs' teaching orientations; in one study, this was a more significant factor than university or departmental TA training [36]. Finally, Plough's work studying the impact of IA attitudes during oral exams, and particularly the extent to which verbal, paralinguistic, and non-verbal discourse behaviors of the examiner are salient to the examinee [37], suggests that these factors should also be a specific focus of training for TAs who will administer oral exams in addition to the general recommended practices outlined above.

It is common for TA training programs to rely on self-reported learning and satisfaction measures to assess their effectiveness. However, to address gaps between self-reported teaching behaviors and observed behaviors, direct measures to assess TA training effectiveness have been recommended alongside satisfaction and self-reported learning, such as observations and tools that measure gains in student learning and students' achievement of course learning outcomes when taught by a trained TA [34], [38], [39].

3. Year 1 Activities

During the first project year, the research team has conducted activities as planned in all four areas of the project components.

Design and Implement Oral Exams

During the first project year (January 2021 to December 2021), a total of 7 instructors, 86 instructional assistants, approximately 2400 undergraduate engineering students, from two engineering disciplines, Mechanical Engineering (ME) and Electrical Engineering (EE), participated in the project. The instructors designed and implemented pilot oral exams in 26 courses representing 9 distinct courses (6 from ME and 3 from EE). The instructors took a teamwork approach to design and implement a variety of oral exam configurations that best fit the context and learning outcomes of each course. The various configurations allow us to investigate if and how different oral exam designs impact student learning and their experience in the course. The outcomes will be measured after year 2 implementation when data can be compared longitudinally and across all courses.

Develop and Implement Instructional Assistant Trainings

From January to June 2021, participating instructors created their individual instructional training methods. To varying degrees, the training included mock-up oral exams, practice sessions, observations, and feedback. During summer 2021, education specialists in the Teaching + Learning Commons, who are members of the research team, developed official training

materials for instructors and instructional assistants. The training was implemented in participating courses in Fall 2021.

The training included asynchronous and synchronous components. The asynchronous video modules provide: 1) An overview of the purpose and benefits of oral exams; 2) an overview of relevant learning theories and their application to administering oral exams; and 3) effective assessor communication during an oral exam. Specifically, the modules include:

- Module 1: Why Use Oral Exams?
- Module 2: Adopting an Equity Mindset
- Module 3: Managing Anxiety and Reducing Cognitive Load
- Module 4: Communicating Growth Mindset
- Module 5: Effective Communication as the Assessor

Each module concluded with self-assessment questions that IAs were required to complete. Along with the pre-recorded video modules, a mini handbook and IA checklist with key information from the modules was developed. The education specialists also held optional office hours for IAs to address any questions or concerns, or to practice their communication skills.

After the IAs completed the asynchronous training, synchronous training was conducted by each instructor with a focus on the course-dependent and technical perspective of the oral exam administration, such as grading, providing feedback, etc.

Develop Evaluation Instruments

The research team developed multi-faceted data collection and evaluation instruments to collect feedback from students who took oral exams and IAs who completed the IA training and administered oral exams. The research team also conducted a preliminary analysis of collected data to gain insight into the effectiveness of the pilot oral exam design and implementation process and IA training. More details are discussed in the “Data and Methods” section.

Disseminate Project Findings

During the first year of the project, two conference papers were published. Feedback from the conference was taken into consideration for subsequent oral exam designs and implementation.

4. Data and Methods

To assess project outcomes evaluation methods were implemented at each stage of the project and results were used to inform and refine oral exam designs, IA training, and evaluation instruments. The research team collected both quantitative (interval and ratio) and qualitative (nominal and ordinal) data from several sources, including student and instructional assistant surveys, focus groups with students and instructional assistants, and a post asynchronous training self-evaluation/reflection from IAs. The data used in this report was collected from Fall 2021

from the 5 instructors, 29 instructional assistants, and approximately 580 undergraduate engineering students who participated in Fall 2021 quarter. Each of these sources is discussed below.

A. Student Surveys

The project team designed and administered a web-based survey to collect student data for each academic quarter and all courses in which oral exams were implemented. Approximately 2400 undergraduate engineering students from these courses formed the sample of our evaluation. For analysis purposes, surveys were sent to each course individually. The student population presents a large group of students with various demographic and academic backgrounds.

The survey design was iterative and was modified each time after it was administered to better address the research questions. The current version of the survey was implemented during the fall 2021 quarter. There were three types of surveys sent to students: a pre-survey at the beginning of the quarter prior to administering oral exams, a post exam survey which was sent out after each oral exam (some courses had more than one oral exam), and an end-of-quarter survey to collect overall reflections. Each survey included both likert-scale questions, as well as open-ended questions.

Pre-survey: One of the main goals of the pre-survey was to establish a baseline for the end-of-quarter survey. It inquires about students' expectations and concerns about oral exams, through Likert-scale questions, as well as providing the opportunity for students to communicate their overall thoughts about these kinds of exams through an open-ended question. It also asks about students' prior exposure to oral exams to further provide calibration.

Post-exam survey: The post-exam survey asked students about their recent oral exam preparation and experience, and how the oral exam impacted their learning. It also provided students with an opportunity to express, via open-response questions, what they liked or what could be improved about the oral exams. The post-exam surveys, while providing useful snapshots of student sentiment and allowing the research team to look at questions of how familiarity with the exam format impacted students' perceptions (in the case of multiple exams), also served as an important formative assessment tool. The results of the post-exam survey were frequently used to guide modifications to the exam format within the same quarter (if multiple exams were offered) or for subsequent quarters.

The end-of-quarter survey: The end-of-quarter survey provided the most rich dataset of students' overall oral exam experience. It included several Likert-scale questions, addressing issues of preparation, study habits, impact on academic integrity, impressions of fairness, etc. In addition, open response questions added to the dataset. Together with the pre-survey, the end-of-quarter survey was the main tool to gauge student opinion about the exams.

Survey response rate: The response rate for the surveys varied significantly, from approximately 20% to 85%. As instruction was mostly remote during the current progress of this project, survey fatigue was an important concern (the university and departments, as well as instructors, showed great concern for students, resulting in numerous surveys being sent to them throughout the various quarters). While the team initially mainly relied on repeated requests to students, in Fall 2021, we decided to adopt a strategy of providing limited incentives. These were left up to the instructor and were implemented in a way that maintained confidentiality and anonymity (e.g., if the overall anonymous response rate was above a certain percentage, the lowest scoring homework would be dropped). Similar approaches are already common to encourage students to fill out the UCSD quarterly course and instructor evaluations (CAPEs) and often our study-specific surveys were lumped into these incentives. With these incentives, we set forth to obtain response rates above 60%, which most courses were able to meet.

Data integrity: For Spring 2020, Fall 2020 (pre-funding trial), Winter 2021, Spring 2021 and summer 2021, surveys were made anonymous and did not collect any demographic information. The surveys were handled by the individual course instructors, as the anonymous nature of the surveys did not present a conflict of interest. In Fall 2021, the research team moved to a more centralized survey strategy. Surveys were sent out by a research team member who was not an instructor. Instructors only were given access to survey data after it was de-identified. Student IDs were collected as part of the survey to be able to relate it to demographic and academic information.

B. Instructional Assistant Survey

Instructional assistant input was also collected via a web-based survey. Between 4 courses and over 2 quarters, 30 Instructional Assistants (IAs) participated in this survey. The survey was restricted to IAs who had participated in the oral exams as examiners. The sample group was calibrated based on their experience with oral exams, both as past participants or as past examiners. The sample group was split almost 50/50 in terms of IAs with experience and those without. The survey questions were organized into two groups: asking about their impressions of the benefit to students and asking about how they experienced the process (in terms of their understanding of the material, their nervousness, their level of training, etc.). Some of the more important results are that the IAs felt that one of the main benefits of the oral exams for them is that it allows them to get a better understanding of what students are struggling with. This is an important aspect of the teacher-student relationship and can help guide IA support for student learning.

A second important lesson from the surveys is that IAs generally reported not being exceedingly nervous when conducting the exams and felt that they had sufficient training. For the quarters they provided feedback on, the training was solely provided by the instructors and our formal training modules were still under development. Nevertheless, personalized training was shown to

be effective. These training experiences were the basis on which we subsequently built our training modules.

Open ended questions on what worked and what could be improved completed the IA survey. This feedback was used as formative feedback for the instructors to inform the changes in oral exams in subsequent quarters. IA feedback has been instrumental in gauging the effectiveness of the exams and tweaking the exam structure accordingly.

C. Student Focus Groups

Project team members from the Teaching + Learning Commons conducted two focus groups (March and December 2021) with undergraduate students who had taken at least one oral exam. The first focus group discussion evaluated students' perception of the oral exams in a more open-ended manner. Invitations were sent to all students in courses implementing oral exams from this project. Students from different courses and disciplines were mixed together. The second focus group focused on whether the experience with oral exams positively contributed to their overall experience in the course. There were 6 students who attended the focus groups in total. Each focus group lasted approximately 45 minutes, and included the following questions:

1. How did you feel when you found out oral exams were going to be used in your class?
2. How did you feel about oral exams at the end of the course?
3. Did the oral exams contribute to your learning in this class? If so, how (e.g. engagement with material in in class)?
4. Did the oral exams contribute to your class experience in any other ways? If so, how?
5. How did you study for the oral exams? (follow-up) How does that compare to how you study for written exams?
6. Did the oral exams present any challenges or difficulties? Do you have any concerns about this type of exam?
7. Did your course instructor give the class instructions or advice about how to prepare for oral exams, or strategies for how to be successful? Is there any additional support that would have benefitted you?
8. What advice would you give to a student who is taking a course with oral exams for the first time?
9. What advice would you give to instructors or TAs who are administering oral exams?
What would you like them to know?

D. Instructional Assistants Focus Group

Project team members from the Teaching + Learning Commons conducted two focus groups (March and December 2021) with IAs (n=7) who conducted oral exams. Focus group participants were recruited from all courses implementing oral exams with instructors involved in this project. Course instructors were not present at the focus groups. Responses were

summarized and presented anonymously to the research team. The focus groups lasted approximately 1 hour, and included the following questions:

1. What are the goals of oral exams in this class? Why is your instructor using them?
2. Do you think students have benefitted from the oral exams? If so, how?
3. How did you feel when you found out you'd be administering oral exams? How do you feel now, after administering two rounds?
4. When administering the oral exams, did you ever encounter a situation that you weren't sure how to handle? If so, what did you do?
5. When you think about the diversity of students who take this course, are there certain students who seem to favor and/or do well in oral exams more than others?
6. Prior to administering oral exams, you participated in some preparation and training with the course instructor. What aspects of that preparation were most helpful?
7. What additional training or support would have been helpful to you in administering oral exams?
8. What advice would you give for how to fairly and equitably administer oral exams?
9. Do you have any concerns about the use of oral exams, in this course or in general?

In general, IAs expressed a high degree of satisfaction in the oral exam process, particularly noting the efficacy of oral exams in supporting student learning and increasing students' comfort with the instructional team. Instructional assistants expressed questions about how to best manage students' anxieties, put students at ease, and provide appropriate and supportive feedback during the exam sessions. Team members in the Teaching + Learning Commons used the feedback gathered in these focus groups to inform the design of training materials, including the selection of topics to be prioritized in recorded modules and made recommendations for an agenda for course-level training provided by course instructors.

E. Students Results: Diagnostic Value of Midterm Oral Exams in Addition to Written Exams

To assess whether adding midterm oral exams to the traditional written exam structure helps instructors better diagnose students' conceptual understanding midway through the academic term, the project team is conducting a series of statistical analyses comparing two models: 1) A traditional exam structure model where the final written exam is predicted just by the midterm written exam; and 2) a bigger model where the midterm oral exam also serves as an additional predictor (along with the written midterm exam) for the final written exam. The project team is also interested in exploring an ideal format of the oral exam that serves better as a diagnostic tool, especially looking at the granularity of rubrics that capture the variance in students' performance. This study will help instructors understand the utility of implementing midterm oral exams as a potential diagnostic tool for students' conceptual understanding, as complemented by a midterm written exam. If oral exams improve midterm diagnostics, they will

provide actionable information instructors can use to make interventions to foster students' meaningful learning before the end of the term.

F. Instructional Assistant Asynchronous Training Assessment

Prior to administering oral exams, in fall quarter 2021, 18 IAs from 6 courses completed the first iteration of the asynchronous training. Participating IAs were asked to watch 5 instructional videos (discussed above) that ranged from 5 to 18 minutes in length, for a total of 45 minutes. Each module included 2-3 reflection and/or application questions related to the content, and IAs were asked to complete their responses to the questions on a web form. The purpose of the reflection assignment was to assess what IAs learned from each module, how they could apply what they learned to administering an oral exam, and to elicit feedback on how the instructional videos could be improved for future training. Based on the depth of the responses, the videos were effective in helping IAs learn the purpose and benefits of oral exams, conveying key learning theories related to supporting students and their learning when administering oral exams, and in generating ideas for how they would apply what they learned when giving oral exams. While a systematic qualitative analysis still needs to be completed on the responses, our cursory analysis shows that IAs recognize the importance of both challenging and supporting students during oral exams who are at various levels of learning in the course, are able to apply specific strategies to do so, recognize areas in which they as instructors still need more guidance and training, and found the modules to be helpful and engaging. Our next step in assessing the efficacy of the training is to develop and implement an oral exam observation protocol to examine if and how IAs are applying what they learned when administering oral exams.

5. Data Analysis and Summary of Key Findings

The evaluation employed several different analytical approaches to address the research questions.

- A. Descriptive analysis: To address both research questions, the project team employed descriptive analysis methods to examine the impact of oral exams and differences in survey responses across different courses, as well as the outcome of the training.
- B. Qualitative analysis: The project team analyzed the qualitative data collected from surveys, and focus groups discussions.

The key findings are organized under the main research questions and data type that guided the evaluation.

Research Questions	Data	Methods
RQ1. What is the impact of oral exams on students' learning?	• Student surveys • Student focus group discussion • Students course work Performance results • Focus group with faculty	• Descriptive statistics of students to examine trends in the participation of underrepresented groups, including women, underrepresented minorities, first generation students • Inductive identification of themes and trends; rough frequencies • Qualitative research methods (coding of focus group data)
RQ2. How well has the instructor and instructional assistants training program prepared them to successfully deploy oral exams in their engineering courses?	• IA surveys • IA focus group discussion • IA training assignment performance	• Inductive identification of themes and trends; rough frequencies • Qualitative research methods (coding of focus group data)

Table 1. Mapping of Research Questions, Data and Methods

RQ1. What is the impact of oral exams on students' learning?

5.1 Descriptive Analysis of Students Surveys

Through descriptive analysis of student survey results, students' perceptions toward oral exams were investigated. The results show that overall, students hold a very positive attitude toward the oral exams and recognize the benefit of oral exams. Many students reported the oral exam positively impacted their educational experiences in several ways. The analysis is based on data from Fall 2021, as the new survey system was implemented starting from Fall 2021.

Academic Integrity

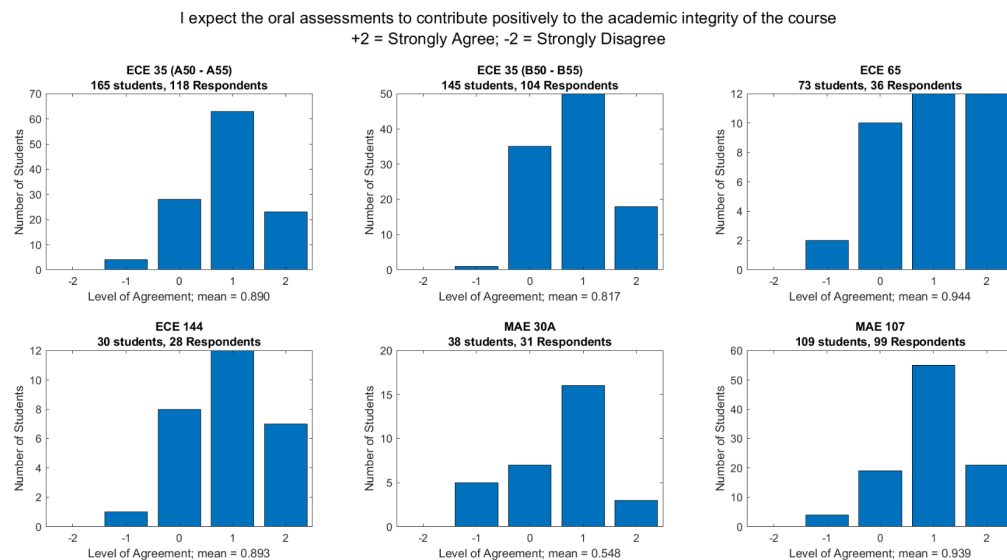


Figure 1.Pre-Survey: Academic Integrity

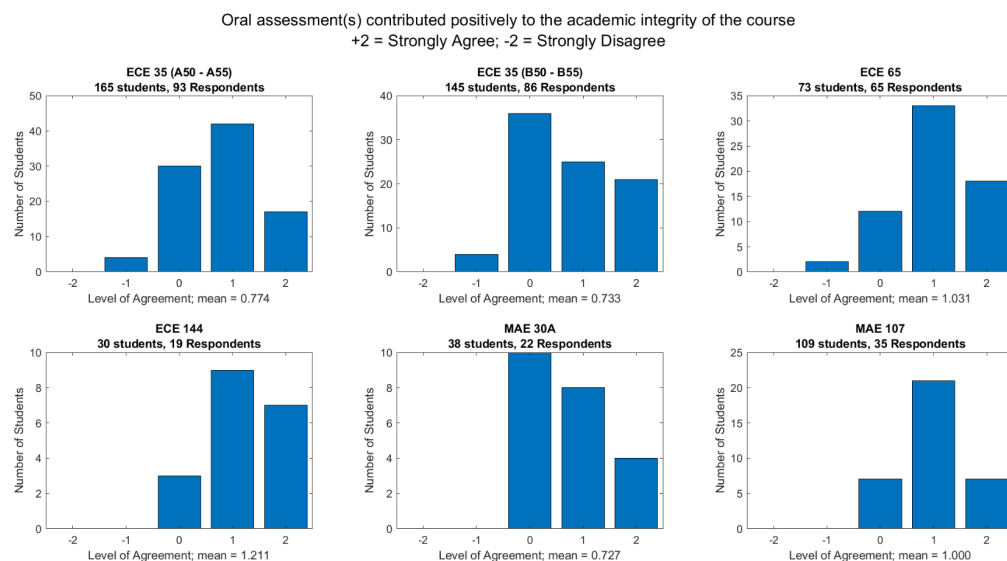


Figure 2. End-of-Quarter Survey: Academic integrity

Comparing the pre-survey (figure 1) and end-of-quarter survey (figure 2) results, there is much stronger agreement from student respondents on the oral exams' positive contribution to the academic integrity of the course after having the oral exam experience, compared to pre-oral exam experience. In the pre-survey, 33% to 55% (varies among courses) respondents agreed or strongly agreed that oral exams would contribute positively to the academic integrity of the course, while 55% to 85% (varies among courses) agreed or strongly agreed that oral assessment(s) contributed positively to the academic integrity of the course at the end of the quarter.

Increase Understanding of the Course Subject Matter

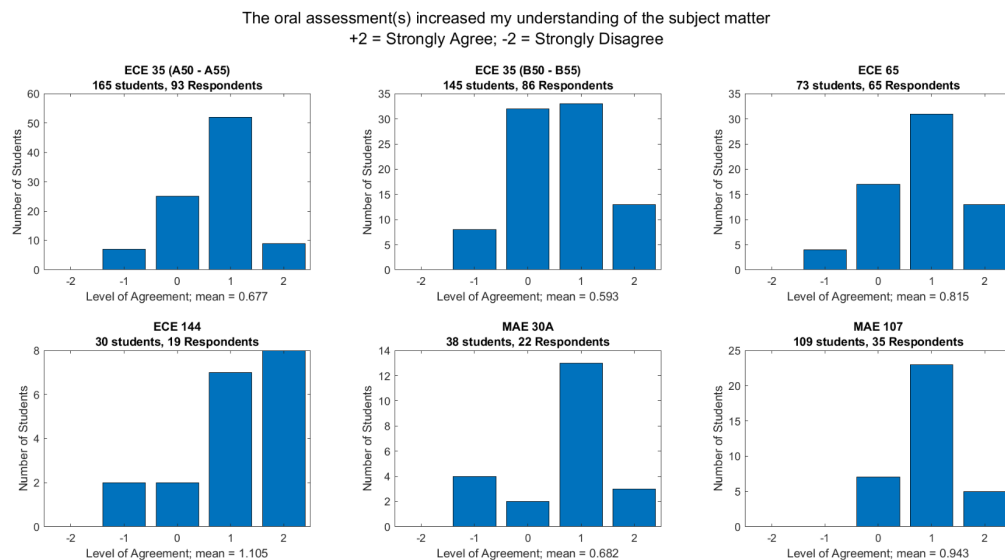
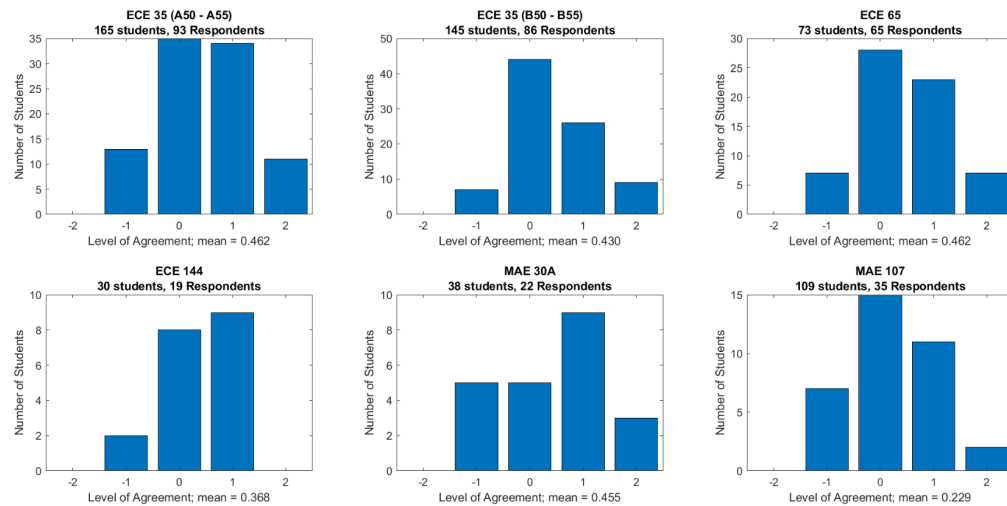


Figure 3. End of Quarter Survey: Understanding of Subject Matter

The survey data show that 54% to 80% (varies among courses) of the student respondents agreed or strongly agreed that the implementation of oral exams help students to better grasp the subject matter. In both surveys and focus group discussions, students reported oral exams helped them to understand the topics more in-depth and cleared misconceptions.

Comfort Reaching out for Help from Instructional Team

Taking oral assessments made me more comfortable (or more likely) to reach out to the instructional team for help (such as office hours, email, or other methods)
+2 = Strongly Agree; -2 = Strongly Disagree



**Figure 4. End of Quarter Survey: Comfort Reaching Out for Help
From Instructional Team**

Survey results show that oral exams had a positive impact on students' comfort level in reaching out to the instructional team for help. Varying from course to course, 37% to 55% of student respondents reported that taking oral assessments made them more comfortable (or more likely) to reach out to the instructional team for help through office hours, email, or other methods. It is important to note, however, that the instructional team found a flaw in the survey in that there is no baseline to compare students' comfort level reaching out since we don't have pre-oral exam data on this measure. It is possible that some students who did not claim they were more comfortable could have done so because they were comfortable in the first place. In the next data collection phase, a new question will be added to the pre-survey to ask students their level of comfort as a baseline.

Confidence and Self-Efficacy

Interactions with the assessor(s) during the oral assessment(s) positively contributed to my confidence in myself and my abilities
+2 = Strongly Agree; -2 = Strongly Disagree

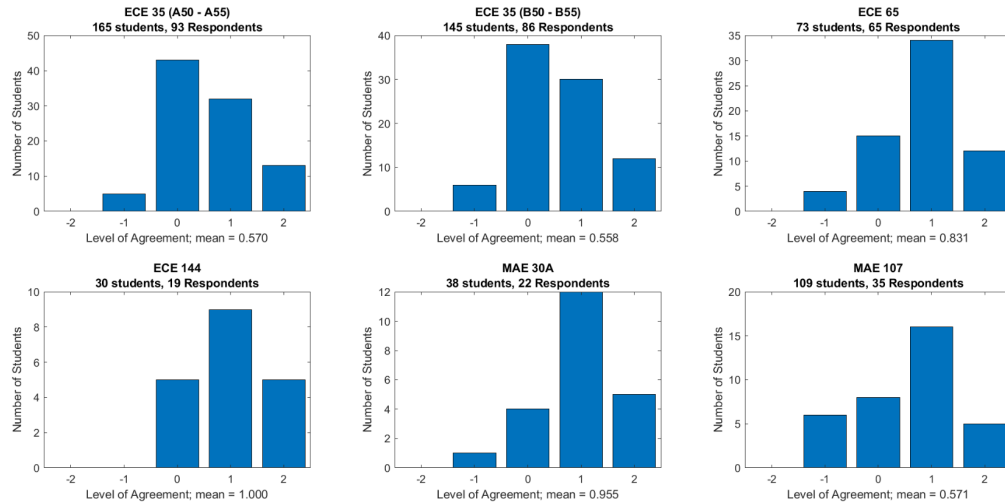


Figure 5. End of Quarter Survey: Impact on Confidence in Self and Abilities

Varying from course to course, 48% to 77% of student respondents agreed or strongly agreed that interactions with the assessor(s) during the oral assessment(s) positively contributed to their confidence in themselves and their abilities.

Impact on Stress-Levels

Rate how much stress the written exam(s) have caused you in this course
1 = No Stress At All; 10 = Extreme Stress

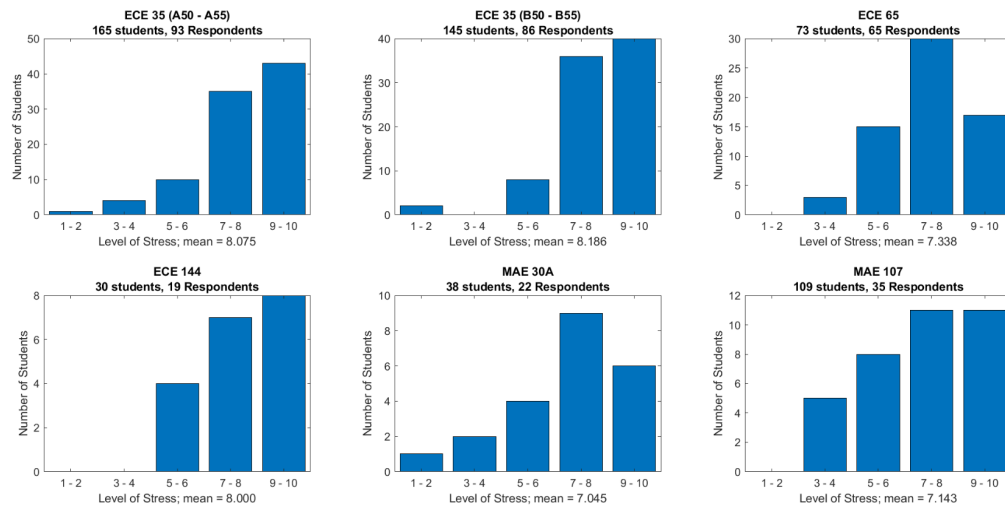


Figure 6. End of Quarter Survey: Written Exam Impact on Stress

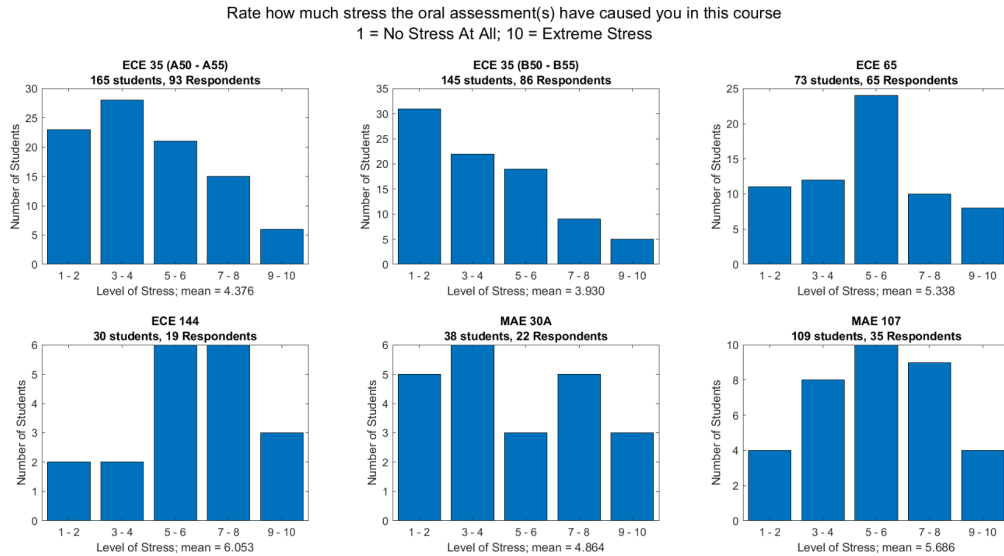


Figure 7. End of Quarter Survey: Oral Exam Impact on Stress

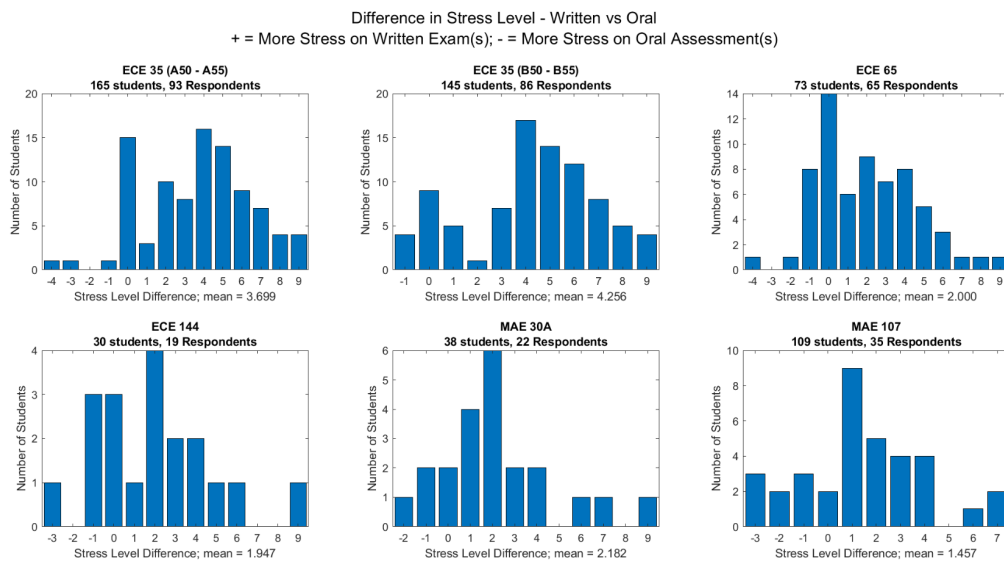


Figure 8. End of Quarter Survey: Comparison of Stress in Written and Oral Exams

Students from all courses reported low-medium to medium level stress about their oral exam experience, where the same students reported low-high to high level stress towards written exams for the same course. By comparing students' responses on an individual basis, it is found that on average, students experienced 10% to 40% (varies by course) less stress from the oral exam compared with written exams. Depending on the course, 63% to 84% of student respondents indicated they experienced higher stress from the written exam than oral exams in the particular course that survey was being sent. Only a small portion of students, 3% to 22% (varies by course) claimed they experienced higher stress from oral exams, and the rest of the students claimed there was no difference. When first disseminating the findings with the

engineering education community in early 2021, some reviewers expressed concerns that oral exams would cause students excessive stress. This early data suggests that in general, stress is not inherent to the oral exam format, but rather likely related to many other factors, such as difficulty of the exam, access to preparation materials, how well the assessors handle the oral exams, weight of the oral exam in the final course grade, and other possible factors.

Other Impact

Our results so far also indicate that oral exams had a positive impact on learning in other ways. For example, students reported oral exams positively contributed to improving technical communication skills. Some students indicated that the skills they learned from oral exams were used in their internship interviews. Students also reported oral exams provided a great opportunity to validate their knowledge and thought process. More details are discussed in the coding analysis section.

5.2 Student survey open-ended comments coding analysis

Student responses to open-ended questions on the surveys provided richer information about their perceptions on a given topic and the potential reasons behind them. We analyzed responses to open-ended questions and assigned a unique “code” that reflects the essential idea behind each response. These codes were then mapped to a broader topic tied to the research questions. Finally the topics were categorized as positive or negative, and by changes in learning habits (not claimed as positive nor negative). The frequency reflects how many times the code was assigned. One student’s comment can often be assigned to several codes. Thus, the frequency does not reflect the population. The codes are also not mutually exclusive. For example, the comment from one student “I liked the oral exams a lot, it is a good way to demonstrate my knowledge, and motivate me to learn” are labeled into three codes: “positive emotions”, “better demonstration of knowledge” and “motivation”. The comments are from both post-exam and end-of-quarter surveys, so there are likely similar comments from the same students. About 300 out of 560 (53%) student respondents provided comments in addition to the likert-scale responses.

In the six courses in which oral exams were implemented during the fall 2021 academic quarter, positive sentiments toward the oral assessments appeared more frequently in survey responses than negative sentiments—315 occurrences of positive sentiments post-assessment (Table 2), and 171 for negative sentiments/areas to improve (Table 3). In addition to higher frequency, positive sentiments are also more rooted in the inherent nature of oral assessments, whereas negative sentiments are generally more directed toward factors that are often within the control of instructors and/or instructional teams. These findings are explained in more detail below.

Overall Category and frequency	Code group and frequency	Codes
Positive (315) Note: Positive refers to students directly commenting positively about the oral exams, and does not include those positive changes in instructor's perception. Change in learning habits has been listed as a separate category.	Positive emotions towards oral exams (130)	Increased confidence
		Enjoy the interaction and increase connection with the instructional team
		Enjoy it being conceptual based
		Benchmark how well they are doing in the class
		Like it being low-stake
	Assessor Actions (71)	Being kind and supportive, good atmosphere
		Assessor gives good feedback/ hints
		Assessor have good competence, give new perspectives to the knowledge
	Improved grasp of course materials (64)	Improved thought-process and understanding
		Improved understanding from the interactive hints, guidance and feedback
		Identify weakness
		Reinforce learning
	Assessment Format (20)	Better demonstration of knowledge
		Conceptual-focus
		A chance to explain themselves
	Increased motivation to learn (5)	
	Improved skills beyond the course (1): useful for interview	
	Assessment Logistics (1) Oral exam held before written exam is helpful to prepare for written exams	
	Other positive perceptions (23)	

Table 2. Summary of Positive Comments Coding Analysis

Positive Comments

A significant number of positive sentiments collected from students after taking oral assessments can be attributed to the verbal and interactive nature of how we designed the oral assessments. A number of students directly commented on the fundamental nature of oral assessments which they enjoyed. There were 20 occurrences of positive sentiments toward the oral assessment format, where students expressed ideas such as oral assessments being better demonstrations of their knowledge, enjoying the conceptual nature of the assessments, as well as being able to receive guidance or feedback through live interactions. Closely related are the emotions that many students revealed through their survey responses. The most common positive emotion, with 36 occurrences, is that students felt a stronger connection and felt more comfortable with the instructional team, to which increased student to instructor interactions could be attributed. A large number of students mentioned that they enjoyed the oral assessments and/or felt relaxed about them. While many (53 occurrences) did not specify reasons, some (13 occurrences) attributed low-stakes grading as a factor that contributed to low stress.

In the open-ended survey question responses, students also identified actions taken by their assessors that positively contributed to the outcome of the oral assessments. In fact, almost all assessor actions are only possible because of the live, interactive nature of the oral assessments, where the assessor plays a significant role. Among the identified assessor actions, one recurring theme is that the assessor was kind, supportive, and able to make students feel at ease (28 occurrences). A second recurring theme regarding assessor actions is their ability to provide helpful technical information, guidance, and/or feedback to students during the assessment (32 occurrences). The opportunity to provide this type of immediate support and guidance to students is a unique feature of oral assessments that written exams do not provide.

A number of students also identified improvements in their understanding of the course material as a result of oral assessments, which can once again be traced to the nature of such assessments. One frequently-mentioned factor related to improvements in understanding is that oral assessments provided an opportunity to identify weaknesses. In addition, another frequently-mentioned contributor to improved understanding is the guidance, feedback, and/or explanations from assessors during the oral assessments, with 17 occurrences. These positive outcomes heavily rely on oral assessments being live and interactive.

Overall Category and frequency	Code group and frequency	Codes
Negative (171)	Negative students emotions (120)	Decrease confidence
		Embarrassment due to low performance
		It is not a common exam format
		Stressful because needs to be on time
		The oral exams is difficult
		Dislike because it tests conceptual understanding
		Stressful due to lack of preparation
		Stressful due to time limit
		Stressful due to unknown expectation for first time taking oral exams
		Stressful due to unknown grading standard
		Stressful due to non native english speaker
		Stressful because of not being able to explain through process
		For written exam follow up oral exams: stressful due to not remembering how the problem was solved during written exams
	Assessment logistics (20)	Lack preparation guide
		Scheduling challenge due to oral exams are outside of class time
		Late start due to delay of previous student
		Sign-up process is not convenient
	Assessment format (13)	Questions not being clear
		Thought princess is easier on paper, not verbal
	Assessor actions (5)	Not being kind and supportive
		Did not provide helpful feedback and hints
	Negative Motivation to learn (1): demoralized due to the TA did not provide any feedback make the student feel hopeless	
	Other negative perceptions (12)	

Table 3. Summary of negative comments coding analysis

Negative Comments

Overall, there were fewer occurrences of negative sentiments (Table 3) than positive sentiments in students' responses to the open-ended survey questions; however, there were still a significant number of negative sentiments (171 occurrences). It is worth noting that many of these negative sentiments were not targeted toward the nature of oral assessment, but about factors that are within control of instructors and assessors and can be improved. A number of negative sentiments pointed toward assessment format and logistics (33 occurrences in total). Assessment logistics purely depended on individual courses' implementation of oral assessments, while the negative sentiments about assessment format mostly centered around the short duration of oral assessment not providing sufficient time for students. Furthermore, all negative sentiments associated with assessor actions focus on a few individual assessors, rather than the overall assessment structure. The vast majority of these concerns can be resolved through redesigns of assessment parameters, and ongoing training and mentoring for instructional team members who are involved in administering oral assessments.

Negative emotions associated with the oral assessments warrant a closer look, though most cases are still not directly targeting the fundamental nature of oral assessments. Stress is perhaps the most significant negative emotion related to oral assessments. The most common source of stress students identified, with 25 occurrences, is a lack of understanding of the course material. A number of students mentioned that they simply lacked preparation or did not fully understand the material. In a sense, this source of stress is one that is common for all assessments, and is not unique to oral assessments. Another common source of stress, with 15 occurrences, was being unfamiliar with the assessment format. For example, one student stated that "not being sure of what to expect" was a contributing factor of stress. Such factors of stress can be greatly reduced by providing students with additional information and instructions prior to the oral assessment; hence, it is more of an implementation shortcoming than an inherent problem of the assessment format. A third commonly-occurring contributor to stress is live verbal interactions, with 13 occurrences. As some students mentioned in their responses, the stress results from "social anxiety" and being uncertain about their communication skills. Related to this are student comments about feeling embarrassed when their answers were incorrect. This concern is closely tied with the inherent nature of oral assessments, though the design of the assessment and assessors' actions and demeanor can play a significant role in reducing this type of stress.

Overall Category and frequency	Code group and frequency	Codes
Had change in study habits due to oral exams (160)	Other specific actions (63)	Review concepts they struggled because it was participation based they wanted to ask questions during the oral exams
		Rewatch lectures
		Review quiz/homework
	focus on concept and practice out loud(78)	
	Less oral exam exclusive prep time compared to written exam (11)	
	Started studying in a group rather than alone(7)	
	Began using a learn through teaching strategy to study (1)	
No change in study habits (116)	No change due to confidence in knowledge and learning habits.	
	Confident after the written exam (for oral exam that follows up written exam questions)	
	Do not feel necessary due to low-stake or participation based grading	
	Did not know how to prepare due to lack of information	
	No time, due to world from other classes	

Table 4. Summary of Comments on Learning Habit Coding Analysis

Changes in Study Habits

The surveys also included questions about students' changes in study habits due to oral exams (Table 4). The changes are only classified into the reasons behind whether or not they have changed their habits, as it is ambiguous whether or not each change is strictly positive or negative. In the surveys students completed after taking an oral assessment, there were 160 occurrences of changed study habits in contrast to 116 occurrences of unchanged study habits. Most changes include either increased focus on concepts/explanations and reviewing specific content they would be tested on, which aligns with the general goals of the oral assessments. Those who claimed no change in studying habits were already confident in the material in many cases, though a small portion of this group did not know how to change their study habits.

Coding analysis of student responses to open-ended survey questions allowed for the identification of a number of specific factors that contribute to students' emotions and learning outcomes. The vast majority of respondents appear to have no negative sentiments towards the overall idea of a live oral assessment, and many expressed positive sentiments. Those who expressed negative sentiments mostly identified factors related to individual implementations and/or design parameters, most of which can be adjusted to improve upcoming oral assessments.

5.3 Student Focus Group Key Findings

The student focus group data is still under analysis, but our preliminary analysis converged on two main themes: 1) students reported feeling closer to the instructional team and they appreciated having a chance to get feedback during the oral exam; and 2) students would benefit from getting more information on how the oral exam session would go, either as a live demonstration in class or as a pre-recorded video. Reflecting on these student feedback, the research group is now working on scaffolding students more with oral exam procedures earlier in the quarter, and also discussing preparation strategies we can provide that will help our students get the most benefit from preparing for and participating in oral exams.

5.4 Impact of Oral Exams on Underrepresented Students

Through descriptive analysis and coding analysis, we investigated the impact of oral exams on students who represent several demographic groups based on gender and first generation students. We intend to disaggregate the data by Underrepresented Minority by ethnicity (URM)/non-URM students in future analyses. The overall results show that oral exams did not create a learning disadvantage for any underrepresented group, but rather generated a very positive impact, such as increasing their understanding of the subject matter, improving their confidence and self-efficacy, and building a stronger connection with the instructional team. The results from disaggregating the data based on these demographic categories suggest that implementing oral exams had a similar impact on all students who completed the survey. In a few areas, the oral exams generated a stronger positive impact on underrepresented student groups, the details of which are elaborate as follows.

A. Gender Difference

Confidence and Self-efficacy

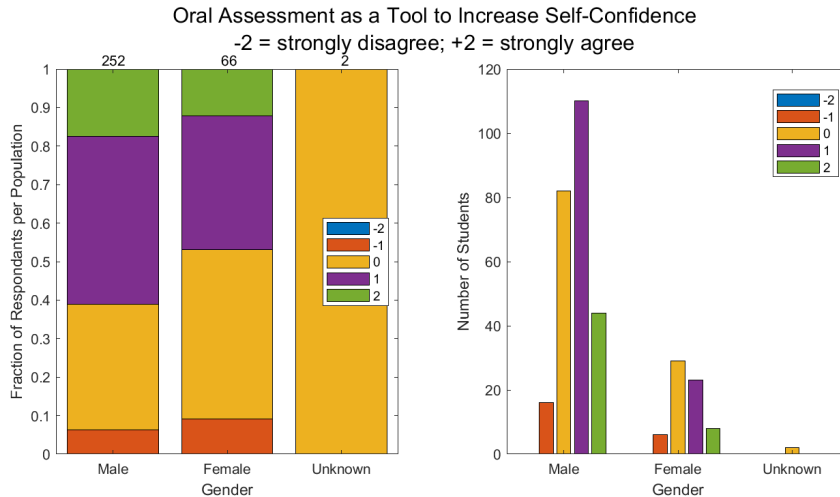


Figure 9. Gender Difference on Oral Exams Increase Self-Confidence

Consistently across all courses, the oral exam positively contributed to students' confidence and self-efficacy. On average, male students reported they benefited slightly higher from oral exams in building confidence in their engineering competency than female students. Sixty percent of male student respondents agreed or strongly agreed the oral exam positively contributed to their confidence and self-efficacy, and 49% of female respondents hold the same opinion. Five percent of male students did not believe the oral exam positively contributed to their confidence, while 9% of female students reported the same. These results could be skewed due to dramatic population differences in the engineering courses.

Stress Level

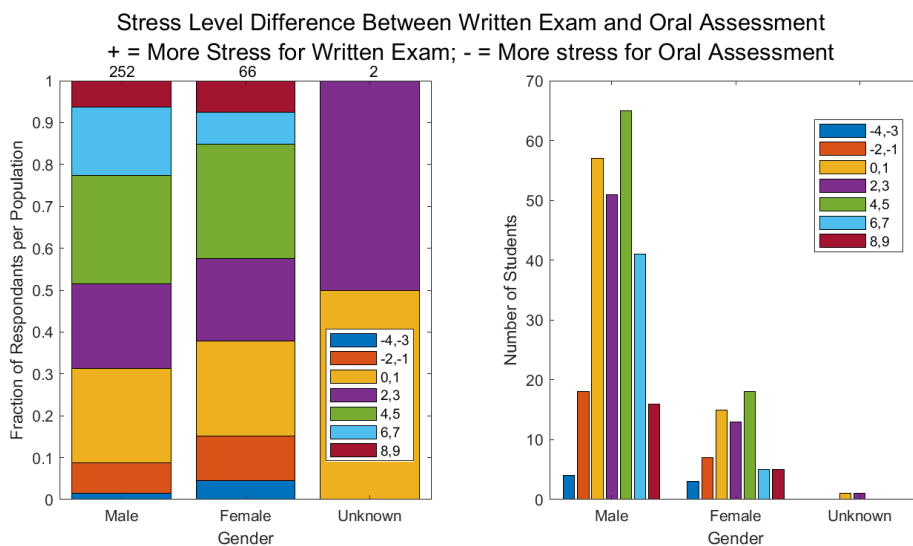


Figure 10. Gender Difference on Written Exam Stress and Oral Exam Stress Difference

Compared to written exams in the courses, students overall reported lower stress levels in oral exams than written exams. Female students consistently reported higher stress levels in oral exams than male students. Male students reported: 23%-much less stressful, 47%-somewhat less stressful, 20%-equally stressful, and 10%-more stressful. While for female students, the fractions for the same categories are around 15%-much less stressful, 40%-somewhat less stressful, 20%-equally stressful, and 15%-more stressful. But this higher stress level among female students is not particular for oral exams, as female students also reported higher stress levels in written exams than male students. And consistently with the all student populations, female students reported higher stress levels towards written exams than oral exams.

B. First-Generation Students (FG)

Descriptive analysis shows that more FG students reported they benefited from oral exams and in a few areas show that they benefited more than non-FG students.

Increased Understanding of the Subject Matter

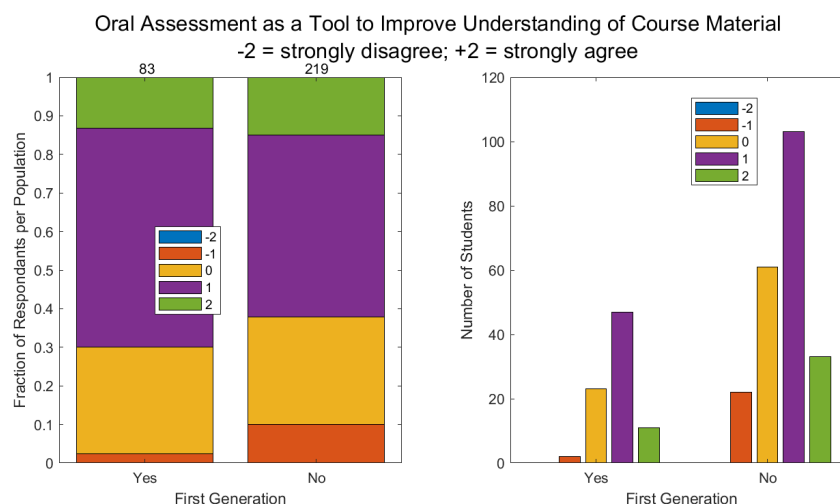


Figure 11. FG & Non-FG Students Difference on Increased Understanding of the Subject Matter

In most courses, FG respondents reported a stronger agreement that the oral exam increased their understanding of the subject matter. Seventy percent of FG students agreed or strongly agreed that the oral exams increased their understanding of the subject matter, while 65% of non-FG students reported the same. Three percent of the FG respondents do not believe oral exams increase their understanding of the subject matter, and 10% of non-FG students reported the same. Among the students who hold neutral or disagreement perceptions, there might be different causes. Some students who are performing well in the class may already have mastered the concepts, thus do not find oral exams add any additional value. To further understand this, in our next project stage, we will encourage students to specify the reason they reported a negative

response in any of the survey questions. We will also conduct a relation analysis between students' course grade and their answers to gain more insights.

Build Better Students and Instructional Team Relationship

Oral Assessment as a Tool to Strengthen Connections between Students and Instructional Team
-2 = strongly disagree; +2 = strongly agree

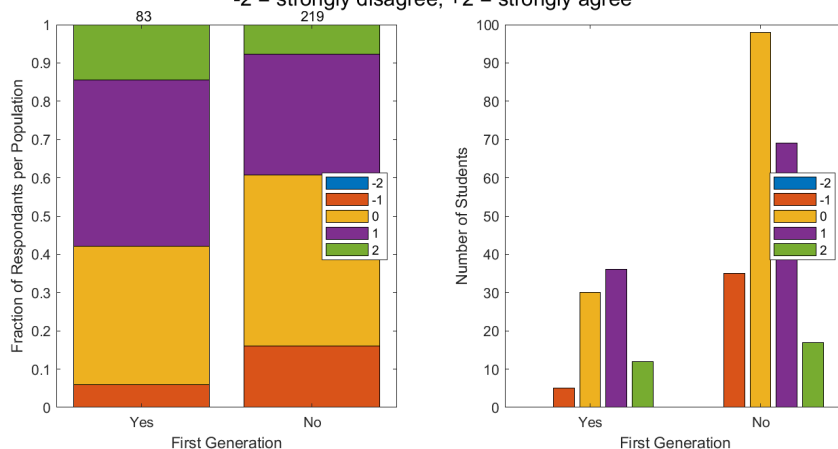


Figure 12. FG & non-FG Difference on Oral Exams Builds a Better Students and Instructional Team Relationship

On average, for the overall survey respondents, FG students (58%) presented a much larger increase in change in being comfortable with reaching out to the instructional team, compared to non-FG students (40%).

Confidence and Self-efficacy

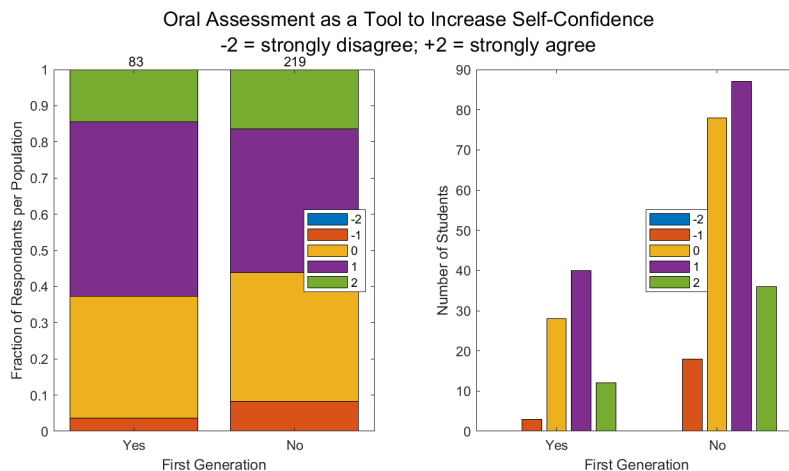


Figure 13. FG & non-FG Difference on Oral Exams Increase Self-Confidence

More FG students (68%) than non-FG students (58%) agreed or strongly agreed that oral exams increased their confidence and self-efficiency.

RQ2. How well has the instructor and Instructional Assistant training program prepared them to successfully deploy oral exams in their engineering courses?

In this first year of our project, our evaluation of the IA training we developed focused on the efficacy of the asynchronous training consisting of video modules that provided a foundation for IAs to understand the purpose and potential benefits of oral exams, as well as important learning theories that inform the use of oral exams as both a teaching and assessment tool. As discussed in section 4, a cursory analysis of IA responses in the reflection/application assignment they completed after each module indicates that the modules were effective in equipping IAs with essential and helpful knowledge prior to administering oral exams. Further investigation is planned through the development of an observation protocol that will be used in oral exam observations to assess if and how IAs are applying what they learned in the training. Additionally, course instructors are developing more systematic and intentional training related to the content of their specific courses.

6. Recommendation for Year 2

The findings and data converged on a number of strengths of the project. Some recommendations for improvement emerged both directly from the study participants and from project evaluation efforts to interpret and synthesize the findings. These recommendations will be implemented in project year 2. The details are discussed around each project component.

Oral Exam Design and Implementation

In the second year of the project, we intend to revise and improve our oral exam designs based on our first year findings and experiences. Such revised oral exams will be deployed across a wide range of engineering courses, including theoretical, computational, design or project-based, and laboratory courses, basic (lower division) and advanced (upper division), offered by two or more engineering departments, and enrolled by students of diverse academic and social backgrounds. A fraction of these courses will be the same as some of those in which oral exams have been implemented in the first year of the project, so as to allow effective comparisons between the two years in terms of the impact of the oral exam designs on students' learning and satisfaction, as well as assessors' experiences, foremost in relation to time commitment and resource expenditures, but also the exam's diagnostic utility.

Our diverse team of instructors from multiple disciplines participating in the project, together with the broad spectrum of courses in which oral exams will be trialed, is one of our projects key strengths; it shall be leveraged to investigate from many angles and in a multitude of contexts the relationships between oral exam design parameters on the one hand, and student motivation, self-efficacy, communication skills, stress and anxiety, academic integrity, and personal growth

on the other. Such comprehensiveness of investigation afforded by the large number of courses involved and the many participating researchers and students is expected to contribute to the generation of more general and interpretable results, which will be essential in informing future oral assessment practice more broadly.

Beyond optimization of existing oral exam designs, the second year of the project will see research efforts directed towards the diversification of oral exam implementations, with particular attention on the melding of oral exams and other evidence-based pedagogical strategies such as inquiry-based learning, peer and self-assessment, and peer instruction. By expanding the space of possible oral exam designs and exploring the benefits of combined student-centric pedagogical practices, we will aim to relate and innovate along multiple axes of education practice and theory.

Preparatory interventions serving to familiarize students with oral exams will be further elaborated as well. Ensuring students are adequately acclimated to the new testing environment will help clear the way for more accurate measurements of the impact of oral exams on student learning and satisfaction by ridding some of the unwanted or hidden factors adding to the fluctuations in gauged quantities. Examples of preparatory interventions which will be pursued include providing clear expectations, guidelines, rubrics, and video tutorials to students, as well as mock or practice exams with the instructor, IAs, or peers.

Training Development and Implementation

The dominant benefits of oral exams which we seek to maximize, such as deep learning, improved communication skills, boosted self-confidence, enhanced sense of belonging, and commitment to academic integrity, are sensitively dependent on the dimensions of interaction between the student and the assessor during the oral examination. To realize these benefits in maximum, it is vital to establish best practices for the facilitation of dialog and the provision of feedback to students. By drawing on education, psychology, and cognitive science literature as well as existing expertise within our own multidisciplinary research group, we will develop specific training modules to equip assessors (instructors and IAs alike) to conduct deep, meaningful conversations with students, efficiently probe and diagnose students' state of knowledge and understanding through dialog, and offer constructive, actionable feedback to drive engagement and positively shape students' approaches to learning. Our first year results indicate that honest but encouraging feedback is something students need and very much appreciate and expect from the oral exam process. Thus, a portion of second year efforts will be geared toward developing oral exam observation protocols to allow for in-depth review and analysis of oral examination as carried out by our many participating instructors and educational specialists, which will help inform the development of more effective training materials, including interactive modules and training videos, for future assessors.

Project Evaluation

As described above, we have made significant progress in the first year of the project. We developed and implemented oral exams in various configurations in multiple engineering courses, developed an evaluation plan and multiple instruments to assess and inform our work at each stage of the project, analyzed results from the various evaluation instruments we used, and developed and used foundational instructional videos to prepare instructional assistants to effectively administer oral exams. While we have made significant progress, we have identified several areas that need improvement: 1) While the current version of our pre and post-oral exam student survey provided good information about student experiences with oral exams, we need to refine some questions on the survey and continue to find ways to encourage students to complete it; 2) Participation in student focus groups was low and thus, we need to develop a strategy to incentivize and encourage more students to participate; 3) To identify optimal oral exam configurations, we need to conduct a deeper analysis of survey results through more statistical inference analysis and find correlations between design parameters and student perceptions and performance; 4) We need to develop additional evaluation instruments such as longitudinal impact assessments, to make the assessment complete; and 5) To ensure the instructional team is well prepared to administer oral exams that promote student learning, we need to refine and expand our current training methods for all members of the instructional team.

Dissemination and Engineering Education Community Engagement

We will continue to engage with the engineering education community, explore and make use of more publication venues, and gather further feedback which will help us better understand educational needs across the STEM fields and from a broad range of higher-education institutions, and identify the dominant hurdles perceived by educators standing in the way of oral assessment adoption at their institutes or within their courses. We will present our project activities and research findings at annual conferences such as the American Society of Engineering Education (ASEE) Annual Conference, Frontiers in Education Annual Conference, and other educational meetings and workshops, where we plan to exchange experiences and best practices with educators and education specialists from around the globe. We will also disseminate our developed models and research findings through publications in peer-reviewed academic journals such as the Journal of Engineering Education run by the ASEE, and other established journals devoted to the advancement of STEM education and pedagogy. We will also work to provide oral assessment training modules to faculty and instructor assistants beyond our team.

7. Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 2044472. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. We thank the following colleagues for the helpful discussion and help provided

during the planning and execution of the project: Dr. Tricia Bertram Gallant and Joanna Boval. We would also like to thank the project advisory committee members - Dr. Christine Alvarado, Dr. Elizabeth Holcombe, Dr. Adrianna Kezar, and Dr. Sheri Sheppard.

8. References:

- [1] G. Joughin, *A short guide to oral assessment*. Leeds Met Press, in association with University of Wollongong, 2010. Available: <https://eprints.leedsbeckett.ac.uk/id/eprint/2804/> [Accessed Feb. 7, 2022].
- [2] A. Akimov, M. Malin, "When old becomes new: a case study of oral examination as an online assessment tool," *Assessment & Evaluation in Higher Education*, vol. 45, no. 8, pp. 1205-1221, 2020.
- [3] B. B. Jensen, "Oral Assessment in Engineering Education," *The International Journal of Electrical Engineering & Education*, vol. 47, no. 4, pp. 375-379, 2010.
- [4] P. Iannone, A. Simpson, "Students' views of oral performance assessment in mathematics: straddling the 'assessment of' and 'assessment for' learning divide," *Assessment & Evaluation in Higher Education*, vol. 40, no. 7, pp. 971-987, 2015.
- [5] Y. Zhao, "Impact of Oral Exams on a Thermodynamics Course Performance," in *ASEE Zone IV Conference*, Boulder, Colorado, 2018.
- [6] G. Joughin, "Student conceptions of oral presentations," *Studies in Higher Education*, vol. 32, no. 3, pp. 323-336, 2007.
- [7] L. K. Davids, "A study on the effectiveness of team-based oral examinations in an undergraduate engineering course," in *ASEE Annual Conference and Exposition Conference Proceedings*, San Antonio, Texas. AC 2012-3459, 2012.
- [8] M. Huxham, F. Campbell, J. Westwood, "Oral versus written assessments: A test of student performance and attitudes," *Assessment & Evaluation in Higher Education*, vol. 37, no. 1, pp. 125-136, 2012.
- [9] V. U. Odafe, "Oral examination in college mathematics: An alternative assessment technique," *Problems, Resources, and Issues in Mathematics Undergraduate Studies*, vol. 16, no. 3, pp. 243-256, 2006.
- [10] L. Roecker, "Using oral examination as a technique to assess student understanding and teaching effectiveness," *Journal of Chemical Education*, vol. 84, no. 10, pp. 1663-1666, 2007.
- [11] R. Boedigheimer, M. Ghrist, D. Peterson, and B. Kallemyn. "Individual oral exams in mathematics courses: 10 years of experience at the Air Force Academy." *Primus* 25, no. 2 (2015): 99-120.

- [12] P. Sotiriadou, D. Logan, A. Daly, and R. Guest. "The role of authentic assessment to preserve academic integrity and promote skill development and employability." *Studies in Higher Education* 45, no. 11, pp. 2132-2148, 2020.
- [13] P. Ohmann, "An Assessment of Oral Exams in Introductory CS." In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*, pp. 613-619, 2019.
- [14] A. Bradner, "Oral Exams in Symbolic Logic: Lessons from the Covid-19 Pandemic," in *What Works: The Conference on Teaching and Learning*. Paper 1, 2021.
- [15] M. Lubarda et al., "Oral exams for large-enrollment engineering courses to promote academic integrity and student engagement during remote instruction," *2021 IEEE Frontiers in Education Conference (FIE)*, 2021, pp. 1-5, doi: 10.1109/FIE49875.2021.9637124.
- [16] K. A. Gamage, R. G. G. Pradeep, V. Najdanovic-Visak, N. Gunawardhana, "Academic Standards and Quality Assurance: The Impact of COVID-19 on University Degree Programs," *Sustainability*, vol. 12, no. 23, p. 10032, 2020.
- [17] D. Dumbaugh, "Revitalizing Classes Through Oral Exams," in *Inside Higher Ed*, 2020. Available:
<https://www.insidehighered.com/advice/2020/09/09/how-use-oral-examinations-revitalize-online-classes-opinion> [Accessed Feb. 7, 2022].
- [18] A. McKenzie, "COVID-19: A silver lining for academic integrity from a pandemic," *Canadian Perspectives on Academic Integrity*, vol. 3, no. 2, pp. 23-25, 2020.
- [19] M. A. Broeckelman-Post, "Faculty and student classroom influences on academic dishonesty," *IEEE Transactions on Education*, vol. 51, no. 2, pp. 206-211, 2008.
- [20] P. A. Hutton, "Understanding student cheating and what educators can do about it," *College Teaching*, vol. 54, no. 1, pp. 171-176, 2006.
- [21] D. L. McCabe, L. K. Trevino, K. D. Butterfield, "Academic integrity in honor code and non-honor code environments: A qualitative investigation," *The Journal of Higher Education*, vol. 70, no. 2, pp. 211-234, 1999.
- [22] J. L. Kisamore, T. H. Stone, I. M. Jawahar, "Academic integrity: The relationship between individual and situational factors on misconduct contemplations," *Journal of Business Ethics*, vol. 75, no. 4, pp. 381-394, 2007.
- [23] C. O'Neal, M. Wright, C. Cook, T. Perorazio, and J. Purkiss, "The Impact of Teaching Assistants on Student Retention in the Sciences: Lessons for TA Training," *Journal of College Science Teaching*, vol. 36, no. 5, pp. 24-29, 2007.

- [24] J. B. Stang and I. Roll, “Interactions between teaching assistants and students boost engagement in physics labs,” *Physical Review Physical Education Research*, vol. 10, no. 2, p. 020117, Sep. 2014, doi: [10.1103/PhysRevSTPER.10.020117](https://doi.org/10.1103/PhysRevSTPER.10.020117).
- [25] L. B. Wheeler, J. L. Maeng, J. L. Chiu, and R. L. Bell, “Do teaching assistants matter? Investigating relationships between teaching assistants and student outcomes in undergraduate science laboratory classes,” *Journal of Research in Science Teaching*, vol. 54, no. 4, pp. 463–492, 2017, doi: [10.1002/tea.21373](https://doi.org/10.1002/tea.21373).
- [26] D. Doucette, R. Clark, and C. Singh, “Professional development combining cognitive apprenticeship and expectancy-value theories improves lab teaching assistants’ instructional views and practices,” *Phys. Rev. Phys. Educ. Res.*, vol. 16, no. 2, p. 020102, Jul. 2020, doi: [10.1103/PhysRevPhysEducRes.16.020102](https://doi.org/10.1103/PhysRevPhysEducRes.16.020102).
- [27] S. M. Ruder and C. Stanford, “Strategies for Training Undergraduate Teaching Assistants To Facilitate Large Active-Learning Classrooms,” *Journal of Chemical Education*, vol. 95, no. 12, pp. 2126–2133, Dec. 2018, doi: [10.1021/acs.jchemed.8b00167](https://doi.org/10.1021/acs.jchemed.8b00167).
- [28] M. C. Wright, I. Bergom, and M. Brooks, “The Role of Teaching Assistants in Student-Centered Learning: Benefits, Costs, and Negotiations,” *Innovations in Higher Education*, vol. 36, no. 5, p. 331, Sep. 2011, doi: [10.1007/s10755-011-9197-5](https://doi.org/10.1007/s10755-011-9197-5).
- [29] H. Danielsiek *et al.*, “Undergraduate teaching assistants in computer science: Teaching-related beliefs, tasks, and competences,” in *2017 IEEE Global Engineering Education Conference (EDUCON)*, Apr. 2017, pp. 718–725. doi: [10.1109/EDUCON.2017.7942927](https://doi.org/10.1109/EDUCON.2017.7942927).
- [30] D. B. Luckie, B. W. Mancini, N. Abdallah, A. K. Kadouh, A. C. P. Ungkuldee, and A. A. Hare, “Undergraduate teaching assistants can provide support for reformed practices to raise student learning,” *Advances in Physiology Education*, vol. 44, no. 1, pp. 32–38, Mar. 2020, doi: [10.1152/advan.00090.2019](https://doi.org/10.1152/advan.00090.2019).
- [31] A. M. Ahmed and J. Blankenship, “Sustainable individualized instruction of biochemistry: A framework for recruiting, training, and utilizing undergraduate teaching assistants,” *Biochemistry and Molecular Biology Education*, vol. 47, no. 5, pp. 560–564, 2019, doi: [10.1002/bmb.21278](https://doi.org/10.1002/bmb.21278).
- [32] L. B. Wheeler, C. P. Clark, and C. M. Grisham, “Transforming a Traditional Laboratory to an Inquiry-Based Course: Importance of Training TAs when Redesigning a Curriculum,”

Journal of Chemical Education, vol. 94, no. 8, pp. 1019–1026, Aug. 2017, doi: [10.1021/acs.jchemed.6b00831](https://doi.org/10.1021/acs.jchemed.6b00831).

[33] A. R. St. James and D. Campbell, “Inquiry in oral communication: adapting oral examinations for teaching introductory physiology students to evaluate scientific research studies,” *Advances in Physiology Education*, vol. 44, no. 2, pp. 192–202, Jun. 2020, doi: [10.1152/advan.00087.2019](https://doi.org/10.1152/advan.00087.2019).

[34] S. A. Wyse, T. M. Long, and D. Ebert-May, “Teaching Assistant Professional Development in Biology: Designed for and Driven by Multidimensional Data,” *CBE - Life Sciences Education*, vol. 13, no. 2, pp. 212–223, Jun. 2014, doi: [10.1187/cbe.13-06-0106](https://doi.org/10.1187/cbe.13-06-0106).

[35] F. K. Lang, C. A. Randles, and K. A. Jeffery, “Developing and Evaluating a Graduate Student Teaching Assistant Training Course in the Chemistry Department of a Large American University,” *Journal of Chemical Education*, vol. 97, no. 6, pp. 1515–1529, Jun. 2020, doi: [10.1021/acs.jchemed.9b00686](https://doi.org/10.1021/acs.jchemed.9b00686).

[36] J. Gilmore, M. A. Maher, D. F. Feldon, and B. Timmerman, “Exploration of factors related to the development of science, technology, engineering, and mathematics graduate teaching assistants’ teaching orientations,” *Studies in Higher Education*, vol. 39, no. 10, pp. 1910–1928, Nov. 2014, doi: [10.1080/03075079.2013.806459](https://doi.org/10.1080/03075079.2013.806459).

[37] I. Plough, & P. Bogart, “Perceptions of Examiner Behavior Modulate Power Relations in Oral Performance Testing,” *Language Assessment Quarterly* vol. 5., pp. 195-217, 2008.

[38] J. S. Boman, “Graduate student teaching development: Evaluating the effectiveness of training in relation to graduate student characteristics,” *Canadian Journal of Higher Education*, vol. 43, no.1, pp. 100-114, 2013.

[39] T. D. Reeves *et al.*, “A Conceptual Framework for Graduate Teaching Assistant Professional Development Evaluation and Research,” *CBE - Life Sciences Education*, vol. 15, no. 2, Jun. 2016, doi: [10.1187/cbe.15-10-0225](https://doi.org/10.1187/cbe.15-10-0225).