



Implementation of Mock Exam Structure for an Introductory Engineering Course

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Work-in-Progress: Implementation of Mock Exam Structure for Introductory Engineering Course

Abstract

This work in progress paper analyzes the impact of collaborative mock exam review participation on academic performance in an introductory computing course. In fall 2019, 65% of students enrolled in the course attended two or more of the three total exam reviews offered, and showed an increase in overall course grade GPA with weak statistical significance. When comparing course performance using predictors of preparedness for college (SAT scores), those exam attendees (attending 2 or 3 exam sessions) outperformed their non-exam (attending 0 or 1 exam session) attending peers with similar scores. Qualitative survey data indicated strong positive perceptions of the collaborative exam review and its impact on students' study time and use of effective study strategies.

Introduction

In the summer of 2019, our research collaborators attended the Annual ASEE Conference and in particular, a session presentation on the use of collaborative practice exams in historically difficult introductory math and science courses at the University of Kansas [1]. The method implemented by this team is detailed in their paper and described below.

The collaborative mock exam review consisted of three phases:

1. First, students work independently through the exam for 30-40 minutes, as they would during the actual exam. No assistance is provided other than clarifications, similar to the real exam.
2. Next, students work collaboratively with their peers at their table for 30 minutes. Again, during this time students are not given assistance from instructors.
3. Lastly, a student instructor lists answers to the exam (not the solution) and students self-grade their work. Then members of student organizations with exam solutions arrange themselves around the room and work through problems on boards. Participating students can move around the room, viewing solutions to problems with which they had difficulty. This section can range up to one hour, but students stay as long as they need to get their questions answered.

The required introductory courses for our Electrical and Computer engineering students, including Introduction to Computing, also report high percentages of D's, F's, Q's (drops), and W's (withdraws). The impressive results seen from the aforementioned article inspired the research collaborators from the University of Texas at Austin to implement the collaborative mock exam session protocol prior to each of the midterm exams of our introductory computing course, EE 306, with a few changes in our implementation.

Seminal papers by Karpicke and Roediger [2] and Karpicke and Grimaldi [3] provide extensive evidence for the positive impact of retrieval practice, as opposed to the common practice of repetitive study time. These research articles indicate that multiple rounds of retrieval practice for students on even complex, exam-type questions can have the largest impact on overall learning gains. Felder and Brent [4] encouraged providing multiple opportunities for students to practice varied retrieval, explaining that desirable difficulties will assist them in being successful in their current courses but also shift their perceptions, awareness and use of effective strategies for all types of learning.

Exam reviews are a common support intervention offered within and across courses, sometimes supported by departments, learning centers and success centers. Most exam review formats utilize the lecture or direct teach format, with instructors reviewing material, solving and explaining problems and students following along. When testing the differences in active vs passive exam reviews, Balch [6] found that students of all academic ability benefitted from active exam reviews and outperformed those who participated in typical (passive) exam reviews.

Shew et al.[2], were able to compare students with similar ACT scores and found a more pronounced positive effect on average end of semester course GPA for those who attended the exam reviews compared to those who did not. As the collaborators are aiming to improve grade outcomes in first year engineering courses and in turn retain more students to the engineering program, we compared attendees vs non-attendees grade outcomes using SAT/ACT scores for a more accurate reflection of the effects of the exam review. This report investigates the effects of the collaborative mock exam review on student grade outcomes. The study utilizes a quantitative approach, incorporating data relating to grades and attendance with data relating to student perceptions about the impact of the exam review to their performance on the actual exam, as well as changes to their study approach.

Motivation for Study

As student retention and four-year graduation rates in engineering are of continued interest and concern at our university, a collaboration between the Cockrell School of Engineering and the Sanger Learning Center continues to work on effective interventions that will promote student learning and positive grade outcomes in first year engineering courses. This historically difficult course (EE 306) has warranted multiple forms of academic support, including undergraduate TA office hours, tutoring and Supplemental Instruction (SI). Careful attention has been paid to individualize these programs to emphasize the content and study skills students need to be successful in these specific courses. Encouraged by Shew et al's findings [2], we wanted to implement the collaborative mock exam reviews as a new and innovative option to assist students in their planning, preparation and overall actual exam performance.

Limitations of Study

Limitations of assessing correlations between grade outcomes and exam review attendance occur due to the voluntary nature of offered exam reviews. In order to control for self-selection bias, we considered standardized test scores (SAT scores) as indicators of student preparation for college level coursework. Therefore comparing students with similar scores will provide a more accurate measure of the impact of the exam review. However, this only accounts for one of a multitude of factors that could impact grade outcomes, including student's prior educational experiences, variations in the student preparation, access to resources and resource-seeking behaviors, overall motivation and mindset. These factors make a causation-based analysis of overall course performance and exam review attendance difficult.

A review of the current literature revealed no one standard for comparing students according to their attendance to multiple exam reviews. Considering the lack of a consistent n-value for exam review attendance, we defined the "exam" group as students attending 2 or 3 collaborative mock exam reviews and the "no exam" group attending 1 or none. We considered attending one exam review as not receiving the intervention, as the student would have completed the structured, timed retrieval practice only once, which would most likely not produce significant learning gains.

Definitions Used in Study

The following terms utilized in this study are defined according to the authors' and the university's use:

- Q-Drop: students may leave a course after the 12th class day with a "Q" noted on their transcript [17].
- QDFW% rates: the percentage of students in the course who Q-dropped the class, made a D, F, or withdrew (and received a W on their transcript), in comparison to the whole student population for that course.
- "Exam" group: students who attended 2 or more exam reviews;"non-Exam" group: students who attended 1 or no exam reviews.

Research Questions

To assess the impact of the collaborative mock exam reviews on participants, this report addresses the following questions:

- 1] Is there a difference in DFWQ rates between students who attended the majority of exam reviews offered versus students who did not attend the exam reviews?
- 2] Is there a course GPA difference between students who attended the majority of exam reviews offered versus students who do not attend the exam reviews?

3] What are the overall perceptions and perceived benefits of the exam reviews by participating students?

Design and Implementation

Shew et al.[1] detailed the protocol for creating and implementing the collaborative mock exam review structure, which our university collaborators followed closely with a few modifications. The collaborators implemented this initial pilot for EE 306, as the course is capped at under one hundred students and is also taught by one of the collaborators. Close contact and communication between the staff member and faculty member facilitated the administrative and logistical tasks required to conduct the exam review. The mock exam was created by the faculty member which closely resembled material and format of problems from the upcoming exam about a week prior to the exam review, and the staff member produced marketing materials for promotion and oversaw the overall exam review space and logistics.

With limited collaborative learning space, the learning center's drop-in tutoring center fit the expected number of attendees. Thus, the exam review did not require registration, simply accurate capture of attendees, using our attendance collection system. Using predetermined engineering undergraduate and graduate TA support for the course to proctor the mock exam sessions, as well as conduct the third portion of the exam review meant the cost of the program was kept to a minimum. The commitment of the faculty member in developing the mock exam and the professional staff member developing marketing materials and overseeing the mock exams was determined to be a worthy investment of time.

One week before the actual exam, students were made aware of the collaborative mock exam review, both by in-class faculty announcement, Canvas announcement reminders from the TAs and marketing materials detailing information about the exam (date, time, location) and structure (1.5 hours total, with three thirty minute sections). The reviews were conducted in an active learning space with movable white boards around the room, where students sat at moveable table/chair combinations facing each other. Exams supplied by the faculty member and copied by the staff member were distributed to students after a short set of instructions about how to follow the exam protocol.

Shew et al.[1] did not allow students to take photos of the mock exams at their exam reviews. The faculty member collaborator maintained the no-photo rule, but amended the option to post the exam; after the review session, the exam was posted online along with answers (but not solutions), should students who were not able to attend the practice exam still wished to test themselves. Additionally, the mock exam was made a homework assignment, but only for a completion grade. In this way, the majority of students enrolled in the course would have worked through the mock exam, but not all received the specific intervention of the collaborative mock exam review protocol. This further establishes the possibility of the structure of the mock exam

having impact on actual exam performance versus the simple act of exposure to exam-type problems.

Our mock collaborative exam review consisted of the same three parts as Shew et al's (2019) protocol, but for one major difference. During the first exam review, students moved about freely to the boards of their choice to watch the TAs and look over the solutions. However, this created inequities in times spent on each problem and difficulty for the TAs to complete solutions for all problems. So in the second and third exam review, the third section was further broken down to 10-12 minute increments and students rotated around 3 stations, where each station had 1-2 problems detailed and explained. This period was usually 45 minutes total, but students were able to stay until all their questions were answered.

At the end of the semester, the staff collaborator collected all three exam reviews' attendance data, end of course grades and GPA, SAT scores and student demographic data. A survey was created and sent to all exam review participants, to collect qualitative data on student perceptions of the exam review, aspects that were most beneficial and feedback on how to improve the intervention.

Methodology

This study uses a quantitative approach to investigate the research questions. By collecting both quantitative and qualitative data we gained a better understanding of the student population choosing to attend the collaborative mock exam reviews, their motivations for attending, and the perceived value of the reviews. Considering a combination of quantitative and qualitative measures, we took a quantitative approach to examine the relationship between exam review attendance and student's overall course performance.

As the intervention is aimed at reducing the DFWQ rates in first year engineering courses and in turn retain more students to the ECE program, the collaborators collected multiple types of data, including students' exam review attendance and grade outcome in the course, students' demographic data, and the DFWQ rates for attendees and non-attendees. As mentioned in the limitations section, the voluntary nature of the reviews does create some difficulty in making a direct link between exam review attendance and student success. Therefore, we used SAT scores to group students with similar high school preparation, for a more accurate reflection of the effects of the exam review. Qualitative data was collected in the form of end of semester surveys administered to attendees, less than one week after the actual exam.

Quantitative Data Collection

Two forms of quantitative data were collected:

1. Exam Review Attendance: students signed in with their university unique identification number.

2. Grade Data: course letter grades and GPAs for all students enrolled in the course were gathered.

Students attending zero or one exam review were categorized as the *no exam group*, whereas repeat attendees (those attending two or three of the exam reviews) were categorized as the *exam group*. With these definitions, the quantitative data focuses on the outcomes for students who showed investment in using this resource versus those who did not. To examine the effects of the collaborative mock exam review on student academic performance, course grades were converted from nominal to ordinal data as per the university's numerical grade point equivalents.

Qualitative Data Collection

Qualitative data was used to answer research questions regarding students' perceptions of the exam reviews, its influence on change of study method or exam preparation, and the perceived benefits of the exam review by participating students. The method of qualitative data collection was through post-surveys. The survey consisted of 15 questions and was administered about one week after the actual exam, but prior to students receiving their actual exam scores. In general, the survey collected students' names and university identifier numbers, and then polled the students on how they learned of the exam review, their thoughts on each component of the collaborative mock exam review structure and the students' perceptions of if and how participating in the mock exam review impacted their actual exam performance. Students who participated were asked to rate the usefulness of each aspect of the exam, such as the collaborative section and the TA-led solutions section. One issue that arose was that no surveys were collected after the third exam review. While the survey link was sent to participants, we are unsure if there was human or technological error that either did not correctly send the survey or collect responses. We report on the first two post-exam reviews surveys below.

Findings and Discussion

The first exam review had the highest attendance, with more than 60% of enrolled students participating in each of the exam reviews offered throughout the semester, and 65% of the total enrolled students attending two or more of the three offered exam reviews. This high attendance rate indicates that the exam reviews were perceived as useful and effective by the students.

In Figure 1, we compare the DFWQ rates between the *no exam* and the *exam groups*. We see that attending two or more of the three offered exam reviews reduces the failing rate by more than half (from 30% to 14%), suggesting that there is a relationship between attendance and course completion. Chi-square tests revealed that the differences between the percentages of students passing and failing the courses for the two groups (*no exam* and *exam groups*) was moderately statistically significant (p value = 0.056204).

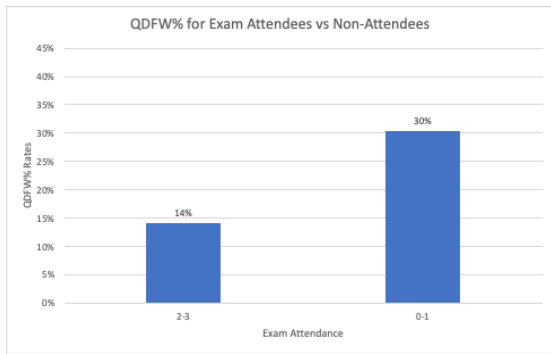


Figure 1: Comparison of QDFW rates for EE 306 for exam group vs no exam group, Fall 19
 chi-square test p value = 0.056204

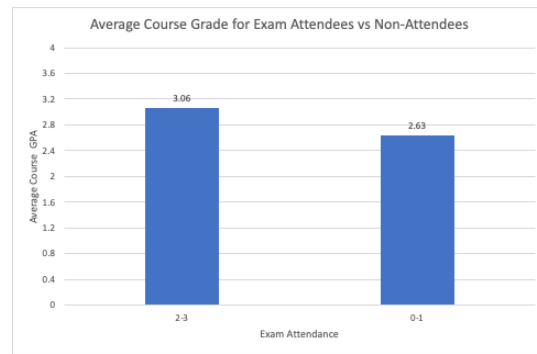


Figure 2: Comparison of course GPA for EE 306 for exam group vs no exam group, Fall 19,
 t-test p value = 0.0832918 (weak statistical significance)

When we compare the *exam group*'s overall course GPA to the *no exam group*, we see a weak statistically significant difference, in favor of the exam group. Figure 2 demonstrates this, with a p-value of 0.0832. Many critics of voluntary support programs attribute any positive impacts to self-selection. Therefore, students who come to the university highly prepared either use these services at higher rates or may not seek out any support, but still perform well in the course. In an effort to better compare student performance based on predictors of preparedness for college, all enrolled students in the class were divided into three groups, each with a 100 point range of SAT scores and then analyzed for course GPA between *no exam group* and *exam group*. As seen in Figure 3, the data shows for every SAT category, the exam group outperformed the non-exam group and that students in the lower SAT categories (which we interpret as being underprepared) see the biggest gains from attending two or more exam reviews by having higher course GPAs than their counterparts who did not attend exam reviews. Statistical analyses (such as t-test and chi-square test) did not reveal significant differences, which could be attributed to the small data set.

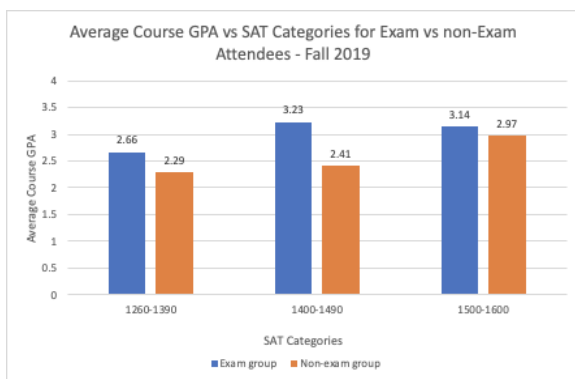


Figure 3: Comparison of average course GPA for EE 306 for exam group vs no exam group, for different SAT score ranges, Fall 19

These results more accurately reflect our predictions of the impact of regular retrieval practice when comparing students with similar preparedness and show students who may come in underprepared to The University of Texas at Austin benefit most from these interventions.

To address our third research question (What are the overall perceptions and perceived benefits of the exam reviews by participating students?), we reviewed answers from the post-surveys that were administered after the first and second collaborative mock exam review (the survey was not correctly administered after the third exam review). Of the participants surveyed, 68.7% of participants completed our surveys. Several questions are detailed in Table 1 (Appendix), showing several aspects of student perceptions of the collaborative exam review. One positive outcome is that there was an increase in the number of survey participants that SA/A that “I felt the second 30 minutes, where I collaborated with others, was a good use of time”, perhaps showing a shift in perception about collaborative study to a more positive outlook. Lastly, the last question has a much lower SA/A percentage than the others, “Taking the mock exam made me change my study strategy”, it is still an impressive result, in light of research that shows most undergraduates are not metacognitively aware of which study strategies are most effective [6]. We see this as an important measure of impact, as the act of retrieval and assessing what they know and don’t know possibly contributed to the success of the students who participated. We are encouraged by these results and will continue to analyze these trends to better understand students’ motivations and perceptions of the collaborative mock exam review.

Summary and Future Work

We have outlined our implementation of a mock exam review session for an introductory engineering course in computing selected for this research because of its high DFQW percentage. The structure of these sessions was based on practice exams offered in engineering courses at the University of Kansas [1], with a few changes made to further the learning experience of the students. Both quantitative and qualitative data were used to assess the impact of these sessions on student preparation and performance. The following are our main takeaways:

- (i) The majority (~ 60%) of the students participated in all the *optional* mock exam review sessions, and almost all of them considered the sessions to be a good use of their study time.
- (ii) Attending two or more mock exam sessions improved the DFQW percentage dramatically, making this a very promising success program.
- (iii) The mean course GPA of those students who attended the majority of the sessions was 16% higher than those who did not attend. Further, the biggest impact on GPA was seen in the students with the lower incoming SAT scores.

In the future, we plan to continue implementing this intervention for this course and assessing the longitudinal effects to students’ grade outcomes and study effectiveness.

References

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Appendix:

	Strongly Agree/Agree	
	Exam 1	Exam 2
The content of the mock exam was relevant to the actual exam.	93%	87%
The mock exam I attended was a good use of my study time.	97%	97%
I felt the first 30 minutes, where I worked alone, was a good use of time.	94%	82%
I felt the second 30 minutes, where I collaborated with others, was a good use of time.	79%	86%
I felt the third 30 minutes, where I watched the TAs work out solutions, was a good use of time.	97%	93%
Taking the mock exam made me change my study strategy.	40%	39%

Table 1. Student attendees rating of various aspects of collaborative mock exam reviews, Fall 19