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Impact of Oral Exams on a Thermodynamics Course Performance

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Abstract

Oral exams are more commonly used in graduate level courses, as the exams usually demand in-depth preparation and different skills other than written tests, and they usually serve as valuable practices for future professional activities. Yet oral exams can also be beneficial to lower division undergraduate students, since they can provide instructors direct and dialogic feedback, as well as provide an excellent opportunity to immediately correct any major misconception.

In this pilot study in Spring 2017, the author introduced oral exams into a junior level mechanical engineering course--"ME 301: Thermodynamics I"—at California State Polytechnic University, Pomona (Cal Poly Pomona). Thermodynamics is a major bottleneck in many mechanical engineering programs. It is taken by third-year mechanical engineering and civil engineering students and is characterized by high enrollment and high-repeat rates (30%).

A voluntary oral exam was introduced to students after the midterm exam. During the oral test, students were given problems of similar difficulty level as the examples discussed in class. Students were given 8 minutes to work out the steps to solve the problem without calculating any number. Students' performance was graded to receive up to 5% extra credits towards their overall grades. Scores in the midterm and final exams, as well as overall course grades were collected to compare between students who took oral exams (Group A) and those who did not (Group B), while student perceptions of the course were also examined using surveys. 40 out of 76 students (52.6%) participated in this oral exam. While the midterm exam showed that students from Group A performed slightly better than those in Group B on average, the difference was not statistically significant (t-test, $p>0.05$). In the final exam, however, Group A outperformed Group B with an average score of 46.9 compared with 28.2. The result was statistically significant ($p=0.0001$). As to the overall grade, only 2 out of the 40 students in Group A (5%) received a D/F rate, while 19 out of 36 students in Group B (52.8%) received a D/F rate. The average letter grade of Group A was B-, while the average grade of Group B was D+. As to the survey, 16 students from Group A responded, while only 2 students from Group B responded. Students from Group A tended to feel the class more friendly, supportive, and their effort was appreciated. They also considered that the oral exam was helpful for their understanding of the content. The results from this preliminary study suggest that the adoption of oral exams has the potential to positively impact student performance in the thermodynamics course.

1. Introduction

An oral exam is a type of assessment in which the instructor poses questions to the student verbally. The student must answer the question to demonstrate sufficient knowledge of the subject to pass the exam[1]. Many researchers argue that oral exams, combined with other evaluations, are ideal for achieving higher levels of student understanding[2]. The potential benefits of oral exams are better preparation for the exam, immediate feedback for both instructors and students, long term retention of academic concepts, improvement in communication, reduction in academic dishonesty, and encouraging critical thinking[3, 4, 5].

Oral exams are most commonly used in graduate school, where a student's research is presented and followed by questions from faculty members. Despite their benefits, oral exams are used much less frequently compared to written tests for the evaluation of undergraduate students due to time restrictions for large classes, low degree of objectivity in evaluation, and anxiety affecting those who are unfamiliar with the format leading to a poor performance that does not reflect the students' actual ability[3,4,5]. An oral exam format is most often seen in business school[6,7], law school[3], and in some other social science majors[8], where case analysis is often part of their tests.

On the other hand, traditionally, written tests are more preferred in science and engineering classes. The less adoption of oral exams as an evaluation tool could be contributed to the nature of engineering problems, which very often require derivations and calculations. Because of this, it has not been difficult to generate written questions to assess the students' ability of critical thinking and higher levels of understanding. While oral exams could potentially add some values in evaluating students' performance in addition to the traditional written tests, they were less utilized due to the considerations mentioned above, especially because of their time-intensive nature and sometimes low degree of objectivity in evaluation. As a result, despite a few reports on oral exams being used in classes[4], written tests are still the mainstream of assessment.

In this study, the author introduced a voluntary oral exam in a junior level mechanical engineering course--"ME 301: Thermodynamics I". The impact on the grade performance and students' attitudes was evaluated. Since the process involved subjectivity in performance evaluation, the author's feedback was also examined. It is hoped that this study could serve as a blueprint for other instructors who would be interested in implementing oral exams in a thermodynamics course.

2.1 Description of course

ME 301 (Thermodynamics I) is a 10-week course for both mechanical and civil engineering students at Cal Poly Pomona that introduces students to core topics in energy, substance properties and engine cycles. Students attend class for three 65-minute sessions per week, and there are no discussion sections. Homework consists of reading assignments and problems from the textbook. The assessments are usually a combination

of in-class or online quizzes, midterm exams, and one final exam. The overall letter grade is given based on the performance in different assessment, shown in Table 1.

Table 1. Weighting of graded assessments for Spring 2017

Homework problems (online)	7%
Reading Assignment (online)	7%
Quizzes (4 total)	16%
Midterm exam (1)	30%
Final exam (1)	40%

Historically, ME 301 has been a significant bottleneck due to high enrollment and high repeat rates. Table 2 shows that among the 3106 students enrolled in ME 301 from Fall 2008 to Winter 2017, 29.56% received a D, F, or withdrew (W). The average GPA was 1.97, slightly short from a flat C.

Table 2: Grade distribution for ME 311 students from Fall 2008 to Winter 2017

Grade	Number of students
A	409 (13.17%)
B	663 (21.35%)
C	1116 (35.93%)
D/F/W	918 (29.56%)

2.2 Introduction of the Oral Exam to course

In Spring 2017, two sections of ME 301 were taught by the author. After midterm, in week 6, a voluntary oral exam was offered to all the students to earn up to 5% extra credit towards their overall grades. Students scheduled to meet with the instructor outside class on a one-on-one basis. During the oral exam, they were given 8 minutes to solve one problem, which was similar to the examples discussed in class. Though they were only asked to work out the process without calculating any number, they had to explain why they chose to apply certain equations. They were not allowed to bring any note, but they would be provided with charts or tables when necessary. The grade was given based on accuracy and completion of their answers. By the end of the oral exam, the instructor also made comments on students' performance and provided suggestions on how they could improve their study methods to prepare for the final exam.

3.1 Results

There were 18 out of 39 (46.2%) students in section 01 and 22 out of 37 (59.5%) students in section 02 participated in the oral exam, which made up an overall 52% participation rate (Table 3). These students are referred as Group A in this report. Those who did not participate in the oral exam are referred as Group B.

Table 3. Participation of Oral Exam in different sections

	Total Students	Group A (Took oral exam)	Group B (Did not take oral exam)
Section01	39	18	21
Section02	37	22	15
Total	76	40	36

Student performance on the midterm and final exams in Spring 2017 is presented in Figure 1. Before taking the oral exam, Group A performed slightly better in the midterm exam (53.8) compared with Group B (46.3), but the difference was not statistically significant (p=0.06). By the end of the course, Group A performed much better in the final exam on average (46.8) compared with Group B (28.2). The average of the final exam score among Group A was 66% higher than that of Group B students. And the result was statistically significant (p=0.0001).

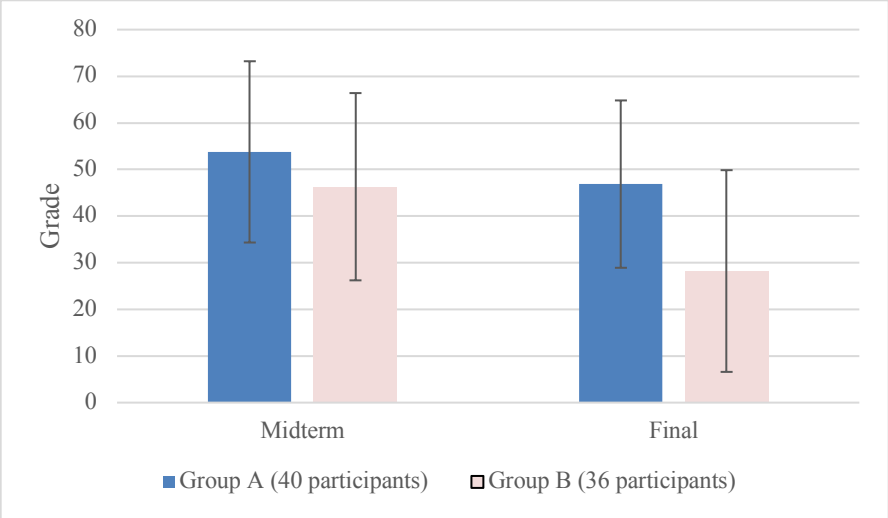

Figure 1: Student performance on the midterm and final exams. The bars and whiskers represent the mean scores and 1σ values, respectively. A t-test reveals that the difference between the two groups is statistically significant at the 95% confidence level for the final exam (p = 0.0001), but not the midterm (p = 0.06). All t-tests were one-tailed for this report, unless otherwise indicated.

The grade of each group is also normalized by dividing the average grade of all 76 students. This way of comparison gives a sense of how each group performed compared with the overall average. In Figure 2, it shows that in midterm, Group A performed slightly better (7%) than average while Group B was 7% below average. But the gap between two groups was not significant (p=0.06). By the time of the final exam, Group A's performance improved to 26% above the overall average, while Group B dropped down to 74% of the overall average grade. And this difference was significant (p=0.0001). It seems that after the oral test, the performance of the two groups performance split even more: Group A students improved after the midterm while Group B students fell behind on average.

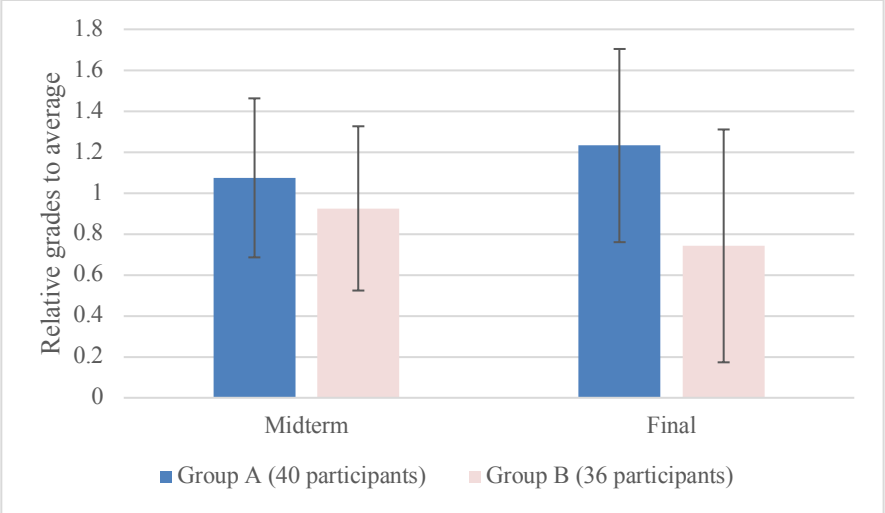

Figure 2: Normalized student performance on the midterm and final exams. A t-test reveals that the difference between the two groups is statistically significant at the 95% confidence level for final exam ($p = 0.0001$), but not for midterm ($p = 0.06$).

The higher exam scores also helped Group A result in a lower repeat (D and F) rate (5%) comparing to Group B (52.8%), as shown in Figure 3. This good performance in Group A lead to an average letter grade of B+ (GPA 2.74), whereas Group B achieved an average letter grade of D (GPA 1.28).

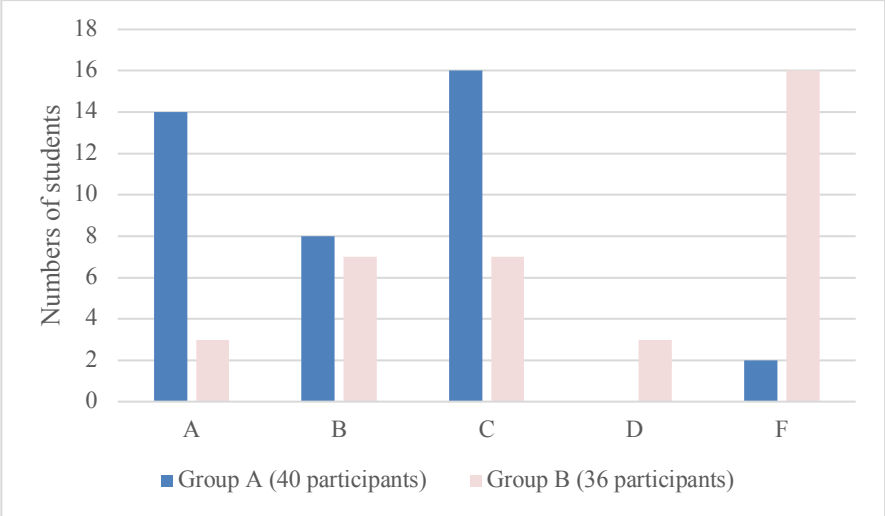

Figure 3: Overall course grades distribution. Group A had a significant lower rate of D and F scores (5.0%) comparing to Group B (52.8%).

The big difference between the average GPA of the two groups was possibly contributed by the extra credit that Group A received from participating in the oral exam. Averagely Group A received 4% extra credit from the oral exam. Another overall grade distribution is achieved by deducting the extra credit of the oral exam from Group A, and result is shown in Figure 4. After removing the contribution by the oral exam credit, Group A would have 4 more students receiving a D/F grade, which would have increased the D/F

rate to 15%. The GPA of the class would also have dropped down to 2.48 compared to 2.74 previously.

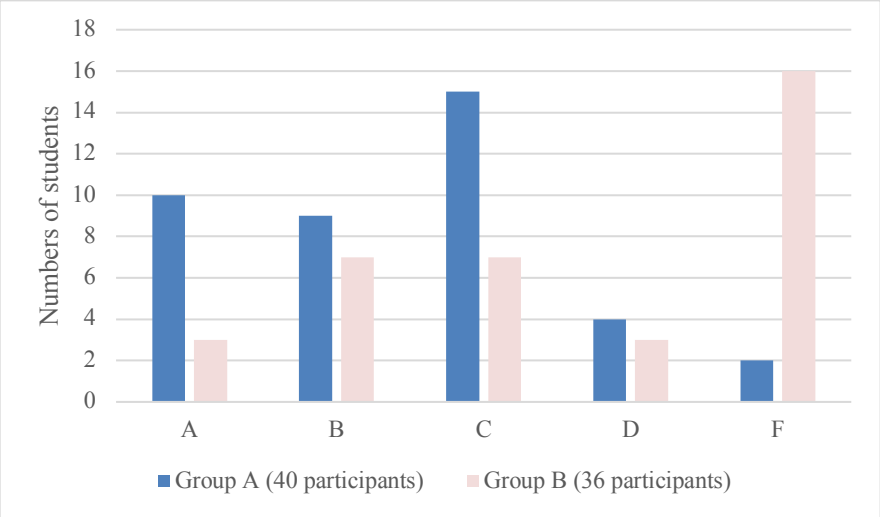

Figure 4: Overall course grades distribution after removing the extra credit effect from the oral exam. Group A still had a significant lower rate of D and F scores (15.0%) compared to Group B (52.8%).

A survey was administered by the end of the course asking about students' attitudes, feelings, and perspectives. 16 students from Group A responded (40%), while only 2 students from Group B responded (5.5%). It seems that Group A students tended to feel that the class was more friendly, supportive, and their effort was more appreciated. The low responding rate from Group B seemed to imply that Group B students were less engaged in the course. However, since the number of responded survey was small, the result cannot reflect the attitude of the whole class.

A focus group administered indicates that the students who took the oral exam mostly had positive opinions toward it. Most of them felt that the oral exam was helpful as it forced them to study harder to get prepared. Many of them pointed out similar idea, such as "if you can explain something then it means that you actually know it", "It helped me realize areas I had misunderstood without realizing I had. It also filled up certain gaps and corrected issues with the way I tackled the problem". There is also a proof that the personal interaction during the exam can provide a positive effect on the student's perspective and performance in the course, as one student pointed out, "At the time I was struggling a bit in the class and the professor's input restored my confidence and gave me tips on what I should work on. I think for that reason I was able to pass the class". At the same time, many of them considered that the oral exam made them "nervous". One student noted, "My biggest issue was that I knew the material, just under pressure I would forget how to apply it." Besides, another student had concerned about the subjectivity of evaluating the oral exam performance and suggested "Since everyone got a different question the effect it had on peoples' grades was somewhat random. A curve would probably have been a better solution."

3.2 Role of voluntarily in the overall course grades

One big factor to consider is that the oral exam was offered as a voluntary method to earn extra credits, which means that the students could choose to take it or not. This factor could naturally separate students, as the ones who cared more about their grades in class would tend to participate in the oral exam in order to earn extra credit (Group A). In Figure 1, it is shown that Group A did perform better than Group B in the midterm exam, though the difference was not statistically significant. Besides, Group A entered class with an average GPA of 3.29 while Group B entered with an average GPA of 3.04. And the difference in GPA prior to class was statistically significant. ($p=0.009$).

3.3 Role of major in overall course grades

ME 301 was served not only to students in mechanical engineering (ME) major, but also to students in civil engineering (CE) and manufacture engineering (Manu) majors. ME 301 served as a pre-requisite to the ME students, whereas it only serves as required tech elective course for other majors. This could greatly alter the students' perspectives and motivation in the class. The difference in the oral exam participation rate among different majors reflected this difference in attitudes. Table 4 shows that there were 36 out of 62 ME students (58.1%) chose to take the oral test. But only 4 out of the 14 non-ME students (28.6%) participated in the oral test.

When comparing their performance in exams, Figure 5 shows that averagely ME students performed better in the midterm and final exams. Yet only in the final exam, ME students performed significantly better ($p<0.5$) compared to the non-ME students, but not in midterm exam ($p>0.5$). ME students finished with a better overall grade in class with a GPA of 2.2, comparing with the non-ME students with an overall GPA of 1.7. However, the result of difference in GPA was not statistically significant. There could also be errors in the comparison due to the small population of non-ME students in class.

Table 4. Major distribution in different sections and Participation of Oral Exam in different majors

	Total Students	**Total ME Major**	**Total non-ME Major**	**ME Major in Group A**	**Non-ME Major in Group A**
Section01	39	26	13	15	3
Section02	37	36	1	21	1
Total	76	62	14	36	4

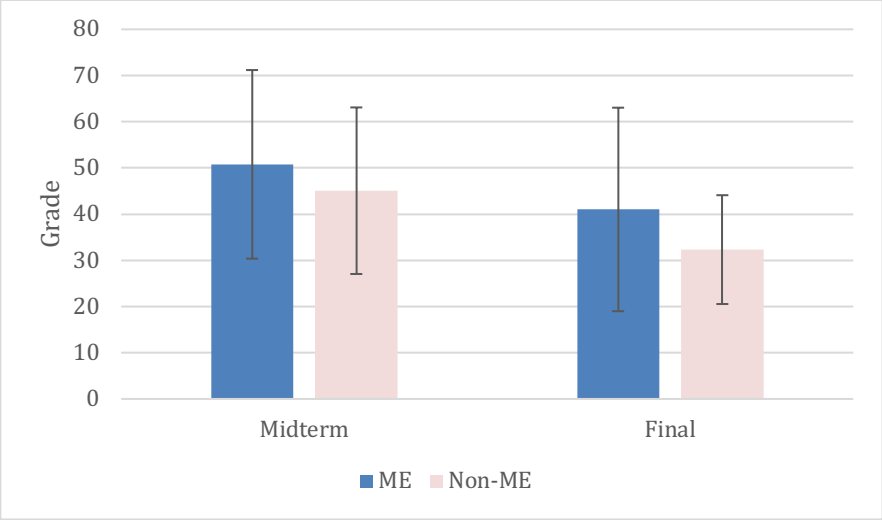

Figure 5: Student performance on the midterm and final exams. A t-test reveals the difference between the two groups is statistically significant at the 95% confidence level for the final exam ($p = 0.023$), but not in midterm ($p = 0.15$).

3.4 Role of gender in overall course grades

In Spring 2017, there were 14 female students in the two sections, which counted for 18.4% of the overall population. As shown in Table 5, 7 out of the 14 female students (50%) participated in the oral exam, while the participation rate of male students was 53.2%. When comparing female students' performance on exams, Figure 6 shows that averagely, female students scored slightly less than the male students in the midterm, and both genders scored nearly the same in the final exam. However, neither of the difference was statistically significant. The female students received a better overall grade in the course with a GPA of 2.28, comparing with the male students who received an overall GPA of 2.06. This could be possibly contributed by female students' better performance on quizzes and homework. But again, the difference in GPA was not statistically significant. During this period of the study, gender did not seem to be an indicator of grade in this class. Nevertheless, the population of the female students in class was also small and it could affect the accuracy of the results.

Table 5. Gender distribution in different sections and participation of Oral Exam

	Total Students	**Total Female**	**Total Male**	**Female in Group A**	**Male in Group A**
Section01	39	9	30	4	14
Section02	37	5	32	3	19
Total	76	14	62	7	33

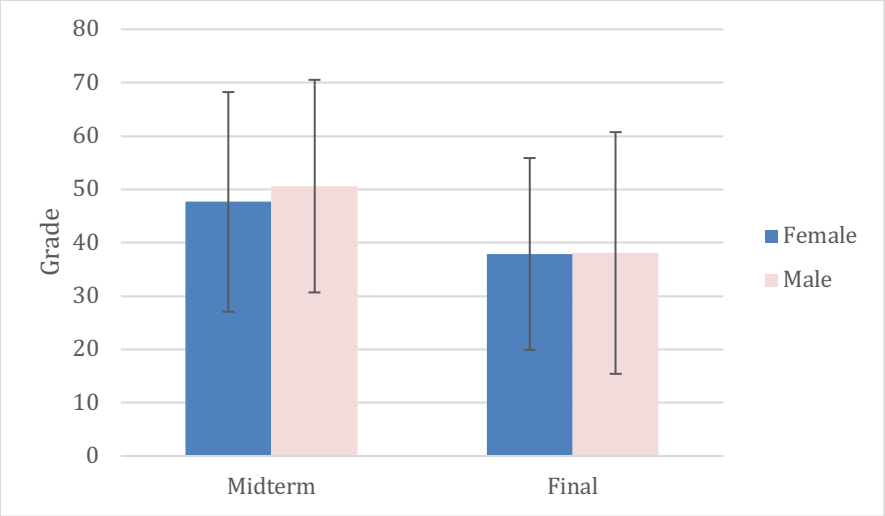

Figure 6: Student performance on the midterm and final exams. A t-test reveals the difference between the female and male groups is not statistically significant at the 95% confidence level for either the midterm ($p=0.32$) or the final exam ($p = 0.49$).

3.5 Other Factors that may alter the results

The students' compositions, such as races, and prior GPAs, were different between the two sessions of class. Yet there was no significant difference between the two sections when comparing distribution of students' prior GPA or their final grades ($p>0.1$). Moreover, GPA of a student prior to this class did not seem to predict how well they performed in this class.

4. Discussion and future work

In this pilot study, a voluntary oral exam was performed in the course ME 301. The group of students who took the oral exam tended to perform better in the class and they seemed to improve their score after the midterm exam. Though there were a lot of other factors that could contribute to this result, such that students in Group A might already had a stronger ability in engineering study, at the very least, we can conclude that oral exam did not pose a great risk to students' academic performance and perceptions of the course. It also appeared that students in Group A were more willing to participate in class, as seen from the survey participation rate, and felt more positive towards the course.

From the instructor's perspective, this oral exam was helpful to learn more about each student. While teaching 76 students in ME 301, it was almost impossible for the instructor to interact with each individual or to provide feedback on each student's performance, especially of those who are too nervous to speak in class or too shy to actively seek help after class. During the interaction in the oral exam, it was much easier for the instructor to learn how much students knew about the content and to point out the students' strength and weakness in analyzing problems. And it was much easier to reach out to students who would not actively seek help from the instructor. By learning more about the students, the instructor would be able provide more constructive advice and encouragement to the students. The personal interaction might make students feel

encouraged or motivated to study harder, to learn that they needed to practice more efficiently, or to take other adjustment in their current study methods. Or even, they might just feel more comfortable sitting in the classroom and be more focused to the lecture. This positive change in attitude toward the class, in the author's personal view, might also contribute to the improvement of Group A in the final exam and their overall performance in the course.

This pilot study gives the author an initial experience in executing an oral exam in ME 301. Based on the positive results obtained during this study, the author will attempt to carry on with this method into future ME 301 classes. Data will be collected over a longer period to get a larger sample size in order to gain more insight of this method.

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