Homework Methods in Engineering Mechanics

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Abstract

This study observes the efficacy of short in class quizzes used to assess students' understanding of homework assignments in an engineering mechanics (Statics & Dynamics) course. Rather than directly grading assigned problems, a random problem was selected from the assigned homework set and used for a quiz on the following class period. Previously, students submitted scans of completed homework assignments via Canvas (learning management software, LMS) and homework was graded directly. Motivation for this research was generated by negative feedback from students in respect to the difficulty and time spent on homework and a lack of correlation between homework and other assessments of performance (quizzes and exams) in the class. Our hypothesis was that using frequent quizzes would motivate students to understand the problems and improve performance on exams. Results suggest that the change had a minimal impact on overall performance, evaluation of student and instructor perceptions show potential benefits countered by stress and time lost to overly frequent quizzes.

Introduction

Studies have shown that homework is an important part of improving academic achievement[1]. However, research has not fully clarified this relationship between time spent on homework and academic achievement, especially at the student level[2]. The quality and quantity of homework have both shown correlation with achievement[3], and quality of homework is affected by many factors. Direct assessment of homework assignments is limited by a lack of knowledge of the conditions under which the assignment was completed. Availability and utilization of assistance from peers, problem solutions, and even the instructors may lead to the student being able to submit correct solutions without understanding the material. The use of quizzes has been established as an effective tool for assessment and encouragement of self-directed learning. A study conducted in the chemical engineering program at California State University Long Beach found significant increases in grades, time spent on homework, and student perceptions of learning when switching from traditional homework assignments to weekly quizzes[4]. An evaluation of quizzes in physiology has shown that quizzes led to increased performance on advanced examination questions[5].

Methods

Four sections over three semesters (fall 2013, spring 2014, and 2 in fall of 2014) of engineering mechanics were studied. The spring semester courses were taught 2 days a week for 165 minute periods (including a 15 minute break) with a total of 29 lessons and 2 exams (statics and dynamics). The fall semester courses were taught 3 days a week for 110 minute periods with a total of 44 lessons and 2 longer 165 min periods for the exams. Direct assessment of homework was used for the spring semester, as had been traditionally used in the course. In the fall quizzes were used and there was no direct assessment of homework. Homework was typically assigned at the end each lesson and consisted of 3 to 4 problems from the text[6]. For sections H1 & H2 homework solutions were made available after the submission deadline for the assigned problems. For sections Q1 & Q2 solutions were available to the students at the same time the

problems were posted to the LMS. Both the homework and quizzes were graded for both completion and accuracy, and partial credit was awarded for both. For the homework, since a larger number of problems were submitted, only a selection of problems that were submitted were assessed for each assignment.

Table 1: Description of courses included in the study

ID	Assessment	Term	Class Period	Instructor(s)	N*
H1	Homework	Fall 2013	TR 8:00-10:45am	A&B	37
H2	Homework	Spring 2014	TR 8:00-10:45am	A&C	32
Q1	Quizzes	Fall 2014	WMF 8:00-9:50am	A&C	35
Q2	Quizzes	Fall 2014	MWF 11:00-12:50pm	B	33

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

Quizzes typically consisted of one of the assigned homework problems that has been re-phrased and/or had numbers changed. Quizzes were administered at the start of class and students were given 15 to 20 minutes to complete them. Assessment of this transition was based on observation of students' performance on exams, quizzes, homework, and a survey of students' perceptions relative to previous semesters. Institutional review of research protocol determined that full board review of the study and informed consent was not required.

Relevance of quizzes and homework assignments to performance was evaluated by the Pearson's correlation coefficient of student average quiz or homework scores to exam scores. Evaluation of student performance was based on change in mean exam scores for all students who completed the class (students who dropped the class were not included as they did not take the second (dynamics) exam). Student perceptions were evaluated by surveys administered in the class following the statics exam and the class proceeding the dynamics exam. Surveys were administered on paper, were anonymous, and were very similar to surveys used to evaluate student perceptions in semesters preceding those included in this study.

Results

In this section we will evaluate results of the study in terms of each section of the course offered. The use of quizzes much more closely correlated with student performance than observed for homework grades in previous semesters. Average values for student performance as assessed by either quizzes or homework, exams, or self-rating via a paper survey are presented in Table 2. Values given in table 2 are the average assessed performance of the assigned problems as a percentage (100% being complete and correct) with standard deviations (SD), for all items partial credit was awarded based on the discretion of the grader/instructor. Quizzes and homework were typically graded by a teaching assistant, exams were always graded by the instructor(s) of record. Students who failed to submit homework or quizzes received a 0 on that assignments, and these are included in the averages. All students included in this study completed both of the exams.

Table 2: Ratings of student performance for the study semesters.

ID	Statics Mean (SD)				Dynamics Mean (SD)			
	Q/HW	Exam	R	Survey	Q/HW	Exam	R	Survey
H1	67(22)	79(12)	0.200	88(5)	64(28)	74(13)	0.181	85(5)
H2	81(12)	79(14)	0.003	88(6)	75(25)	75(12)	0.254	88(5)
Q1	75(15)	75(17)	*0.708	88(4)	73(18)	63(21)	*0.478	88(5)
Q2	76(11)	81(11)	*0.598	90(4)	77(15)	74(14)	0.280	89(5)

*Indicates statically significant correlation at the $p < 0.01$ level (2 tailed).

Multivariate analysis of variance with Tukey post hoc analysis in IBM SPSS revealed only one significant difference in exam scores over the sections studied. The scores for the dynamics exam of section Q1 were significantly ($p < 0.05$) lower than the score for the other sections. There was also a significant difference between the homework scores of H1 and H2.

Outliers were included in all analysis however it is important to note their effect.
- H1 only had one outlier with the lowest Statics Exam score of 46%.
- H2 had several outliers, one for the Statics Exam score of 18%, one student with a self-rating of 68%, 2 students with a 0% on Dynamics Homework, and a student with a 38% on the Dynamics Exam.
- Q1 had several outliers with 4 students scoring 48% or less on the Statics Quizzes, 2 students scoring 36% or less on the Statics Exam, 2 Students scoring 25% or less on the Dynamics Quizzes, and 2 students scoring 11% or less on the Dynamics Exam (this attributed to both the lower average and higher standard deviation shown).
- Course Q2 had outliers for a student scoring a 47% on Statics Quizzes, a student with 55% on the Statics Exam, a student with a self-rating of 76%, a student with a 39% on the Dynamics Quizzes, and 2 students with 41% or less.

Removing all outliers from the multivariate analysis results in no significant differences between exams for any of the sections. Removing outliers also results in the homework/quiz scores for H1 to be significantly different from all other sections for both statics and dynamics.

Survey of students' perceptions revealed that many students considered the frequent quizzes to be a source of anxiety and stress. Many students felt that the quizzes were too frequent. A few students stresses that reviewing the problems immediately after the quizzes was very beneficial. Instructor's perceptions were that students continued to utilize solutions to homework problems in an attempt to memorize them in the short period of time between the introduction of the material and subsequent quiz. This was based on observations of students studying the solutions rather than their own work, prior to the start of class.

Discussion

Motivating students to practice good study habits early in the course is still believed to be critical to the success of students in this course. Although we have no direct evidence to support this, the opinions of student and faculty agree that these skills are critical to the course. Ideally the homework and quizzes could be excluded from the students' final grades, and students would complete problems based on their intrinsic motivation to learn and practice the material.

However, fear that this would lead students to neglect the course content prevents this methodology from being accepted. This fear is probably justly founded as students typically focus time and effort on tasks they perceive to be urgent and important, and importance is typically tied directly to the impact on their final grade. Anecdotally, students who scored low on homework and high on exams in H1 and H2 expressed the opinion that scanning and submitting homework via the LMS wasn't worth the effort given its low value in the overall grade. Grades in the individual homework assignments in H1 and H2 were generally high, but students sometimes failed to submit their assignments resulting in a lower average over the course of the semester. Some students also failed to complete quizzes in Q1 and Q2, due to being absent or tardy to class, but this had a smaller effect on the overall average than as seen in H1 and H2.

The level of variation in the classroom makes generalizing results from a small number of observations difficult, however the authors feel that the following observations are reasonably accurate and many apply to other universities teaching similar classes.

- Assigned homework grades do not provide substantive information for either the student (who is unlikely to review or learn from it) or the instructor (since the homework performance is often not a good representation of students' future performance on exams).
- Frequent assessment of students via quizzes provides the instructor with details on students learning, but may not lead to improved student performance.
- Excessively frequent quizzes may pose an emotional burden on students and result in a negative influence on the class environment and student motivation.
- Providing students with a specific set of solutions seemed to limit their study efforts to a lower level (memorizing) than expected (understanding) for the course. Student were observed attempting to memorize solutions rather than trying to understand the theory.

One of the primary limitation to the use of Quizzes in class is also the use of class time to complete them, which detracts from the time available for other activities. This supports the argument to limit the number of quizzes. However, while completing quizzes students are actively engaged in solving problems, and it is therefore an excellent opportunity for student to learn and reinforce learning. In this study positive effects of increased feedback and motivation to study material regularly were likely offset by the anxiety students felt in relation to the quizzes, resulting in no significant difference between the methods.

Conclusions

While assessing the students' performance via frequent quizzes had a greater correlation with exam performance than grading homework assignments, it did not improve students' performance on exams overall and may have had a negative impact in one section. This study was designed to have a neutral effect on the grading work of the faculty and teaching assistants that provided the course over the study period. Based on study results and student feedback future courses will use a maximum of one quiz per week. This is likely to be more appropriate for the course and may reduce the stress associated with the quizzes, while retaining the primary benefits of motivating students to review and understand the material.

Acknowledgements

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