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Relationship between Exam Format and Learning Effectiveness

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Abstract

Closed book and open book exam formats are both commonly used in engineering courses. Recent experience has indicated that open book exams may be encouraging poor study habits, as students tend to overly rely on the textbook while completing the exam, than actually learning the material. This study attempts to explore the relationship between exam format and student learning in two types of learning environments, specifically in a mechanical engineering program: a freshman design course and a junior measurements course. This study is based on the exams of these two courses, by giving and evaluating common problems to all the course sections while using different exam formats. Five sections of the freshman design course were taught by three different instructors. Four of the sections administered an open book final exam, and a closed book final exam was administered to the remaining section. The junior measurements course consisted of three sections which were taught by two different instructors. In one section, the class had an open book midterm and final exams, while the other two sections had closed book exams. The total number of students participating in the freshman course was 106, while the junior level course had 56 students. For consistency in evaluation, the same instructor graded the common problems for all the courses. Student performance for each exam format in both courses was compared, and recommendations for future study are presented.

Introduction

The learning process is a shared responsibility between the instructors, on the delivery side, and the students, on the receiving side. As new pedagogical methods emerge frequently, it seems that the focus has been on the delivery of information without much attention to the students' reception. New pedagogical methods are necessary in order to account for all the distractions that students currently have. Methods to ensure that students are insulated from their social distractions such as tweeting, or updating their Facebook page, while helping them to be engaged in class, are ever more important and call for a lot of innovation (and patience). It seems a logical hypothesis that the format of course exams have an influence on how students will prepare for those exams. For example, does an open-book exam promote poor studying habits due to the reliance of the students on the notes and books during the exam? Or, does a closed-book exam improve students' engagement into their learning?

Certainly, the initial motivation from this study came from our rather frustrating observation that our students would tend to come unprepared to open-book exams. However, a number of factors must be considered when choosing the best exam format for engineering courses. Good reviews of the arguments in the open versus closed-book exam debate were given by Therrialt et al [1] and Anaya et al [2]. It should be noted that most of the research cited by these sources was

related to non-engineering academic fields .A summary of the key arguments in support of open-book exams are as follows:

- The questions on open-book exams tend to be more realistic, and require higher order thinking and synthesis of knowledge from multiple sources
- Open-book exams are more realistic in terms of their relevance to actual engineering practice
- Students are less stressed taking open-book exams because they are not worried about memorizing specific facts
- Closed-book exams tend to encourage "cram and forget" study habits
- An instructor's teaching practices are more driven by the content of the exam questions when closed-book exams are the only form of assessment in a course

On the other hand:

- Students taking open-book exams tend to have a false sense of security and thus don't prepare as well
- Open-book exams often encourage students to waste too much time flipping through books and notes while taking the exam

This last point, that students waste time on reading the text during open-book exams, was supported by the results of Therrialt et al [1], where it was found that "there was a significant negative correlation between the times spent reading the textbook and students' grades".

Anaya et al [2] also noted the importance of student demographics when considering the effect of exam format on learning. Our institution has a very diverse student body, both ethnically and economically. Our students tend to work significant number of hours while attempting to carry heavy course loads. The result is that many students tend to "cut corners" with respect to their academic work.

In the study presented herein, we attempt to conduct an in-class experiment to evaluate the influence of exam-format on the outcomes of the midterm and final examinations of selected freshman and junior engineering classes. First, the experimental procedure and details to evaluate the effect of exam format are discussed. The results are then presented, followed by discussion and conclusions.

Experiment Details

Two engineering classes participated in this experiment: a freshman level class and a junior level class. Computer-Aided Design (CSUN-ME186) was selected for the freshman level; it is worthwhile to note that this class is often taken by sophomore students as well as transfer students from community colleges. ME186 consisted of five different sections taught by three different instructors during the Fall-2011 semester, with a total of 106 enrolled students. Four sections were taught by two different instructors, divided equally. The remaining section was

taught by a third instructor. The class objective is to teach students the fundamentals of engineering drawings and introduce the students to modern three-dimensional solid modeling tools using SolidWorks®. A common question was administered to all students during the final exam only. Four sections had an open-book exam policy, while only one section was given a closed-book final exam. The question type was "Short Answers" based on a student's understanding of engineering drawing format, symbols and rules. This question consisted of thirteen sub-questions focused on the same engineering drawing provided as part of the question. The students were exposed to a similar question format and materials in class-discussions, homework assignments, and midterm examinations. The common question was included as the last question in all the exams, where all questions were a required part of the exam. However, while the exam included other questions, only the common question grades were considered in this experiment. The freshman class did not participate in the midterm exam experiment. The experiment was conducted as a blind-experiment, where the students did not know either before or after the examination of the details of the experiment.

The second class participating in the study was Mechanical Measurements (CSUN-ME335), a junior level class with 56 students enrolled. ME335 was taught by two different instructors and consisted of three different sections. The objective of the class is to familiarize the students with the basics of the measurement process with a focus on the statistical data analysis methods, data reduction techniques, and various measurement sensors. The experiment also took place during the Fall 2011 semester. One common question was inserted as part of the midterm examination. The midterm was administered to all sections, two of which had a closed-book exam while the remaining section was given an open-book exam. The question format required the students to calculate the solution to a problem that was compromised of multiple steps, testing the students understanding of measurement uncertainty and propagation of errors. It is worth noting that a similar question to that included on the midterm was discussed during lectures in the section which took the open-book exam. No similar examples were discussed with the students who were given the closed-book exam. The final exam, alternatively, included three common questions, all of which required calculations. Similar examples were discussed in all three sections during lectures and during review sessions held prior to the exam. ME335 students who participated in the closed-book examinations were supplied with necessary formulas and tables. All relevant formulas and tables for the whole course were compiled into one packet.

In order to control as many experimental variables as possible, the grading of the common exam questions was done by the same instructor. The students, however, are not the same, but are obviously selected from the same population of mechanical engineering students; they have an average overall GPA of 2.72 and 2.91 and CSUN GPA of 2.68 and 2.85, for ME186 and ME335 students, respectively. The questions used within each class were testing the fundamentals discussed in class and the same question format was used consistently. However, while personality and delivery methodology differ from one instructor to another, this variability was not evaluated during the experiment. This was based on the experiment's focus on the reception of the students more than the method of delivery. Table 1 summarizes all experimental conditions.

Table 1: Experiment conditions/details

		ME186	ME186	ME335	ME335
Condition	Exam Format	Open-book	Closed-book	Open-book	Closed-book
	No. of sections	4	1	1	2
	No. of instructors	2	1	1	1
	No. of students	82	24	20	36
	Midterm Exam (MT)	No	No	Yes	Yes
	No. of questions MT	0	0	1	1
	Final Exam (FE)	Yes	Yes	Yes	Yes
	No. of questions FE	1	1	3	3
	Question type	Short Answers		Problem Solving	
	Overall GPA	2.68	2.87	2.97	2.87
	CSUN GPA	2.64	2.82	2.91	2.82
	Experiment type	Blind – students did not know			

Results

Figure 1 shows the average normalized exam scores for the freshman class (CSUN-ME186), where the closed-book and open-book exams results are 0.72±0.18(SD) and 0.83±0.14(SD), respectively. In the freshman class, the short-answers question format has been used as the common question on both exam types. The normalized scores were calculated by dividing each student's grade by the maximum possible score. The results also show only 21% of all students enrolled in the closed-book section scored above 90%, while 50% of the students enrolled in the open-book sections scored within the same category. Additionally, only 22% of the open-book students scored below 70% versus 46% of the closed-book students.

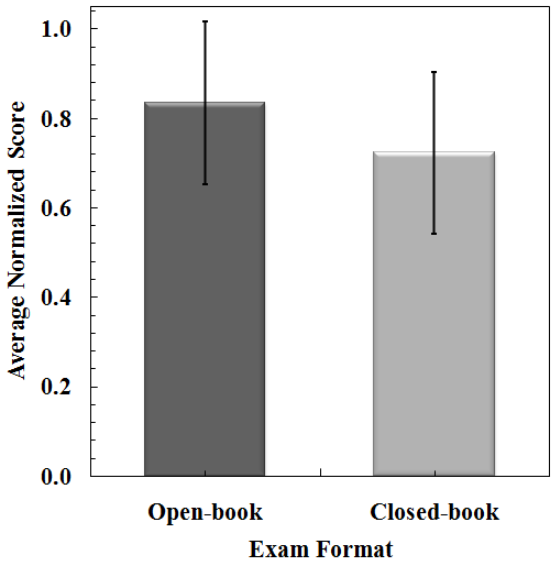

Figure 1: Freshman class average normalized exam scores for closed-book and open-book final exam formats

Figure 2 shows the midterm normalized scores for the junior class (CSUN-ME335), where the average normalized scores for the open-book exam was 0.5±0.3(SD) and 0.3±0.2(SD) for the closed-book exam. The common question used in the midterm exam was a calculated problem consisting of multiple sub-questions. While 71% of all students participated in the open-book exam policy scored below 70% of total possible points, almost all the students tested using closed-book exam scored in the same category. Only 14% of students scored above 90% in the open-book exam and no student scored in the same category from the closed-book exam participants. The maximum normalized score in the closed-book exam and open-book exams were 0.8 and 1.0, respectively.

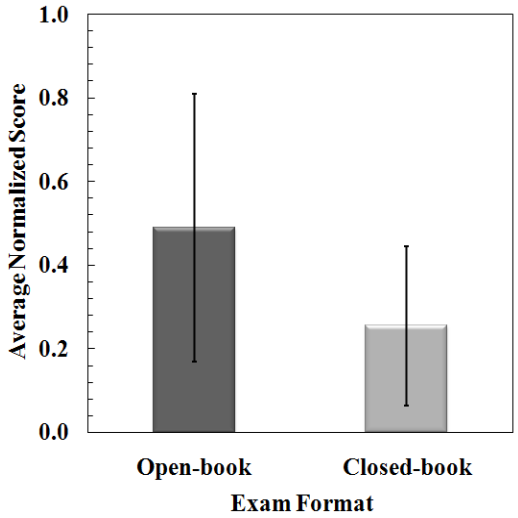

Figure 2: Junior class average normalized exam scores for midterm closed-book and open-book exam formats

While these differences are significant, there may have been an influence of the lectures prior to the exam; the "open-book instructor" worked a similar problem in class during a review session.

Finally, shown in Figure 3 are the results from the ME 335 final examination for both open-book and closed-book formats, where the average and standard deviation of all three common problems are included. For the first problem, the normalized scores were 0.4±0.3(SD) and 0.3±0.3(SD) for open-book and closed-book formats, respectively. The scores for the second problem were 0.58±0.30(SD) for the open-book participants and 0.64±0.30(SD) for the closed-book students. Lastly, 0.2±0.3(SD) and 0.5±0.3(SD) were the scores for the third problem for the open-book and closed-book exam , respectively. Table 2 includes the percentages of students scored above 90% and below 70% for all the problems for both exams formats. It is important to note that none of the problems normalized scores exhibit Gaussian Normal Distribution.

Table 2: Students percentages for all three common problems on final exam

	Open-book			**Closed-book**		
	P1	**P2**	**P3**	**P1**	**P2**	**P3**
Scores ≥ 90%	10%	19%	5%	3%	34%	3%
Scores ≤ 70%	90%	62%	95%	91%	57%	83%

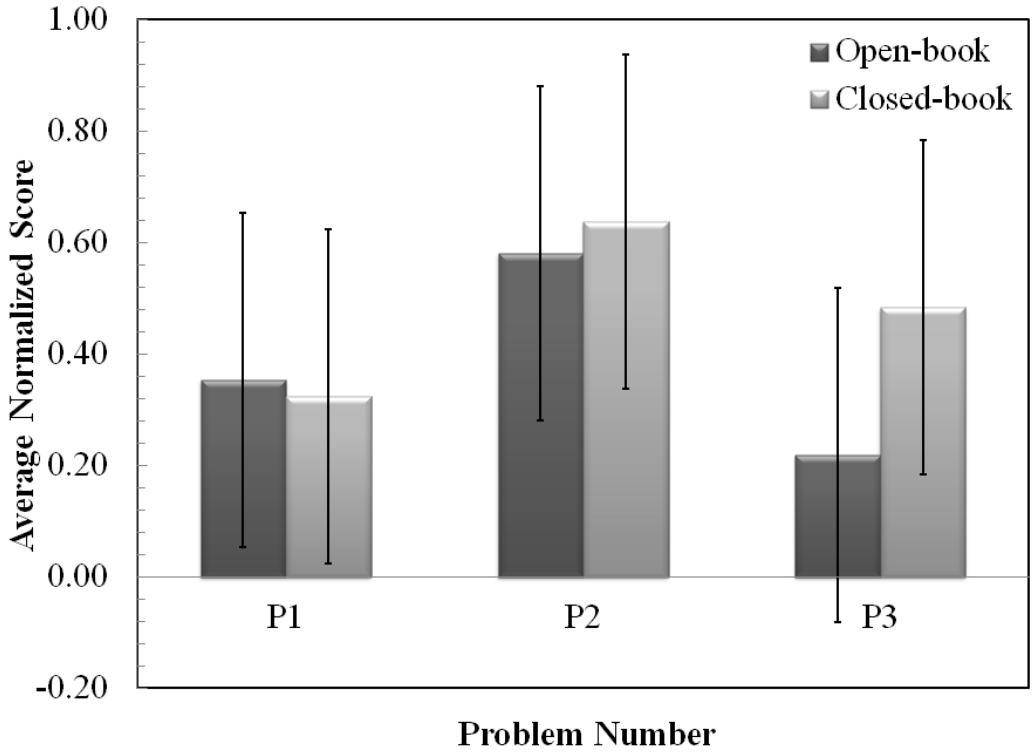

Figure 3: Junior class average normalized exam scores for final closed-book and open-book exam formats

Discussion and conclusion

When short answer questions are used to evaluate students' performance using the different exam formats, the results show bias towards the open-book. However, the gap between student performances can be considered insignificant by comparing the average scores for the ME186 class, which were found to be 0.72 and 0.83 for the closed-book and open-book exams, respectively. One might expect that if the students participating in the open-book exam had studied as much as their closed-book peers, they would have outperformed them by a greater margin. Not only they would have prepared for the exam, but also the study materials are allowable during the exam. It can then be argued that the closed-book exam policy might have changed the students' study habits and may, in turn, affect their long term retention (not evaluated in this study). Since different sections were taught by different instructors, the results appear to be instructor-independent; that is, the outcome is only dependent on the study habits of the students.

For the midterm exam in the junior level class, the open-book participants seemed to outperform their peers who took the closed-book exam. A calculated question was used to evaluate all students. However, a similar example to the problem included in the midterm was discussed with the open-book students but not with their closed-book peers. This can therefore explain the apparent performance improvement. On the contrary, in the final exam, the closed-book students outperformed the open-book students on two of three problems. The poor performance of open-

book students in the final exam can be attributed to their reliance on study materials during the exam without sufficient prior preparation. Thus the argument, that exam format affects the study habits and exam outcome, is supported by the results from both classes.

Closed-book exams may have long term beneficial effects on the students' retention; nonetheless this is not clear since it was not evaluated as part of the experiment presented herein. The similarity of the results between closed-book and open-book exams suggests that attainment of the course learning outcomes are favorably biased towards using closed-book only on the merits that a closed-book exam forces the student to better prepare. However, if an alternative method could be found to encourage and motivate the students, the exam format might be less important.

Our results have encouraged us to continue to study the effects of exam format on students' study habits and their ability to learn and retain engineering skills and concepts. Additional exam results will be studied from the Spring 2012 semester, supplemented by student surveys designed to ascertain their approach for studying for different exam types. Finally upon collection of more data, an in-depth statistical analysis will be performed and published.

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Biographical Information

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