

Homework Methods in Engineering Mechanics: Part 3

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Homework Methods in Engineering Mechanics

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 present the impact of utilizing the "adaptive follow-up" modules in Pearson Mastering Engineering, as well as a reflection on the different methods used over the study period.

As in previous years, assessment of the efficacy of homework assignments will be based on observation of students' performance on exams, and a survey of students' perceptions relative to historical norms. Institutional review of research protocol determined that full board review of the study and informed consent was not required.

Introduction

Over the past 3 years the authors have been collecting and reporting data on homework, quiz, and exam performance, as well as survey data on students' perceptions of learning and opinions on the methods used in the 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. In this paper we hope to look longitudinally at the data collected over the study period, as well as the impact of modifications to the Mastering Engineering Online system, specifically the inclusion of the Adaptive Follow-Up modules. Adaptive follow-up assignments are reported to promote directed learning by analyzing student's responses to determine areas of weakness, then assign additional problems to better develop fundamental skills and knowledge [3]. It is our hope that these modules will increase the efficacy of the Mastering Engineering system of online homework assignments.

Methods

Over the current and previous study [1, 2] durations, data from 12 sections of an Engineering Mechanics (Statics and Dynamics) course, over a period of 3 years were collected. Data were taken from one section of Fall 2013, and Spring 2014, and two sections each from Fall 2014, Spring 2015, Fall 2015, Spring 2016, and Fall 2016. The Fall 2013 and Spring 2014 semester courses were taught 2 days a week in classes of 165 minute duration (including a 15 minute break), all other sections were held 3 days a week and were 110 minutes in duration from Fall 2014 to Spring 2016 (including a 10 minute break), and were 100 minutes (with no break) for Fall 2016. Each grouping of courses used a slightly different method for formative assessment, detail on each section are given below in Table 1.

Traditional Homework (TH)

For the Fall 2013 and Spring 2014, students were assigned problems from the textbook [4]. Students completed the assigned problems with hand written solutions that were then scanned and uploaded to the Canvas (learning management system) course page. Assignments were graded by the course TA to provide feedback to students, and partial credit was awarded in the same manner as used on exams and quizzes. Quizzes were also given, three prior to the statics exam and two between the statics and dynamics exam.

Frequent Quizzes (FQ)

For the Fall 2014 semester, frequent quizzes were used as the primary formative assessment. Students were assigned homework problems (ungraded) after most lectures and short quizzes were given at the start of the following lecture to assess learning of material and encourage students to complete the assigned problems. Quizzes typically consisted of one of the assigned homework problems that had been re-phrased and/or had numbers changed. Assessment of this methodology was presented in detail in the first paper in this series [1]. In total, 22 quizzes were administered in the statics portion of the class, and 15 were administered in the dynamics portion of the course.

Weekly Quizzes (WQ)

Based on student feedback from the Fall 2014 course it was determined that the frequency of quizzes was stressful for students and used a significant amount of class time. Therefore, a similar model was adopted with less frequent quizzes for the Spring 2015 semester. Quizzes were given on a weekly basis, but were still used as the primary formative assessment, therefore assigned homework problems were not directly graded. In total 8 statics and 6 dynamics quizzes were administered.

Mastering Engineering 1 (M1)

In the Fall 2015 semester the authors decided to test the effectiveness of the Pearson Mastering Engineering software to provide additional formative assessment. Student were assigned to complete homework problems using the Mastering Engineering software, and the number of in class quizzes was reduced to 7 in statics and 4 in dynamics. The evaluation of the Mastering Engineering platform was the primary focus in the second paper in this series [2].

Mastering Engineering 2 (M2)

For the Spring 2016 the same basic course structure was used with some minor modifications to the Mastering Engineering grading system to decrease the penalty for incorrect attempts. A similar number of quizzes were also given with 8 in the statics portion of the course and 4 in dynamics.

Mastering Engineering with Adaptive Follow-Up (MA)

In the Fall 2016 semester the adaptive follow-up modules were added to the student homework assignments. These modules are intended to give the students extra practice on areas that they were weak in based on performance on previous problems. Our hope was that this would help direct students' study habits and improve overall learning. Also, for this semester the number of in class quizzes was further reduced, with 4 quizzes for statics and 2 for dynamics. Also the statics exam was given over 2 class periods, as a common time for both sections of students was not available due to the students' schedules.

Table 1: Description of courses included in the study

ID	Assessment	Term	Class Period	Instructor(s)	N*
TH	Homework	Fall 2013	TR 8:00-10:45am	A&B	37
	Homework	Spring 2014	TR 8:00-10:45am	A&C	32
FQ	Quizzes	Fall 2014	MWF 8:00-9:50am	A&C	35
	Quizzes	Fall 2014	MWF 11:00-12:50pm	B	33
WQ	Quizzes	Spring 2015	MWF 8:00-9:50am	C	30
	Quizzes	Spring 2015	MWF 11:00-12:50pm	D	28
M1	Mastering	Fall 2015	MWF 8:00-9:50am	C	27
	Mastering	Fall 2015	MWF 11:00-12:50pm	B	34
M2	Mastering	Spring 2016	MWF 8:00-9:50am	C	20
	Mastering	Spring 2016	MWF 11:00-12:50pm	D	34
MA	Adaptive	Fall 2016	MWF 9:30-11:10am	A&C	23
	Adaptive	Fall 2016	MWF 11:30-1:10pm	B	37

*N is the number of students included in this study based on exam scores from each section. Students who did not take either of the exams were excluded from the analysis.

Summative Assessment

A similar examination was given for summative assessment of all sections. An exam given at approximately mid-term was used to assess learning of statics concepts, and a final examination was given to assess learning of dynamics concepts. Each exam consisted of approximately 5 full problems that students solved by hand or with NCEES approved calculators, students were given approximately 2 hours and 15 minutes for each exam (with the exception of the Statics exam of the Fall 2016 sections, which was given over 2 class periods of 100 minutes each). Exams were graded based on students understanding on concepts, and partial credit was awarded for using the appropriate methods and drawings accurate diagrams. The instructors used different questions on the majority of exams, but attempted to maintain consistent difficulty, grading scales, and topic coverage. The instructors also tried to maintain consistency between homework and exam problems, problems similar to those used on exam were selected for assigned homework problems, and exam problems were created to resemble assigned homework problems. The weight of each assignment type for each group of courses is given in Table 2, Exams are heavily weighted as the primary formative assessment, homework, quizzes, and projects are weighted lightly to encourage completion, but to minimize overall impact on overall grades.

Table 2: Grade scales used for instructional groups.

ID	Homework	Quizzes	Exams	Projects
TH	10%	30%	50%	10%
FQ	N/A	25%	60%	15%
WQ	N/A	25%	60%	15%
M1	10%	15%	60%	15%
M2	10%	15%	60%	15%
MA	10%	15%	60%	15%

Evaluation of Results

As in previous studies in this series the impact of quizzes and homework was evaluated in part by the Pearson's correlation coefficient of student average quiz and exam scores, and the correlation between average homework and exam scores for both the statics and dynamics portions of the classes. Overall performance was evaluated primarily by performance in the statics and dynamics homework, quizzes, and exams and differences were assessed using multivariate comparisons in IMB SPSS with a Tukey post hoc analysis for differences between section IDs. A critical significance value (p value) of 0.05 was used to determine significant differences.

Results

Grades on homework problems, either on paper or using the Mastering Engineering software, did not correlate with performance on exam scores. This result has been consistent for all of the semesters studied where homework was directly assessed. Quizzes were a better predictor of exam scores than homework in every offering of the course studied except for the dynamics portion of the Fall 2016 semester. The strength of the correlation between quiz and exam scores is not consistent and tends to vary more in the statics section of the course. The correlation coefficient (r value) of each assessment to exam scores are given in Figure 1.

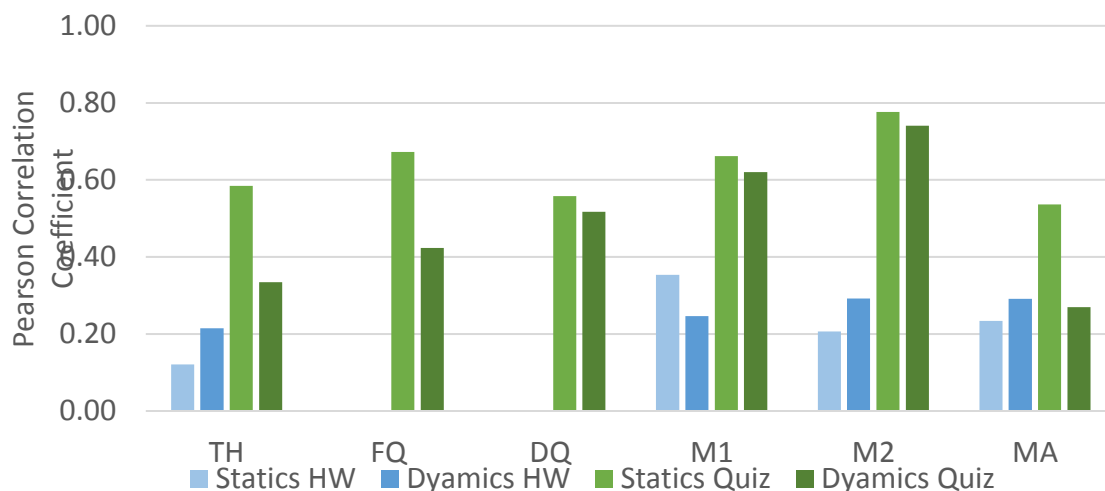


Figure 1: Pearson's correlation coefficient (r value) for each assessment to exam scores.

Overall performance on exams did not vary significantly for any of the sections included in this study. There were also no significant performance differences between the Statics Quiz averages. However, scores on the Dynamics Quizzes for the second term of Mastering (M2), and the Mastering with Adaptive Follow-Up (MA) were significantly lower than the Frequent Quizzes (FQ) and the first term of Mastering (M1). There was much more variance in scores for graded homework than observed for quizzes and exams. For the Statics portion of the courses, Mastering with Adaptive Follow-Up (MA) resulted in significantly increased scores relative to the remaining assessment methods. For the Dynamics portions homework scores were found to be significantly lower for the second term of Mastering (M2), relative to the Mastering with Adaptive Follow-Up (MA) and Traditional Homework (TH) methods. Average performance on each method of assessment is given in Figure 2.

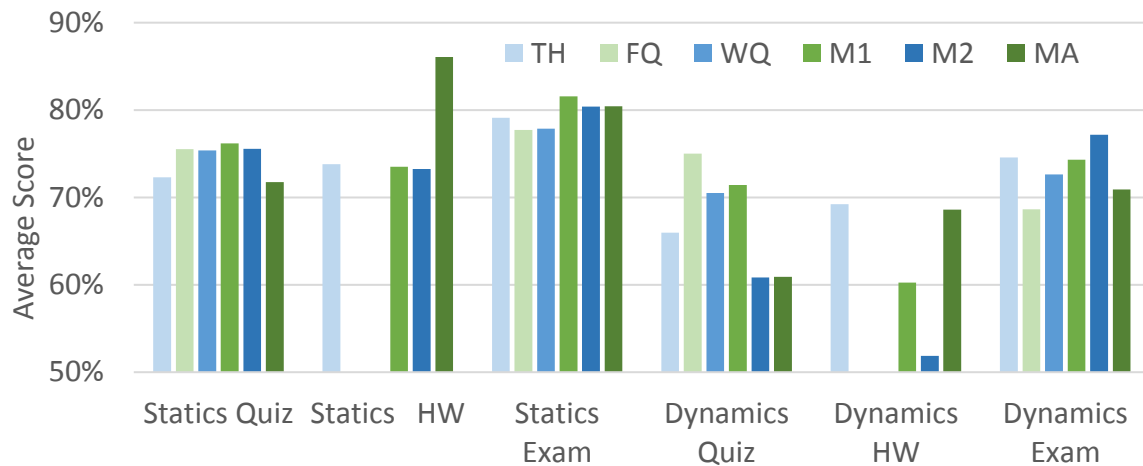


Figure 2: Average performance of students on assessments by type and methods.

Discussion

The longitudinal conclusions of this study agree largely with the conclusions of the initial study reported in 2015. Homework is not a good predictor of student performance on exams, and variations in methods for formative assessment have little impact on students' performance on exams. Some students liked the Adaptive Follow-Up, mostly because if they do well enough the system allows them to "test-out" of the Adaptive Follow-Up questions. In fact because the penalty for missed attempts was small many students did not have to complete the follow-up assignments for the majority of the homework assigned. Some students who did have to complete the Adaptive Follow-Up complained that it was often harder than the initial problem set, which was frustrating to them. All of the students working on the Mastering Engineering system showed a decrease in performance on homework in the Dynamics section of the course relative to the Statics section. An observation of individual scores shows that many more students did not attempt homework assignments in the Dynamics section of the course. Change in homework behaviors also did not seem to correlate with change in performance on exams. Anecdotally, in the second semester of using Mastering Engineering (M2) there was a 21% decrease in homework scores between statics and dynamics (the largest decrease in any assessment score), with only a 3% change in exam scores.

However, it is important to temper these observations with limitations of the variations (or lack thereof) in how each course was delivered. The primary format of the in-class portions of the courses remained the same (except with changes in the number of quizzes). There was not a focused effort on the part of the faculty to change instructional behaviors to match the assessment of homework, or to use the assessment to target specific topics or individuals that needed additional coverage.

It is in part an expectation that students will use the results of the formative assessment to modulate their own study habits, but this is likely limited by the pace of the course. Students often spend their time studying for the next quiz or exam, rather than spending time reflecting and improving their mastering of topics covered in previous quizzes and exams. Another significant limitation of this study was the lack of the inclusion of any initial measure of student performance or baseline skills. Students come into the course with a diverse background, some are well prepared, but others are not. A pre-test of student performance would better allow for tracking improvement and normalizing for the variability of the students.

Conclusions

Varying methods for assigning and assessing homework for students in engineering mechanics continues to show a lack of impact of overall student performance. None of the assessments of homework correlated well with exams scores. Formative assessment without changes in delivery of material to students may have little value. Adaptive follow-up in the Mastering Engineering system was seen as punitive by some of the students rather than as a resource to encourage mastery of the material.

Acknowledgements

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