Work In Progress: A Study of the Effect of Graded Homework in an Engineering Mechanics Course

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A Study of the Effect of Graded Homework in an Engineering Mechanics Course

Abstract

This study continues the work by the authors to investigate the efficacy of homework in an engineering mechanics (Statics & Dynamics) course, starting with data from the fall semester of 2013. Throughout this study we have investigated: hand-written solutions, frequent quizzes based on homework problems, and the Pearson Mastering Engineering software. Thus far variations in homework systems have had only minimal impacts on the student's overall performance in the class, as assessed by performance on exam scores. In this paper authors will investigate whether assigning graded homework is indispensable to inspire the students to understand the concepts and thereby improve their test scores.

Two sections of engineering mechanics in fall 2019 were the focus of this study and only one of the two sections were assigned mandatory homework graded by a TA. Students in the other section were assigned the same homework, however they did not turn it in and but were able to access the solution after the deadline of the first section. Moreover, a survey was conducted to cover students' attitude toward homework.

The goal was to find out whether students need to have required/graded homework to motivate them to work out the problems and improve their performance in the course (quizzes and exams grades).

Introduction

For the last 6 years, the authors have been investigating ways to improve student performance in engineering mechanics (statics and dynamics), a required course for students majoring in bioengineering, civil engineering and environmental engineering at Florida Gulf Coast University. Success in this course is critical to success in follow-up mechanics courses and upper-level engineering courses. Data has been collected on students' performance on homework, quizzes and exams, and on the students' thoughts on learning and course delivery. Thus far, we have concluded that the use of traditional hand-written homework, frequent assessment via quizzes [1], or the Pearson Mastering Engineering [2] software for formative assessment did not have a significant impact on students' performance on exams. It was also observed that neither traditional nor online homework scores correlated well with exam scores; however, in-class quizzes did correlate with final exam scores. More recently, using the Mastering Engineering Online system, specifically the inclusion of the Adaptive Follow-Up modules [3], it was observed that this also lacked any impact on overall student performance. In fact, Adaptive Follow-Up in the Mastering Engineering system was punitive by some of the students rather than as a resource to encourage mastery of the material [4]. Additionally, although Exam Wrappers did not seem to increase exam scores and performance; overall, having students fill out quiz and Exam Wrappers did seem to foster reflection and adjustment in most participants [5]. Most recently, Exam Wrappers appear to be useful. They encourage students to think about their study habits, the types of errors they tend to make, and the variety of ways that they are or could be engaged in the course [6].

The course is a four-credit course taught in a combined lecture/lab environment with three meetings a week for a total of five contact hours. The course is typically taken by engineering students in their second year of study, either fall or spring. Although the course has been taught by seven different instructors over the past several years, it is essentially a team-taught course. The instructors use the same textbook and syllabus, they assign the same homework, they collaborate on writing quizzes and exams, and they use common grading rubrics. The course instruction closely follows the ExCEEd Teaching Model with the use of common board notes among the instructors. Since the course is taught in the combined lecture/lab format, there is ample time and opportunity for active, hands-on learning during the class period. Students spend a good portion of class time working in groups to solve problems under the supervision of the instructor. All instructors require attendance, take roll, and for students who have an excessive number of unexcused absences, there is a grade reduction outlined in the syllabus. The prerequisites for the course are Calculus 1 and Physics 1, and students are expected to be proficient in these areas. Students must earn a minimum grade of C in the course and at least a 70% exam average to move on to follow-up courses that require Engineering Mechanics as a prerequisite. Over the past three years, the overall passing rate for this course is 73%. The average passing rate in 2017 was 70%, in 2018 it was 78% and in 2019 it was 70%.

Our current study examines the performance of students in two sections of the course, where one section is required to submit homework to be graded (control section) and the other section is provided the same problems to use for study purposes but not required to complete or submit for a grade (test section). It is well documented that students who work on problems outside the class period are better prepared to perform at a higher level, but does requiring that work be submitted for a grade and feedback make a difference? In 2003 a study was performed with students in a sophomore level Electrical and Computer Engineering Course. Two semesters were studied with one section having required homework and the other with problems provided but not required homework. The section with graded homework scored significantly higher in the first semester, but the two sections did not differ significantly in their test scores in the second semester [7]. A similar study was performed over a 3-year period in a Numerical Methods course for mechanical engineers. Students in the first year were required to submit a single problem each class period for a grade, whereas students in the second year had three problems to complete but only one was graded. This study reported that graded homework did not improve student performance when compared to the third-year control group that had homework that was not graded [8].

Methods

Two sections of Engineering Mechanics, Statics and Dynamics, were used to conduct the experiment. One section was given graded homework assignments (control section) while the other section (test section) was not. Both sections were taught by two professors who were co-teaching the course and so each section experienced both professors. These two professors have a similar teaching style, have worked together, and have taught this course for over 10 years. The sections were offered from 9:30 am to 11:10 am (control section) or 11:30 am to 1:10 pm (test section) Monday, Wednesday and Friday. Both sections had 13 homework assignments with the same problems and had access to the solutions once the homework was submitted. Since homework was worth 10% of the overall grade, the section without required homework had the 10% evenly distributed across the other course requirements, which included three exams, 6

quizzes and 3 projects. Homework sets were designed to provide students with practice applying concepts and problem-solving strategies to help prepare them for the exams. The first two exams consisted of two versions (A and B), each having the same problems with various dimension and load values changed. Students in each section randomly received either an A version or a B version. The third exam was taken by all students at the same time in the same room. The exam consisted of two versions but with the same problems presented in a different order. The same third exam had been used over the years until recently, when a change needed to be made due to a security breach. A similar exam has been created and used the past two semesters. Each exam problem for both sections was graded by a single instructor to insure consistency of grading.

Statistical analyses were performed using the R statistical software. Inferential methods included Fisher's exact test, regression analysis, and chi-square tests. All tests were performed at the 5% level of significance.

This study was reviewed and approved by the university's Institutional Review Board, IRB Protocol ID# 2014-33.

Results

The two sections were compared in terms of gender distribution and initial math and physics abilities (Table 1). A chi-square test showed that both sections were composed of nearly the same percentage of males and females such that no difference in the distribution of gender was detected.

Table 1. Gender Distribution Between Sections

	Control Section Male/Female	Test Section Male/Female	chi_2	df	p
Gender Distribution	24/10	24/11	0.21	1	0.6473

SAT math scores, as well as Calculus 1 and Physics 1 grades, were compared across sections using Bonferroni-adjusted pairwise t-tests (Table 2). No significant difference was found between the initial math abilities across the two sections nor in how the two sections compared in the prerequisites of Calculus 1 and Physics 1.

Table 2. Math and Physics Between Sections

	t	df	p
SAT Math	1.59	36	0.1206
Calculus 1	0.83	31	0.4109
Physics 1	0.68	52	0.5012

The sample sizes differ depending on what was being investigated since information was not available for every student (Table 3).

Table 3. Sample Size Comparison

	Control	Test
SAT Math	16	22
Calculus 1	17	16
Physics 1	25	29

Based on the above results, the authors are confident that the two sections appear to be similar in terms of gender distribution and initial math and physics abilities.

The distribution of all exam scores is similar and the median performance is about the same (Figure 1). The test section slightly outperformed the control section on the first two exams, while the control section outscored the test section on the third exam. Neither the means nor the variances between the two sections were statistically different ($p>0.05$). After careful consideration, the authors think that the possible answer to the slightly better performance of the test section in the first two exams and not the third is in the way the exams were administered. There were two versions of the exam administered and each student, regardless of section, randomly received one version or the other. The control section took the first two exams from 9:30 am to11:10 am and students who finished early were not allowed to leave until 11:10 am. The test section took the first two exams from 11:30 am to 1:10 pm on the same day, so there was a 20-minute period in which students in the control section could share what they knew about the exam with those in the test section. The third exam was administered to both sections simultaneously, so no sharing was possible. This might account for the test section doing slightly better and the wider variation of grades in the control section on the first two exams.

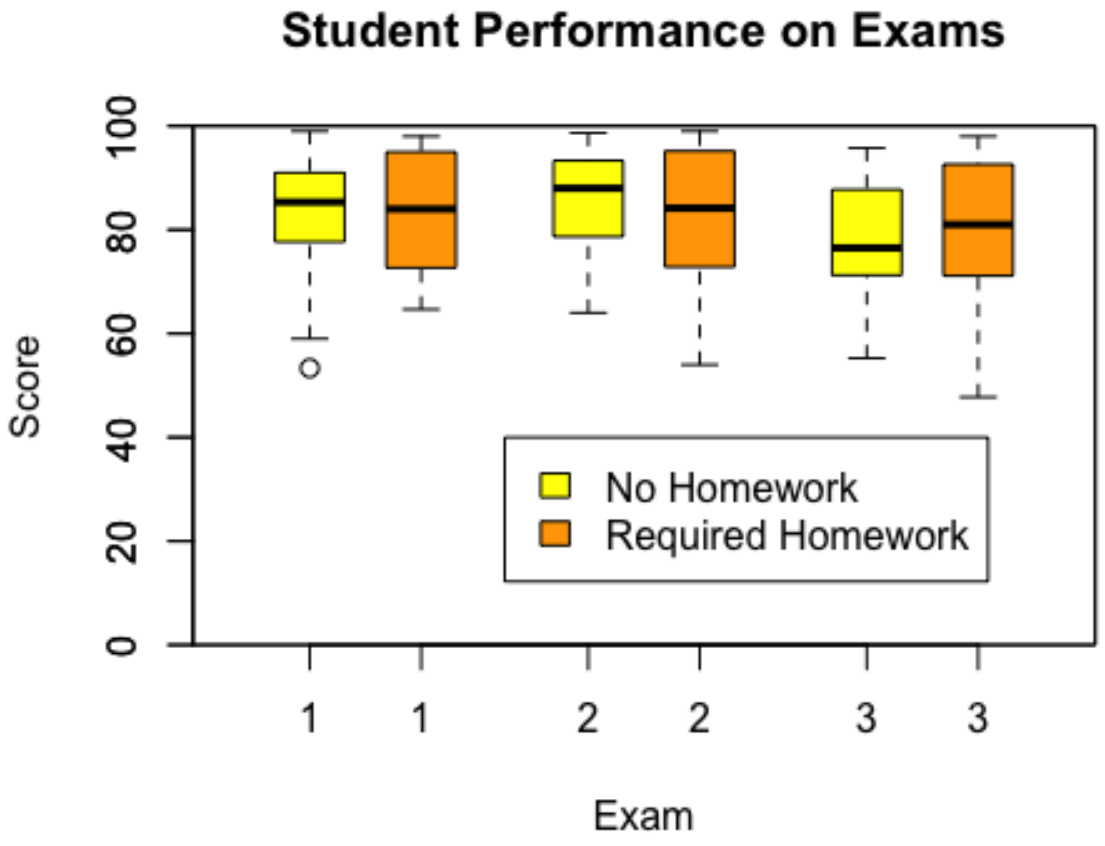

Figure 1. Boxplots for Exam Scores by whether homework was required or not.

Following Exams 1 and 2, the students completed a comprehensive exam wrapper. They were explicitly asked to address the following issues using the Likert scale shown:

Strongly Disagree Disagree Neutral Agree Strongly Agree

1. I usually work all assigned homework problems in my engineering courses by the time they are due.
2. Solving homework problems helps me understand the concepts discussed in class.
3. Working homework problems helps me perform better on tests.
4. I can use my study time more effectively than by working homework problems.
5. I need to have required/graded homework to motivate me to do it.
6. I need to have feedback on my homework from the instructor/grading assistant.

Not surprisingly, students in the control section were more likely to complete the assignments by the due dates ($z=3.31$, $p=0.0005$), feel that the homework problems helped them understand concepts discussed in class ($z=3.28$, $p=0.0005$), and perceive that working homework problems helped them perform better on tests ($z=2.70$, $p=0.0034$) than students in the test section.

No significant difference was found in the percentages that felt they could use their time more effectively than doing homework problems ($z=0.40$, $p>0.05$), need homework to be graded to be motivated to do it ($z=0.65$, $p>0.05$), or require feedback on their assignments ($z=1.23$, $p>0.05$).As expected, 81% in the control section said they usually complete their homework by the due dates compared to just 30% in the test section.

Part of the Exam 2 Wrapper asked students to self-assess their ability on a list of ten items such as drawing free-body diagrams, calculating resultant forces, and solving static dry friction problems. None of the response distributions differed between the two classes; however, there was nearly a significant difference ($p=0.083$), per Fisher's exact test, regarding solving static dry friction problems (Figure 2). Students enrolled in the required homework section tended to lean towards the extremes of either feeling their ability was excellent or marginal compared to those enrolled in the optional homework section.

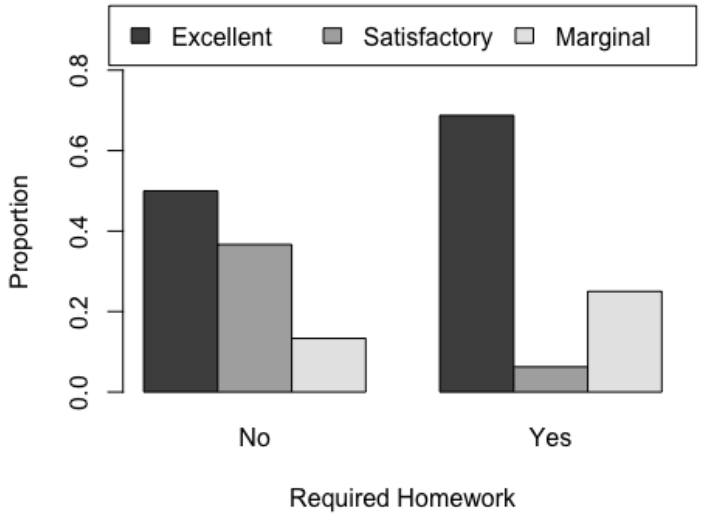

Figure 2. Distribution of students' self-assessed ability to solve static dry friction problems

Conclusions

The control section and test section appear to be similar in terms of gender distribution and initial math and physics abilities. This study found that 87% of the control group felt they need the homework to be graded in order to do it, whereas only 53% of the test group felt this way. Since the two classes were deemed statistically the same at the start of the semester, this discrepancy may very well be because one group had been submitting homework to be graded while the other had not. Students were not asked about their motivation till after Exam 1, weeks after submitting or not submitting homework, which may have influenced their perception of what extrinsically motivates them.

In addition to a motivational baseline regarding doing homework assignments, information should be gathered on how students in the test group dealt with the homework. What caliber of student completed the ungraded assignments? While most did not complete them by their due dates, did many use the problem sets for practice just prior to taking the corresponding exam? It may be that graded homework is valuable to a certain type of student.

The scores for all three exams showed no statistically significant difference between the two sections, leading the authors to conclude that requiring students to submit homework for a grade and providing feedback does not improve their performance on exams. It seems apparent that students can prepare themselves for exams without the requirement of graded homework. Considering the instant availability of solutions to any statics problem created, students today think nothing of finding solutions, copying them and turning them in for a grade with little or no learning occurring during the process [9]. The results of this experiment should not come as a surprise.

This experiment was conducted in the fall of 2019 and is continuing in the spring of 2020, thus giving the authors another semester of data to consider the question. If requiring graded homework does not improve exam performance, it may be more effective to reallocate teaching assistants to interacting with students in small group settings rather than grading homework.

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