

# Can Oral Exams Increase Student Performance and Motivation?

## Abstract

This is a Research paper. A large number of students never raise their hand during lectures or go to office hours. This is especially the case for large undergraduate classes. It is hypothesized that many students would benefit from more interaction with an instructor or teaching assistant. This study is part of a larger project of implementing oral exams in undergraduate engineering courses with potential benefits including improved assessment and reduction in academic integrity concerns. In addition to these benefits, this study paper explores whether oral exams can increase student motivation to learn and performance in the class. In this study, 560 engineering students in 6 classes were given oral exams and were surveyed about their experience. In one of the classes with 37 students, a controlled trial was performed with students randomly assigned to 3 groups. After the first written midterm one group had an oral exam with the instructor, one group had an oral exam with the Teaching Assistant (TA), and the last group did not have an oral exam. In the second written midterm the group with the instructor increased their grade by 14%, the group with the TA increased by 3%, and the group with no oral exam had a negligible change in performance. Potential reasons for the larger impact of an oral exam with the instructor were explored with one possibility being increased student motivation. A survey question about student motivation was administered to all 560 students in the study for which a majority of the oral exams were administered by TAs or other Instructional Assistants. Overall 338 students responded to the survey question and 70% of them Strongly Agreed or Agreed that the oral exams increased their motivation to learn. A correlation analysis was run using the demographic data of the students. First generation status had a statistically significant correlation with  $p=.031$ , where 78% of first generation students indicated that oral exams increased their motivation to learn compared to 66% for students that are not first generation. Other statistically significant correlations occurred with Cumulative GPA ( $p=.001$ ) and Term GPA ( $p=.003$ ), but with a negative correlation coefficient. The students that Strongly Agreed that the oral exam increased their motivation to learn had the lowest GPA (Cumulative GPA = 3.23 and Term GPA=2.89). These 3 statistically significant correlations all indicate that students who may likely benefit from more academic support had a larger increase in motivation following an oral exam. Hypotheses are presented for the reasons for student gains following oral exams, and proposals are made for the roles of Instructional Assistants and instructors in future studies and classroom implementations.

## Introduction

The research question explored in this paper is whether a 15 minute oral exam can increase student motivation and performance in a class. In large classes many students do not raise their hand in lecture or go to office hours, and thus have very limited direct interaction with faculty members or instructional assistants. Students who report more interaction with college faculty members tend to show greater social integration into the college setting, and better academic performance [1], [2], [3]. A nationally representative survey of over 30,000 college graduates found that the ability to identify one adult mentor at college predicted greater work engagement and subjective well-being in the years after college [4], [5], [6]. Interaction with faculty has been

shown to be especially important for Underrepresented Minority students [7]. In large public institutions it can be difficult for the majority of students to work closely with faculty members over an extended period of time. However, we wish to explore whether a short but intense oral exam can result in some of the benefits of longer interactions cited above.

The impetus for the oral exam project was the COVID-19 pandemic and a desire to improve the educational experience during remote learning. The COVID-19 pandemic has had many detrimental effects on education. However, this paper describes an initiative to take advantage of the opportunity provided by the pandemic to create a long-term positive change in education especially in large public institutions with high student to faculty ratios. Due to the pandemic both faculty and students were more willing to try alternative learning approaches that they may have been hesitant to try otherwise. Academic integrity concerns have been raised regarding written exams taken remotely, and the use of video conferencing has become commonplace for both faculty and students during the pandemic. Both of these factors allowed for a project to be initiated at a large public university to implement oral exams for the purpose of addressing academic integrity and also providing an improved summative and formative assessment. This study aims to explore how oral exams may also increase student motivation and performance. We will study the effect of faculty-student interaction during oral exams and to what extent these effects can also be achieved with interactions between students and Instructional Assistants when they are administering oral exams.

In this study at the University of California, San Diego, 6 courses with a total of 560 students in Mechanical and Aerospace Engineering (MAE), and Electrical and Computer Engineering (ECE) were modified to include oral exams. These courses were taught in the Fall quarter of 2021, and class sizes ranged from 30 to 165 students. There were 5 faculty members teaching these courses, and each developed their own approach to implementing oral exams. This paper describes work that is part of a project studying the effectiveness of various oral exam methods [8], [9], [10], [11]. The overall project includes more quarters and thus more courses than covered in this paper. Surveys were implemented at the beginning of the course, end of the course, and after the oral exams. This paper evaluates the impact of an oral exam on written exam performance for one course in the study that implemented a controlled trial. The paper also evaluated the survey responses related to a question about increased motivation to learn that was administered to all 560 students. Student demographic data was used to identify for which subgroups of students the oral exams had a larger impact in terms of increasing motivation to learn.

## **Literature Review**

The idea of supplementing conventional written exams in STEM fields with oral assessment springs from the observation that the former testing practice is devoid of many of the student-centric assessment dimensions that the latter is seen to possess, such as authenticity, meaningful dialog, timely individualized feedback, and personal connection. The benefits of oral exams were described in 1926 [12] as well as much more recently [13], [14], [15], [16], [17], [18]. Written examination is criticized as primarily being tailored for evaluating students' procedural knowledge rather than deeper levels of understanding [17], [18], [19], [20] thus

entrenching students in the practice of rote memorization, regurgitation, and imitative reasoning, as opposed to conducting them along the path of deep learning, critical thinking, and creative expression—which oral exams are purported to do [14], [18], [20], [21], [22], [23], [24], [25], [26], [27]. Many of the potential benefits of oral assessment to student learning and professional development may be seen to revolve around the opportunity for personal interaction characteristically afforded by the testing method [13], [14], [15], [16], [28], [29], [30].

Evidence shows that purposeful interactions between a student and the instructor on an individual basis can help improve the student's attitude toward the course and discipline, foster meaningful academic relationships, reduce the likelihood of the student dropping out, and provide motivation to the student for attaining higher learning goals [16], [24], [28], [31], [32], [33], [34]. It has been argued that oral assessments have a built-in reward system that can offer positive reinforcement to those students engaged in productive learning behaviors by evoking in them positively valenced emotions through the provision of personalized feedback and validation. Odafe [33], for example, reflecting on his experience with administering oral assessment in an algebra course, observes “when students feel that their contributions are valued, they will start to 'own' and value the subject of mathematics and this could indicate a turning point in student attitudes towards the subject.” Boedigheimer and colleagues [34], who conducted oral exams across multiple courses in the same field, similarly recognize “students who performed well appreciate the immediate praise.” In her thermodynamics course, Zhao [35] found that students who volunteered to take the oral exam “tended to feel that the class was more friendly, supportive, and their effort was more appreciated.” The important qualification by Sambell et al. [36], of effective alternative assessment as having “the potential to encourage and reward genuine learning achievements,” expressed at the conclusion of their exploratory study of student perceptions of the consequential validity of assessment, is thus shown by the above-cited and other recent work [18], [26], [35], [36], [37], [38] to apply quite well to dialogic testing.

A commonly arising theme in conversations about oral assessment is its capacity to encourage faculty-student interactions longitudinally. Carnell [39] points out that oral exams make it “easier to carry conversations about mathematics or study habits into out-of-exam time.” She concludes “the benefits of these brief obligatory encounters spill over into the rest of the semester.” East and Schafer [29], following their realization of in-person grading, an alternate form of oral assessment, come to the opinion that the one-to-one faculty-student interaction “will lead students to be more willing to ask questions” more generally. Willingness to ask questions and engage in meaningful discourse is a promising sign that a student experiences the material “as having a high degree of personal relevance,” which in turn suggests they are intrinsically motivated to learn [40]. A student's comfort level of engaging with faculty has been observed to predict success [37], and may imply the student is developing a “professional identity” that could contribute to sustaining the student's intellectual engagement well through their academic studies and into professional practice [14], [27].

A key determinant of the effectiveness of oral exams to stimulate student engagement with the course material and faculty is its level of authenticity. A distinctive feature of dialectic assessment is that it provides students with an authentic opportunity to express their knowledge, understanding, and creativity on the spot and in a social context. Practitioners of oral testing

suspect the social and dynamic nature of the assessment derives to a large degree from student preparation. Boedigheimer and colleagues [34] are blunt, “students typically do not want to embarrass themselves in a one-on-one discussion with the instructor,” concluding, “consequently, we expect them to study more thoroughly, emphasizing conceptual understanding over memorization more than they might for a traditional written exam.” Recounting their experiences with implementing oral exams in organic chemistry courses, Dicks and coauthors [16] report that their analysis of student performance “supports the notion that students prepare more rigorously for an oral examination due to the social pressures of answering direct questions.”

As pointed out by Boedigheimer et al. [34] and others [18], [23], [28], [41], in addition to encouraging increased preparation to learn, oral exams tend to direct students’ learning efforts away from surface learning and toward concept mastery. Responsible for this tendency is the assessment’s in-depth probing power, consisting in its permissance of adaptive questioning, to which students are thought to respond by readjusting their approaches to learning toward increased conceptual and relational understanding [18], [20], [37], [40], [42]. This so-called backwash effect on students’ learning [17], [19], [22], [42], [43] when coupled with the provision of formative diagnostic real-time feedback and a system of rewards, creates a positive feedback cycle for enhanced learning gains. Based on the synergism of its benefits to student formation, examination through dialog has been rightly labeled as “assessment for learning,” with all its implicit connotations [44].

## **Methods**

In Fall Quarter 2021, 6 courses with a total of 560 students in Mechanical and Aerospace Engineering, and Electrical and Computer Engineering were modified to include oral exams. There were 5 faculty members teaching these courses, and each developed their own approach to implementing oral exams which is part of a National Science Foundation under Grant No. 2044472 studying oral exams. The details of the various modes of implementation of the oral exams in the different classes are described in [8]. This study has been reviewed and approved by the Human Research Protections Program at University of California, San Diego.

To address the workload associated with administering oral exams, Instructional Assistants (IAs), i.e. Teaching Assistants, Readers, and Tutors, were trained to administer oral exams. Of the 560 students in the study, 88% of them were administered oral exams by an IA. The IA training included asynchronous and synchronous components. Prior to summer 2021, participating instructors provided training to graduate instructional assistants (IAs) that to varying degrees 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 standard training materials for instructors and instructional assistants. The training included asynchronous and synchronous components, which were implemented in Fall Quarter 2021. 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. While concepts of equity and inclusion are woven throughout the five modules (See Appendix I), Module 2: Adopting an Equity Mindset, specifically focuses on implicit bias. The module

includes an overview of how implicit biases can unconsciously contribute to a deficit mindset [45] toward students, which often manifests in blaming students when they are struggling in course as opposed to thinking about how instructional practices may be contributing to inequitable outcomes. The module presents several strategies for disrupting implicit biases when administering oral exams, as well as strategies for implementing an equity mindset. One example strategy is for examiners to recognize that implicit bias is most active when we are rushing, and thus, should take a moment before each exam to consider their own mindset, as well challenge any assumptions they might be making during the exam (e.g. assuming that a student is struggling to answer a question because they did not study). Each module in the asynchronous training concludes with self-assessment questions, which IAs were required to complete. The depth of the responses to the questions suggests that IAs developed foundational knowledge of how implicit biases may show up in oral exams, and that they were able to apply what they learned by giving specific examples of how they planned to implement an equity mindset when administering oral exams. 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.

To measure how students perceived the oral exams, surveys were implemented at the beginning of the course, end of the course, and after the oral exams. Students logged in to the surveys with their student ID, but the results were hidden from the course instructor until they were de-identified by the Dean's office IT department. The IT department also added demographic data for the de-identified students surveys. Per IRB guidelines, students were able to opt out of the study by submitting an email request to an educational research group on campus, and the instructors are not made aware of any students who opted out. If students do not opt out, the deidentified survey results and class performance on assignments and exams were used for this study. Most of the oral exams were conducted via video conference, and were recorded so that the instructor could use the recording for grading purposes. Video recordings could only be used for research if the student actively opted in.

The results presented in this paper include a controlled trial in one of the classes. This controlled trial is described in more depth in the Results Section A and included analysis of performance on a written midterm after some of the students had taken an oral exam and others had not. Another portion of this study includes an analysis of the survey data collected from all 6 classes with a focus on self reported student motivation for learning. This portion is described in more depth in the Results Section B. The results from Section A are used to direct some of the questions addressed in Section B.

This project is in the first year of a 3 year project. Accordingly, the research in this paper is exploratory in that correlations are explored after collection of the data. It is recognized that exploratory research can lead to correlations that are not causal or are the results of artifacts in the data. However, exploratory research is valuable in that it can identify unexpected correlations.

In a later stage of this research project, confirmatory research will be conducted where the data analysis will be limited to validate hypotheses proposed before data collection.

## **Results**

### **A. Analysis of Midterm Performance in a Controlled Trial**

In one of the smaller classes in the study a controlled trial was performed to quantitatively measure the impact of the oral exams. The class, MAE 30A, was a sophomore level class with 37 Mechanical and Aerospace Engineering students that covered 7.5 weeks of Statics and a 2.5 week introduction to Dynamics. There were 3 midterms in the class, and after each midterm there were oral exams, but not all students completed each oral exam. Since oral exams were new to most students, each student was provided with 2 oral exams with the opportunity to drop the grade of the first oral exam. The grades on all oral exams combined contributed 5% of the course grade. To implement this approach all students were required to sign up for a 20 minute time slot following each midterm. The time slots started an hour after the midterm and continued through the following day. The students were notified via email right after the midterm if they were selected to take the oral exam. The student selection after the first midterms were random, but was adjusted for midterms 2 and 3 to ensure that each student completed 2 oral exams in the class. The written exams were conducted in-person, but the oral exams were conducted via video conference using Zoom. The exam questions were posted on the class Learning Management System (Canvas) immediately following the midterm so that students could review the midterm questions before the oral exam.

The oral exams were administered by the faculty member teaching the course, and by the one Teaching Assistant (TA) of the course. The content of the oral exam was written up by the faculty member and included both questions and hints to provide if students were stuck. Appendix II provides the details of the oral exam used, the hints prepared, and the detailed instructions provided to the TA. The exam started by asking a student to explain how they solved one of the midterm questions they just completed. Then a problem extension was incorporated which added a component to the midterm question. The same oral exam questions were used for all students. The oral exams were graded on correctness of response and clarity of explanations. Even if a student made a mistake on the written midterm, they could still get full credit in the oral exam if they corrected their mistake during the oral exam. When a student made a mistake, small hints were provided to give the student the maximum opportunity to demonstrate their knowledge by solving as much of the problem on their own. By the end of the exam the students were notified of the correct solution. The exams were scheduled to last for 10 minutes, with 5 minutes for buffer and another 5 minutes to record the grades. Strong students who quickly answered the question correctly often completed the oral exam in less than 10 minutes, while sessions with weaker students sometimes extended to take the full 15 minute period due to a large number of hints and allowing students more time. In some cases, weak students were provided an extra 5 minutes when time permitted. At the end of the exam students were asked if they had any questions about the midterm, class, major, internships, or career. Student questions typically focused on grading. For those that asked about internships, information about school

resources were provided and an offer was made to have the instructor review their resume. Of the 37 students in the class, 3 of them submitted a resume for review.

Academic integrity was addressed by asking students not to share the content of the oral exam with classmates, and instructor and IA had a comment area in the grading sheet to indicate suspected academic integrity concerns. In Fall Quarter 2021 of MAE 30A there was no evidence of students sharing oral exam content. To the contrary, students on the second day of the exams continued to make mistakes, which would not be the case if the oral exam content had been widely shared between students. It should be noted, that in a prior quarter of administering oral exams, IAs did mention to the instructor that 2 students were suspected of cheating; these 2 students were subsequently scheduled to take their second oral exam with the instructor but dropped the class before having to do so. It is possible that the one-on-one interaction with the instructor and TA deterred cheating. The experience of oral exams reducing or eliminating academic integrity violations was also observed by [46].

The controlled trial allowed for comparison of performance on written midterm 1 and midterm 2. The original research plan was to compare performance on midterm 2, with one group having taken an oral exam after midterm 1, and the control group not having taken an oral exam after midterm 1. However, using this grouping there was not a large difference between the control and the intervention group. Since the research is exploratory at this stage, another grouping was explored to see if who administered the oral exam made a difference. The new grouping included the control group that did not take an oral exam (No OE1), the group that took the oral exam with the TA (TA OE1), and the group that took the oral exam with the faculty member (Faculty OE1). OE1 as an abbreviation for Oral Exam 1. Students were randomly assigned to one of the 3 groups. The results are shown in Table 1, with the averages of each midterm shown and the standard deviation designated  $\sigma$ . About a third of the students are in each group, and there were 3 students who missed either an oral exam or a midterm, and thus were removed from the analysis.

Table 1: Raw Grades on Written Midterm 1 and 2

Groups	Group Size	Midterm 1	Midterm 2	Percent Change
No OE1	13	75.4 $\sigma=20$	75.2 $\sigma=19$	-0.3%
TA OE1	10	71.5 $\sigma=19$	73.7 $\sigma=23$	3.1%
Faculty OE1	11	72.2 $\sigma=19$	82.3 $\sigma=13$	14.0%

As seen in Table 1 the group that did not have an oral exam following midterm 1 had almost no change in their midterm 2 score. The group that took their oral exam with the TA had a 3.1% increase in grade, while the group that took the oral exam with the faculty member had a much higher increase at 14%. The grade on midterm 1 was used as an indication of incoming students' ability prior to any oral exam experience. There were slight variations in the midterm 1 grades among the groups, so the data was normalized by dividing the grades of midterms 1 and 2 by the average of the midterm 1 grades for the group that the student belonged to. The normalized

grades are shown in Table 2.

Table 2: Normalized Performance on Written Midterm 1 and 2

<b>Groups</b>	<b>Group Size</b>	<b>Midterm 1 Normalized</b>	<b>Midterm 2 Normalized</b>	<b>Percent Change</b>
No OE1	13	1	0.997	-0.31%
TA OE1	10	1	1.031	3.08%
Faculty OE1	11	1	1.140	13.98%

The class size of MAE 30A was small, so it was not initially expected that this single trial could indicate a statistically significant difference between the groups. However, considering the large increase in grades among the students who took the oral exam with the faculty member, a one-way analysis of variance (ANOVA) was implemented by comparing the No OE1 group with the Faculty OE1 group. For each student, the change in grade between midterm 1 and midterm 2 was correlated with their belonging in the No OE1 group or the Faculty OE1 group. The analysis was implemented in Matlab using `anova1` command. For the raw grades shown in Table 1 the p-value is  $p=.131$ , and for the normalized grades shown in Table 2 the p-value is  $p=.123$ . Both of these correlations are larger than the threshold of 0.05 that would indicate a statistically significant difference. Nevertheless, the current results indicate that oral exams were followed by an increase in grade in midterm 2, and that the increase in grade was substantially higher when the oral exam was administered by the faculty member. To establish a causal relationship continued studies with more students are required.

It should be noted that the TA in the course was considered an excellent TA by both the faculty member and the students. The TA was in his final year of PhD studies in a topic area related to the course. This was his 3rd time TAing for a class in this sequence, and generally received higher student evaluations than the instructor. The TA had administered oral exams with the same instructor in a prior quarter, and had observed on Zoom the instructor administering oral exams.

Analysis of the impact of oral exams on midterm 3 was not practical. There were 8 different combinations of oral exam sequences; no oral exam, with TA, or with Faculty members in different orders (since each student was administered 2 oral exams in the class, there were no cases where oral exams did not occur after both midterm1 and 2). Accordingly, the group sizes for midterm 3, were mostly 3 students or less which was not suitable for even analysis of averages.



## B. Analysis of Survey Results of All Classes

### B.1 Descriptive Statistical Analysis

The 6 classes in the project generally did not have a control group with some students who took an oral exam and others that did not, and thus it was not possible in these classes to measure the effect of oral exams on written exam performance as was for the MAE 30A class described above. However, all classes did implement surveys at the beginning of the course, end of the course, and after oral exams. The survey after the oral exam (referred to interchangeably as assessment in the survey) is shown in Appendix III and includes a question about motivation to learn, which is:

- “Interaction with a Prof/TA/Tutor/Reader during oral exams increased my motivation to learn,” with answer options being Strongly Agree, Agree, Neither Disagree nor Agree, Disagree, Strongly Disagree.

A statistical analysis of responses to this question was performed for all 6 classes. Overall 70% of the students who answered the survey question (n=338) as Strongly Agree or Agree that the oral exams increased their motivation to learn. In most classes the question about student motivation was asked just once, but in the class in which that survey question was asked multiple times, the lowest ranked value was used. The breakdown of student selection is shown in Table 3.

Table 3: Student Response to Survey Question on Increased Motivation

Student Selection	n	Percentage
Strongly Agree	45	13.3%
Agree	191	56.5%
Neither Disagree nor Agree	81	24.0%
Disagree	19	5.6%
Strongly Disagree	2	0.6%

To study if oral exams had a different impact on various subgroups in the study, a correlation analysis was run using the demographic data of the students and their responses to the question about increased motivation. The survey responses were correlated with the demographic data only after the data was de-identified by the IT department per IRB guidelines. To run the correlation analysis the demographic data and the student selections were converted to numbers. The Likert selections of Strong Disagree to Strongly Agree were converted to a 1 to 5 scale. The demographic data was assigned numerical values, such as Male=0 and Female=1. The analysis was implemented in Matlab using the corrcoef command using the “pairwise” option, which computes each two-column correlation coefficient on a pairwise basis and if one of the two columns contains a Not a Number (NaN) or blank value, that row is omitted. The pairwise option was used since there were a large number of survey questions and most students did not answer 100% of the questions and some demographic data was missing. Table 4 shows the correlation results, with positive R values indicating a positive correlation, and P values of less than 0.05 indicating if the correlation is statistically significant. Statistically significant positive correlations are highlighted green and negative ones highlighted red. The non-highlighted are shown to

illustrate the lack of correlation. For demographic data where there are 2 groups the percent who selected Strongly Agree (SA) or Agree (A) are shown, along with percent Strongly Agree or Agree (SA+A). Also shown is the difference between SA+A for the groups being compared. These groups included: First Generation, Transfer Student Status, Gender, and Underrepresented Minority (URM). As seen in Table 4 the one positively correlated demographic is First Generation where 78% of First Generation students Strongly Agreed or Agreed that oral exams increased their motivation to learn compared to 66% for students that are not First Generation.

Table 4: Correlations of Student Demographics to Survey Question on Increased Motivation  
R=correlation coefficient, P=statistical significance, n=number in group, SA=Strongly Agree, A=Agree

Student Demographics	R	P	Group 1				Group 2				Difference Between Groups of SA+A		
			Group Name	n	SA	A	SA+A	Group Name	n	SA		A	SA+A
First Generation	0.12090	0.03113	Not First Generation	224	12%	54%	66%	First Generation	94	15%	63%	78%	12.0%
Transfer Student	0.08212	0.13189	Freshman Admit	267	12%	58%	70%	Transfer	66	17%	53%	70%	0.0%
Gender	0.02421	0.65833	Male	266	13%	56%	70%	Female	70	14%	56%	70%	0.5%
URM	-0.02109	0.69921	Not URM	277	14%	55%	69%	URM	61	8%	64%	72%	-0.3%
SAT Math	-0.07017	0.28094											
SAT Highest	-0.12638	0.05151											
GPA for Term	-0.15965	0.00325											
GPA Cumulative	-0.17373	0.00134											

The GPA of the students, both cumulative and for the term, showed a statistically significant negative correlation with the survey question, as shown in Table 4. Since the GPA distribution is continuous, the average GPAs are calculated for the student response categories from Strongly Agree to Strongly Disagree, and are shown in Table 5. As seen in the table, there are only 2 students in the Strongly Disagree category (highlighted in red), so for the correlation discussion these 2 are ignored. The students who indicated a Strongly Agree have the lowest cumulative GPA of 3.23, and this GPA monotonically increases until the Disagree response where the average is 3.60. A mostly similar trend is observed with the Term GPA, where the GPA monotonically increases from 2.89 in the Strongly Agree response, up to 3.42 for the Neither Disagree nor Agree response. The Term GPA does dip back down slightly for the Disagree category.

The quantitative analysis of midterm performance reported in Results Section A indicated that oral exams administered by instructors had an increased impact over those administered by IAs.

However, this section shows that oral exams administered by IAs had a strong impact on students' reported increase in motivation to learn. After all, if 88% of the oral exams were administered by IAs, then it would only be possible to have 70% of the students indicating a positive increase in motivation if most of this increase came from oral exams with IAs.

Table 5: Average GPAs Corresponding to Student Responses

There were only 2 students in the “Strongly Disagree” group and thus average values for this row are not significant

Survey Response to Increased Motivation Question	n	Cumulative GPA Average	Term GPA Average
Strongly Agree	45	3.23	2.89
Agree	191	3.35	3.08
Neither Disagree nor Agree	81	3.56	3.42
Disagree	19	3.60	3.31
Strongly Disagree	2	3.43	2.79

## **B.2 Coding Analysis of Student Free Responses**

In addition to Likert response questions, the surveys included free response questions as well. 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. Free response questions can also identify hypotheses and areas of interest for which Likert questions can be drafted in a future phase of the study. We analyzed responses to free response 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). One student’s comment can often be assigned to several codes, and 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.” About 300 out of 560 (53%) student respondents provided comments in addition to the Likert-scale responses. A more in-depth reporting of the student free responses for this project is included in [8].

There were no prompts in the free response questions that specifically asked about student motivation, but unsolicited students did mention motivation or described motivating thoughts. Overall there were 315 positive comments made with 5 of them relating to increased motivation. There were also 171 comments about areas of improvement with 1 negative comment about motivation. Below are comments coded as related to motivation and selected other comments.

1. Question: *In what way have the oral assessment(s) changed your interaction with faculty/TAs/tutors, your studying strategy, or any other aspects of your course experience?*
  - a. It makes me want to understand things taught in [redacted] course better
  - b. know my stuff more
  - c. I got to meet with TA in person and discuss about our class, grad school, possible career directions etc. I don't think I would have gotten to know the TA and get advice if it wasn't for the oral exam. I also felt more comfortable to talk to the professor about other stuff related to our class.
  - d. Taken a oral exam with both TA and professor, it improved my relationship with both and caused me less stress when asking questions.
2. Question: *Please leave any comments that you may have for any oral exam assessor(s) that you have interacted with in this course. Feel free to address what they did well and in what areas they can improve.*
  - a. I think it was great that they answered all the clarifying questions during the oral exam. I think it is important to make sure to let the students know that they have more than enough time and reassure that they can ask clarifying questions in order to understand what is really being asked.
  - b. I thought it was a bit stressful to think on the spot in front of someone and then explain reasoning but the exam was casual and fair.”
3. Question: *Is there anything else that you would like to share with us about the oral assessment (including the positive aspects and areas for improvement)?*
  - a. I think it was a good experience since it made me realize even more what I don't know. It made me want to study and review to do better moving forward. The class was a rough start for me but I want to be smother sailing here on out and I am willing to put in the work necessary.
  - b. I liked that it went over the past exam. I felt discouraged and upset with myself, but motivated to fix my mistakes
  - c. I'm a huge fan of oral assessments. I suggest talking to professor [Redacted] about how he does his weekly oral "exams" (they're more like check ins) in [Redacted] course. I found that they were great for motivating me to keep up with lectures as well as increasing my confidence in my abilities.
  - d. I think that it adds a positive nuance to the class experience. It makes the class more interesting, and gives students a second chance in a way. For example, if you get something wrong on the written exam and later you show you understand the topic during the oral exam, the instructor or TA will have a better understanding of what is going on, and maybe help with strategies about how to take written exams more effectively. It is also a great opportunity to get to know instructors and TA's better and possibly have access to more resources.
  - e. I just wish the person conducting my oral assessment would have been honest with me in terms of how poor my current outlook was while simultaneously motivating me to work harder in the course in order to succeed. I feel like both being realistic and motivating are possible. This might be because I was sensitive because I knew I had performed so poorly, but the way the TA/Reader/Tutor said "Good luck" made it seem like they thought my case was hopeless and I was not

going to succeed in the class. I left the Oral Assessment feeling extremely unmotivated, of course most of this was my own disappointment in my lack of preparedness, but I feel like a more positive outlook could have definitely helped me.

Question 1 about interaction with faculty and IAs indicated that oral exams helped students learn the subject matter (1a and 1b), and that students felt more comfortable asking the questions to faculty and IAs (1c and 1d). In response to question 2 about comments to the oral assessor, a student appreciated the subject matter tutoring (2a), while another student acknowledged the stress but also commented that it was “casual and fair” (2b). In the broad question 3 asking about any other comment both 3a and 3b acknowledged mistakes made in the oral exam, but appreciated the oral exam and indicated that it increased their motivation or outlook on the course. Answer 3c explicitly mentioned increased motivation, and answer 3d comments on both the benefits of learning course content and getting to know instructors and IAs better. It is interesting that even the sole negative comment, 3d, was not against the concept of oral exams, but rather that the feedback could be better during the exam and indicating that if that was the case it would have helped them. Overall, these student comments reflect a genuine and meaningful impact the oral exams had on the students.

### **Limitations of the Study**

This study is limited in a number of important aspects. While overall there were 560 students in the study, only 338 answered the question about motivation. Moreover there were only 37 students in the controlled trial of MAE 30A course, and of these only 34 completed both midterm 1, midterm 2, and appeared at the oral exam when selected. The small number of students in the controlled trial led to results that did not pass the threshold for statistically significant impact in the controlled trial. Accordingly, a larger trial is needed, and indeed a similar controlled trial will be repeated in Spring 2022.

Another important limitation is the long term impact of the measured outcomes. Of the 338 students who answered the question about motivation to learn, 70% Strongly Agree or Agree that the oral exams increased their motivation to learn. However, this is a self-reported impression and there is no measurement if this motivation to learn impacted academic performance. The controlled trial did indeed show an increase in performance on a written midterm following an oral exam by the course instructor, but there was no measurement as to whether this impact extended to the rest of the course, which was not possible because all students eventually completed an oral exam and the number of students who only had oral exams administered by the instructor was 3 or less. No data was collected regarding the impact of the oral exam in following courses.

### **Discussion**

Oral exams are most widely used to increase the quality of assessment and are common in the medical field [47]. Oral exams are less common but have been introduced in a range of undergraduate courses [14], [18], [28], [20], [22], [23], [24], [25], [26], [27], [46]. The analysis

of this paper studied whether oral exams can also be used to increase student motivation and performance in undergraduate engineering courses, and how oral exams administered by IAs compare to those administered by instructors.

Finding an intervention that can help student learning especially among students who need it the most can be a challenge. A range of initiatives have been attempted to improve student performance especially among disadvantaged students, but not all demonstrate success [48], [49]. A study by Schriver [50] showed that increased faculty-student rapport can increase students' sense of mattering and student ratings of a course, but did not have an impact on student grades. However, it should be noted that some positive impacts of interaction with students can appear in years after graduations [5], [6]. The approach of oral exams has some unique attributes which may contribute to its effectiveness. The oral exam is of short duration, but it can be an intense 15 minutes. There is intensity due to the grade component of the oral exam, which distinguishes it from office hours. Moreover, an oral exam is focused on a subject matter of the instructor's choosing, so the discussion can quickly delve into the content.

A framework for understanding how oral exams may increase students' motivation to learn is Self-Determination Theory which addresses factors that guide motivation [51]. Ryan and Deci [51] postulate three innate psychological needs that are the active ingredients to enhance one's motivation: the need for competence, the need for autonomy and the need for relatedness. The oral exam addresses a student's need for competence by offering a venue in which students can express their deeper understanding of the material. Responses to open-ended feedback questions point to this, where students appreciate the ability to show they grasp the core concepts without the issues of involved and mistake-prone calculations. In addition, and directly tying into the topic of this paper, is the need for relatedness, which states that a sense of belongingness and connectedness to the persons or group that are aligned with the goal are key factors to enhance motivation [51]. In a pedagogical setting, this translates to students' need to feel respected and cared for by the teaching and teaching staff, as essential ingredients. It has been reported that students have lower motivation when seeing their teachers as uncaring [52].

The topic of whether oral exams could lead to a measurable improvement in students' performance on written exams was explored in a controlled trial in a single class of 37 students on Engineering Statics and Dynamics. The trial showed that an oral exam administered by the instructor after the first midterm in the course increased students' grades on the second midterm by 14% compared to students in the class that did not take the oral exam. Students who took an oral exam administered by an IA also had an increase in grade but of a smaller amount at 3%. The small number of students in the class limited the ability to draw statistically significant conclusions, and indeed this trial should be repeated to see if the results can be duplicated with a larger number of students.

At this stage a number of hypotheses can be presented for the reason for the increased impact of the oral exam by the faculty member relative to one by an IA. One hypothesis is that the faculty member provided better feedback regarding the course content. Even though the TA was very experienced, the faculty member still had decades of teaching experience which may have resulted in improved explanations. Another hypothesis is that the oral exam with the faculty

member was more motivating, since the indication that a faculty member cared about an individual student's academic success may have made more of an impact. A third hypothesis is that the mannerisms and standards of the instructor were different than those of the IA. These hypotheses will be explored in future research which will include a review of the video recordings made of the oral exams. This review will compare faculty member and TA behavior, and also any differences in how students responded to the different examiners. This future study may also identify factors that will help in training Instructional Assistants to implement more impactful oral exams.

The topic of self-reported student motivation was explored with survey data collected from 6 courses in which oral exams were implemented in a range of formats. The combined classes had an enrollment of 560 students, and of these 338 completed a survey question asking if the oral exams increased their motivation to learn. Overall 70% of these students Strongly Agreed or Agreed that oral exams increased their motivation to learn, which is a strong support for the effectiveness of oral exams regardless of the details of implementation. It should be noted that despite the results from the controlled trial that highlighted the faculty member's role, 88% of the oral exams in the study were implemented by Instructional Assistants. Thus, oral exams by IAs elicited a strong self reported increase in motivation to learn.

A correlation analysis of the demographic data of the 6 courses identified 3 statistically significant factors associated with increased student motivation. First generation students indicated a stronger increase in motivation as demonstrated by the 78% of First Generation students who indicated that oral exams increased their motivation to learn compared to 66% for students that are Not First Generation ( $p=.031$ ). There were also 2 negatively correlated parameters, Cumulative GPA ( $p=.001$ ) and Term GPA ( $p=.003$ ). As seen in Table 5, the students who indicated Strongly Agree have the lowest cumulative GPA of 3.23, and this GPA monotonically increases until the Disagree response where the average is 3.60. A mostly similar trend is observed with the Term GPA. These 3 statistically significant correlations all indicate that students who may need more academic support had a larger increase in motivation following an oral exam. The students' comments to the free response questions described the positive impacts that many students felt.

Overall this study is at its beginning phase. An early objective was to determine if there are any measurable benefits to oral exams, and this paper illustrated benefits of both increase in written exam grades following an oral exam, and a large percentage of students indicating that oral exams increased their motivation to learn. Ultimate outcomes of this study need to recognize that administering oral exams is labor intensive. However, by committing to this initiative of administering oral exams to a large number of students, we are beginning to quantify the benefits of oral exams, so that appropriate tradeoffs can be made. Some tradeoffs may ultimately promote small enough class sizes so that instructors can provide oral exams to all students. Alternatively, lessons may be learned to improve training of IAs to allow for an increase of impact of oral exams. Another benefit of oral exams we wish to explore is how the act of administering oral exams better informs an instructor of where student learning gaps are, and thus can lead to improvement of their instruction in the classroom.

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## **Appendix I:**

### **Asynchronous Training Modules for Examiners**

## Asynchronous Training Modules for Examiners

### Module 1: Why Use Oral Exams?

#### Learning Outcomes:

1. Define “oral exam” in a teaching context
2. Discuss potential benefits of oral exams for students and IAs

### Module 2: Adopting an Equity Mindset

#### Learning Outcomes:

Define implicit bias and describe the potential impact it can have on interactions with students

1. Differentiate between equity mindset and deficit mindset in teaching
2. Identify strategies that support an equity mindset in administering oral exams

### Module 3: Managing Anxiety and Reducing Cognitive Load

#### Learning Outcomes:

1. Explain why it’s important for oral exam assessors to reduce students’ anxieties during an oral exam.
2. Apply specific strategies to set students’ expectations at the beginning of the exam session.
3. Identify ways you can help students feel at ease throughout the exam.

### Module 4: Communicating Growth Mindset

#### Learning Outcomes:

1. Define “Growth Mindset” and explain how mindset impacts learning and motivation.
2. Using the framework of Growth Mindset, identify ways to provide supportive and effective feedback during the oral exam session.
3. Name some specific types of feedback to avoid during the oral exam.

### Module 5: Effective Communication as the Assessor

#### Learning Outcomes:

1. Prepare an oral exam environment that is easy to navigate for the students
2. Ask clear exam questions, and perform attentive listening
3. Identify strategies that support students with reaching their fullest potential in oral exams

**Appendix II:**

**Oral Exam Following Midterm 1 in MAE 30A Statics Class**

## General Instructions for TAs on Administering Oral Exams

### Before Oral Exam on Zoom

- Set yourself in quiet place with good lighting on your face
- You will want to keep your camera on during the oral exam as a sign of engaged listening
- Review any relevant material such as the student written exam as is appropriate

### Example Script for Oral Exam (adjust as needed)

Thank you for joining. Are you (Name of Student)? Great, let's proceed.

The oral exams are being recorded as explained in lecture. Is it ok to start recording?

The goal during this oral exam is to bring out the best of your knowledge and ability to explain your work. If you get stuck, I will offer some small hints, but give you a chance to do as much on your own as you can. If you need extra time, please let me know, and I will provide as much time as the schedule allows. The exam is scheduled for 10 minutes, but I have 15 minutes reserved to avoid a rush. Are you ready to get started?

(Explain oral exam question here. Make sure to check that they can see any material you show on the screen)

Please explain to me the approach you took for solving this problem.

...

(At End of Oral Exam Summarize student performance without committing to a grade. Then wrap up)

We are done with the oral exam.

You did well on Part XYZ. For part ZYX, I felt that you understood some of the concepts, but got caught on ZZZ. It may help to review this material before the next exam. The grades for the oral exam will be posted on Canvas in the coming days.

### Do you have any questions about the exam, course as a whole, engineering, internships, or any general questions?

- If they ask questions about internships, share what you can, but also offer to review their resume if they email it to you (Course instructor can do this)
- If students ask a question that you do not know the answer to, let them know that you will get back to them.

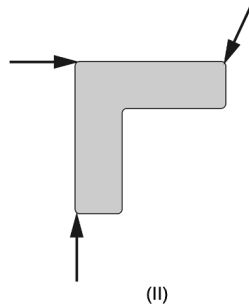
### After Oral Exam

Writeup your notes and any grade or research questions. Do this right after the oral exam while it is fresh in your mind.

## Oral Exam Questions Following Midterm 1 in XYZ Statics Class

**Problem 1:** Repeat of question on written midterm\*(see figure below).

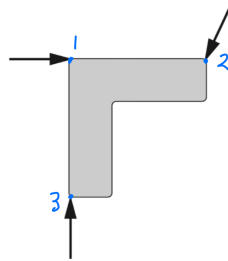
Can this part be in equilibrium given that all magnitudes are greater than zero, and the forces and couple (moment) act in the directions and senses shown? Explain your answer



**Problem E1: Extension Problem 1 (see figure below)**

E1A) How would you change the direction of the force at point 2 so that the sum of the moments about point 1 would be equal to zero?

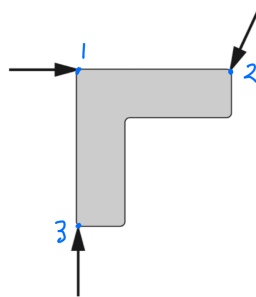
E1B) Would the object then be in equilibrium?



**Problem E2: Extension Problem 2 (see figure below)**

E2A) How would you change the direction of the force at point 3 so that the sum of the moments about point 2 would be equal to zero?

E2B) Would the object then be in equilibrium?



\*Problem 1 was taken from concept inventory question.



## Scoring for Oral Exam for Midterm 1

### Scores and Feedback that the student sees

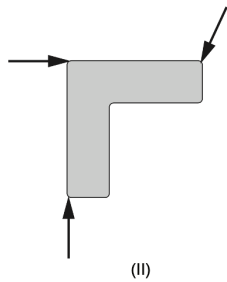
- Initial Problem 1A (1-5)
- Problem Extension 1 (1-5)
- Problem Extension 2 (1-5)
- Quality of explanation (1-5)
- Feedback on areas of strength
- Feedback on areas for improvement
- Grading Criteria for Correctness (1-5)
  1. Mistake even after all hints
  2. Correct after many hints
  3. Correct after a few hints
  4. Correct after 1 hint
  5. Correct with no hints
- Grading Criteria for Quality of explanation (lenient grading). (1-5)
  1. Unintelligible
  2. Hard to follow, but understood somewhat
  3. Hard to follow, but eventually understood all
  4. Could follow well, with some areas for improvement
  5. Could follow well.
- 

### Research Scores and Notes

- Written exam correct (Y/N)
- Initial oral explanation correct (Y/N)
- Correctness of problem extension
- Did the student receive tutoring? (1=no tutoring ... 5 =a lot of tutoring)
- Did student seems to learn from tutoring (1= no learning ... 5 a lot of learning)
- Did student engage with a discussion at the end of the exam after the prompt (1=no engagement, 2 & 3 asked questions about course, 4 & 5 asked question beyond course)
- Comments:

## Prepared Hints for Oral Exam following Midterm 1

### Problem 1A part 2.



If the students made a mistake in the written exam, but got the oral question correct, ask them how they found their error (no accusation of cheating).

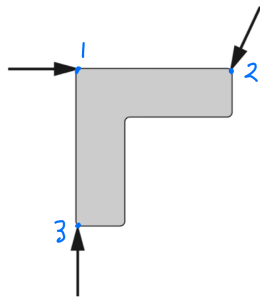
Hints if the student has the in incorrect solution

1. What are the requirements for an object to be in equilibrium?
2. Tell them: They are  $\Sigma F_x=0$ ,  $\Sigma F_y=0$ ,  $\Sigma M=0$
3. Can the  $\Sigma F_x=0$ ? => have them do this and see that it can indeed be valid
4. Can the  $\Sigma F_y=0$ ? => have them do this and see that it can indeed be valid
5. Can the  $\Sigma M=0$ ? =>
6. See if they start taking moments about a point. If they do not, then have them start, and see that it cannot be in equilibrium.

### Problem E1

How would you change the direction of the force at point 2 so that the sum of the moments would be equal to zero?

E1B) Would the object then be in equilibrium?



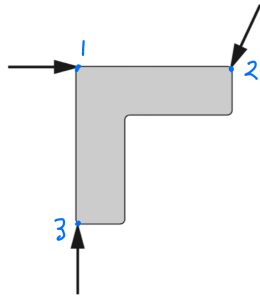
Hints if the student has the in incorrect solution

1. What would happen if the force at 2 points down? Would the sum of the moments be clockwise or counterclockwise?
2. What would happen if the force at 2 points up? Would the sum of the moments be clockwise or counterclockwise?
3. How could you create zero moments?
4. What would happens if the force at 2 points to the left?

### Problem E2

How would you change the direction of the force at point 3 so that the sum of the moments would be equal to zero?

E1B) Would the object then be in equilibrium?



Hints if the student has the in incorrect solution

1. What would happen if the force at 3 points to the right? Would the sum of the moments be clockwise or counterclockwise?
2. What is required for the moments to equal zero when there are 3 forces on a body?
3. Consider taking the moments about any point for which the force does not go through.
4. Explain, that all 3 forces must go through a single point if their combined moment is zero.

**Appendix III:**

**Post Assessment Survey**

## Fall 2021 Post-Assessment Survey

Your instructor would very much appreciate that you complete this brief survey, as it is critical to improving educational methods. Participation is voluntary and will in no way impact your grade or class standing. Your course instructor(s) will only receive de-identified (anonymous) feedback and results from this survey.

This research study has been reviewed and approved by the [Redacted] Human Research Protection Program. For more information about this study please see: [Redacted]

Identifiable information collected through this form will only be available to a small group of pedagogical researchers; strict research protocols are in place to ensure the confidentiality of your identifiable information. If you decide after you complete this survey that you wish to remove your data from the research study please email [redacted]. This opt-out information is also on your course Canvas page.

Please do not complete this survey if you are under the age of 18.

Thank you!

(Before you begin the survey, please verify that your own UCSD email is displayed below)

### Survey Questions

#### Overall Questions

1. I find the course material interesting and engaging (Strongly Disagree ... Strongly Agree)
2. What do you see as the learning benefits of this course?
  1. 100% Solve Course Problems
  2. 75% Solve Course Problems and 25% Apply Concepts to New Areas
  3. 50% Solve Course Problems and 50% Apply Concepts to New Areas
  4. 25% Solve Course Problems and 75% Apply Concepts to New Areas
  5. 100% Apply Concepts to New Areas
3. How much time did you spend preparing for the class assessments in the past week (can include oral and written combined)?
  1. 0 - 2 hours
  2. 2 - 5 hours
  3. 5 - 10 hours
  4. 10-15 hours
  5. More than 15 hours

#### Question for Those That Only Took Written Exam (Question will direct to appropriate section)

4. The stress during the written exam was excessive (Strongly Disagree ... Strongly Agree)

**Question for Those That Took Written and Oral Exam (Question will direct to appropriate section)**

5. Who administered your oral exam?
  1. Professor/Instructor
  2. TA, Reader, or Tutor
  
6. The stress during the oral assessment exam was excessive (Strongly Disagree ... Strongly Agree)
  
7. Interaction with a Prof/TA/Tutor/Reader during oral exams increased my motivation to learn (Strongly Disagree ... Strongly Agree)
  
8. I studied harder for my written assessment because I knew there could be an oral assessment. (Strongly Disagree ... Strongly Agree)
  
9. Describe how your preparation for the oral assessment differed from preparation for a written exam? (free response)
  
10. Please rate the Prof/TA/Tutor/Reader who administered your oral exam in the following areas (Very Low to Very High)
  1. Clarity of speech
  2. Being respectful
  3. Being fair (no bias)
  4. Mastery of course content
  5. Provided sufficient time for me to solve problems on my own
  6. Provided useful hints when needed
  7. Provided useful feedback about my performance
  
11. Is there anything else that you would like to share with us about the oral assessment (including the positive aspects and areas for improvement)? (free response)