

## **AC 2010-131: DOES COLLECTING HOMEWORK IMPROVE EXAMINATION PERFORMANCE?**

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# Does collecting homework improve examination performance?

## Abstract

In this study, our goal is to examine the impact of different homework grading policies on students' final exam performance. We are interested in not only the overall student performance, but also performance of specific student subgroups with varying backgrounds as well as the impact of graded homework on the type of learning that takes place in the course. The study was conducted in a Numerical Methods course at a large university in the southeast of USA over a period of 3 years encompassing data from over 300 hundred Mechanical Engineering students.

## Introduction

As a strategy for college success, the tip most consistently given by professors and college officials is that a student should simply do their homework<sup>1</sup>. Practice, preparation, extension and integration are identified as the most common instructional goals for assigning homework to students<sup>2</sup>. More often than not, to provide an incentive for the students to spend the necessary time on the homework problems, these assignments are graded and the grades are included as a fraction of the final grade in the course.

The idea for this study came about from sheer economics of lack of teaching assistants assigned to a Numerical Methods course that the first author teaches. The common practice is the assignment of a 10hr/week TA in the spring semester and none in the summer semester. With anywhere from 40-70 students taking the class, the first author had to critically think about the best use of the assigned TA. Should the TA spend time to maintain generous office hours, grade computer projects, assist in programming and experimental laboratories, or grade homework assignments? The question we are trying to answer in this paper is whether grading the homework problems improve the student performance. We are not questioning the importance of assigning the homework problems but if they help the students if picked for a grade.

Cartledge<sup>3</sup> presents an interesting review regarding the vastly different views about homework since the turn of the 20<sup>th</sup> century. These views range from “useless and dangerous practice of carrying books home and asking pupils to do evening studies” to conclusions that favored homework as a tool which improved scholarship. The debate over the merits of homework continues today without conclusive research results, especially for college level engineering students, which support the common belief that doing homework improves the students' comprehension and performance.

Weems<sup>4</sup> examines the effects of homework collection on achievement of college level intermediate algebra students. More specifically, the question of a student who is required to hand in homework performs better than one who is not is addressed. The study conducted over 108 students was inconclusive regarding the overall grade distribution, however the group which was required to hand in homework had significantly more number of students who earned A grade in the course than the control group which was not required to hand in homework.

A more in depth study reported by Trussell and Dietz<sup>5</sup> involved a sophomore level electrical engineering course. Two sections where in one section, assigned homework was graded and in the other the same homework was assigned but not graded were compared during two consecutive semesters. The section with graded homework performed significantly better in test scores in the first semester. However, there were no significant differences between the two sections in the second semester.

The common theme in these articles is the lack of conclusive evidence regarding the relationship between picking homework for a grade and student performance. Our work differs from the aforementioned studies in the sense that we try to quantify the impact of homework on specific student subgroups such as those with low/high GPA as well as at specific learning levels such as low and high level Bloom's Taxonomy<sup>6</sup>.

### Experimental Design

The study was conducted in a Numerical Method course at a large university in the southeast of USA. The course includes about 20 to 25 homework assignments (12-15% if picked for a grade), computer programming projects (10-13%), three examinations (approximately 40%) and a final examination (approximately 35%). The course is taught in spring (16 weeks) and summer (10 weeks) semesters every year. In summer 2006 and spring 2007, we assigned one problem at the end of almost every class and required the students to submit it in the beginning of the next class. Since we strongly believe in "the good practice of giving prompt feedback"<sup>7</sup>, we gave the graded homework back in the following class. Sometimes, we found students were doing their homework right before class started, and this led us to change the assignment to three problems after almost each class. We implemented the three-problem assignment in summer 2007 and spring 2008 semesters. Only one problem was graded out of the three submitted and hence did not increase the lone teaching assistant's work load. Anecdotally, seeing little improvement in the final examination grades (shown in Table 1) led us simply to drop the graded homework requirement in summer 2008 and spring 2009 semesters. We still assigned the homework problems but did not collect them for grade. However, we posted solutions to the multiple-choice test problems, which comprised of about 50% of the assigned problems, and used personal response systems in the classroom for reviewing pre-requisite knowledge and checking end-of-topic knowledge through sets of 5-10 multiple-choice questions. Since there are 8 topics in the course at USF, the clickers were used 16 times in the semester.

Table 1. Average Final Grade Data

Type of assignment	Semester	Number of Students	Average Final Exam Grade	Stan. Dev. Final Exam Grade
<b>One problem</b>	Summer 2006	56	63	4.75
	Spring 2007	55	66	3.97
<b>Three problems</b>	Summer 2007	70	69	4.30
	Spring 2008	41	70	3.49
<b>No homework</b>	Summer 2008	55	68	3.75
	Spring 2009	41	69	4.42

The final examination used in measuring the performance of the students throughout the study is a 32 multiple-choice question test based on Bloom's taxonomy. Four questions from each of the eight topics of the course comprise the examination. Two of the four questions on each topic are at the low level of Bloom's taxonomy and the other two are at the high level of Bloom's taxonomy.

The analysis of the final exam grades from the summer and spring semesters where the same homework grading policy was used showed no significant differences between the semesters which allowed us to combine the data from these semesters resulting in 111 students for the one-problem assignments, 111 students for the 3-problem assignments, and 96 students with no graded homework assignments.

To ensure the equity of student composition in each of the homework grading policy categories, we used the average final grade (PR-GPA) of the students from four prerequisite courses (Calculus I, II, III and Ordinary Differential Equations) as an indicator. The average final grades were grouped into three ranges following  $PR-GPA \leq 2.25$ ,  $2.25 < PR-GPA \leq 2.75$  and  $PR-GPA > 2.75$ . Chi-square goodness of fit tests showed no significant differences (using a Type I error rate of 0.05) between the students in the three homework grading policy categories ( $\chi^2 = 0.76$   $p = 0.68$  for one problem,  $\chi^2 = 0.92$   $p = 0.63$  for three problem and  $\chi^2 = 2.54$   $p = 0.28$  for no homework).

## Results

The analysis of variance (ANOVA) conducted to examine the differences between the three grading policies showed significant differences where the grading policy of assigning one homework problem produced significantly different results than the 3-problem assignment and no graded homework policies (See Table 2). The latter two exhibited no statistically significant differences in the final exam grade distributions. Figure 1 shows a histogram of student performance on the final exam based on different grading policies. Note that the proportion of students who performed poorly or below average with one homework problem is significantly higher than the other two grading policies.

We further analyzed the impact of different homework grading policies on students with varying academic performance coming into the course. One of the factors we considered is the average grade in the course prerequisites (Calculus I, II, III and Ordinary Differential Equations). Our analysis indicated that while the three different homework grading policies did not show a significant difference in the final exam grades of students with a course prerequisite  $GPA \geq 3.0$  (See Table 3), the effect of homework grading policy was a significant factor for students with a course prerequisite  $GPA < 3.0$  (See Table 4). Figure 2 shows a histogram of student performance on the final exam for students with a course prerequisite  $GPA < 3.0$ . Note that the proportion of students who performed well and above average with no homework and three homework problem cases are higher than one homework policy grading policy and the difference is much more prevalent in the case where one out of three homework problems were graded.

Table 2. ANOVA Summary for differences in homework grading policy

SUMMARY				
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
one problem	111	2281	20.54	19.28
three problem	111	2458	22.14	16.10
no homework	96	2089	21.76	16.24

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>Fcrit*</i>
Between Groups	152.58	2	76.29	4.42	0.01278	3.02
Within Groups	5436.66	315	17.25			
Total	5589.24	317				

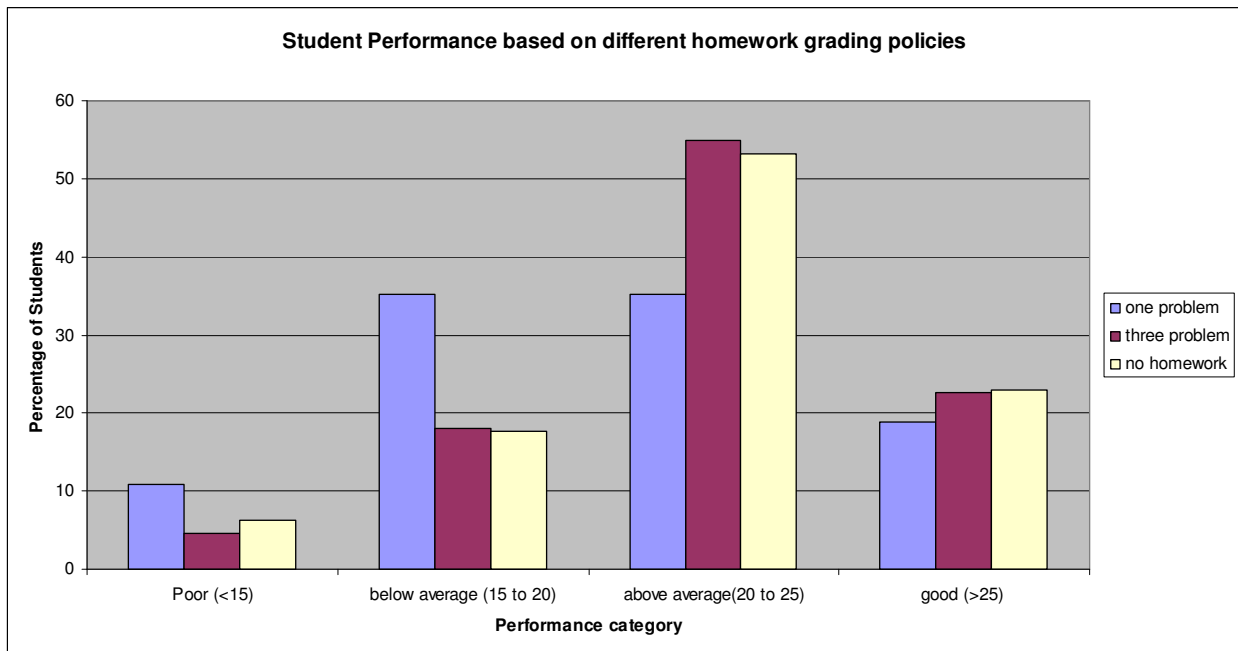


Figure 1. Student performance histogram for different grading policies

\*  $\alpha=0.05$

Table 3. ANOVA Summary for differences in homework grading policy for students with course prerequisite  $GPA \geq 3.0$

SUMMARY					
Groups	Count	Sum	Average	Variance	
one problem	52	1164	22.38	17.61	
three problem	45	1080	24.00	12.50	
no homework	47	1093	23.25	12.41	

ANOVA						
Source of Variation	SS	df	MS	F	P-value	Fcrit*
Between Groups	63.41	2	31.70	2.21	0.1130	3.062
Within Groups	2019.24	141	14.32			
Total	2082.65	143				

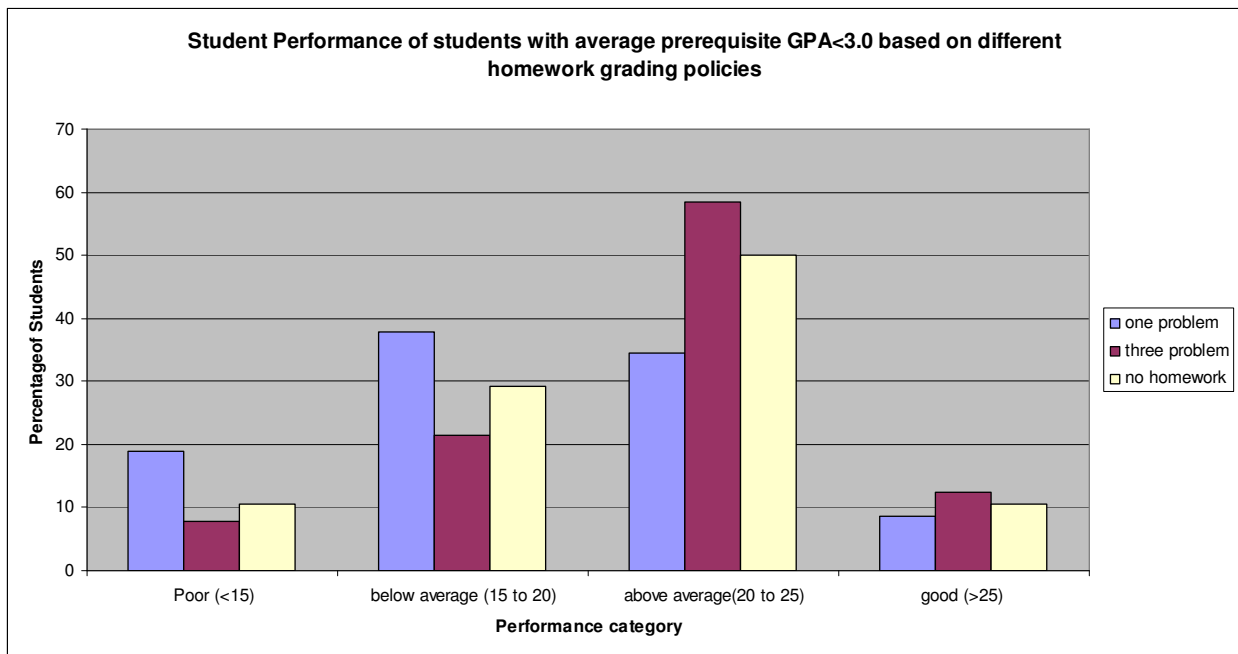


Figure 2. Performance histogram of students with average prerequisite  $GPA < 3.0$  for different grading policies

Table 4. ANOVA Summary for differences in homework grading policy for students with course prerequisite GPA<3.0

SUMMARY						
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>		
one problem	59	1117	18.93	15.40		
three problem	66	1378	20.87	14.78		
no homework	49	996	20.32	15.97		

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>Fcrit*</i>
Between Groups	122.76	2	61.38	4.004	0.01997	3.04
Within Groups	2621.53	171	15.33			
Total	2744.29	173				

We also collected data regarding student learning at the low and high levels of Bloom’s taxonomy. Since the homework was assigned in one class and was collected immediately before the next class, the homework problems pertained to low level Bloom’s taxonomy. Our analysis shows no significant difference between the three grading policies regarding the number of correct answers to questions at the high level of Bloom’s taxonomy. On the other hand, there is a significant difference between these grading policies when the correct answers to questions at the low level of Bloom’s taxonomy are considered. These results are summarized in Tables 5 and 6. Pairwise comparisons between these grading policies show the most significant difference (p-value = 0.001) between the one and three problem homework policies. No significant differences were detected between three problem and no homework options and finally the no homework option was only slightly different (p-value=0.048) than the one problem option at the Type I error rate of 0.05. Figure 3, shows student performance on low level Bloom’s taxonomy questions for different grading policies. Note again the significantly higher proportion of students performing above average or good for the three problem case while the difference is not as pronounced for the no homework case, it is statistically significant at the Type I error rate of 0.05.

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\*  $\alpha=0.05$

Table 5. ANOVA Summary for student performance in the final exam questions at the high level of Bloom's taxonomy

SUMMARY				
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
one problem	111	1117	10.06	6.39
three problem	111	1178	10.61	5.91
no homework	96	1019	10.62	5.25

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	21.90	2	10.94	1.862	0.157	3.024
Within Groups	1851.64	315	5.88			
Total	1873.54	317				

Table 6. ANOVA Summary for student performance in the final exam questions at the low level of Bloom's taxonomy

SUMMARY				
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
one problem	111	1164	10.49	5.94
three problem	111	1280	11.53	5.22
no homework	96	1070	11.15	5.35

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	61.87	2	30.93	5.615	0.004	3.024
Within Groups	1735.33	315	5.51			
Total	1797.20	317				

### Conclusions:

In this paper we have reported on an experimental design and analysis to understand the effects of picking homework for a grade on student performance measured by a multiple choice final examination. *Our results indicate that picking homework for a grade does not affect student performance.* In fact, the students who did not have to hand in homework consistently outperformed those who submitted one homework problem to be graded. The most successful grading policy, especially for the students with a prerequisite GPA<3.0, is where three homework problems are assigned and only one is graded. In none of the cases we tested, this policy produced statistically significant different results than the no homework policy.



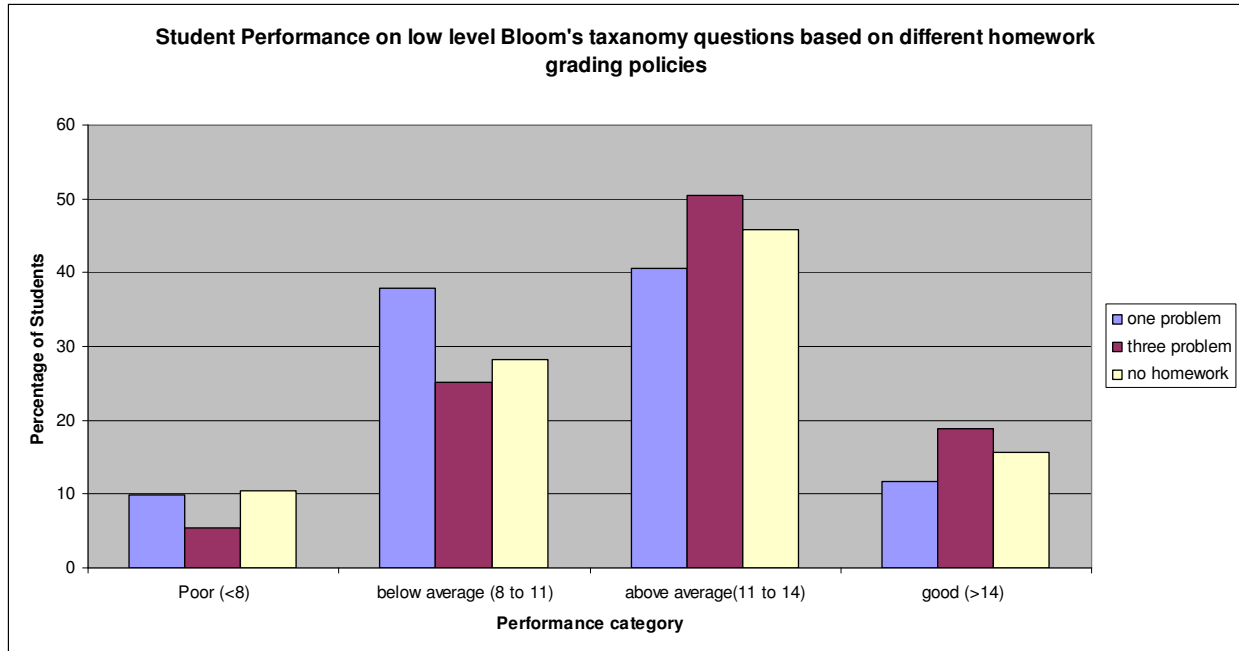


Figure 3. Histogram of student performance on low level Bloom’s taxonomy questions for different grading policies

*We believe that improved student performance is attributed to the amount of practice students are getting.* In the no homework policy the students practiced during class time through the use personal response systems for reviewing pre-requisite knowledge and checking end-of-topic knowledge. In the grading policy where one out of three problems were graded the additional homework problems they had to solve provided the extra practice. Students who only had one homework problem to hand in either did not get sufficient practice or failed to devote the necessary time and effort to the problem and therefore performed consistently worse than the students subjected to other grading policies. This belief is further supported by the finding that students with a prerequisite  $GPA \geq 3.0$  were not affected by the grading policy at all as these students are already sufficiently motivated to get adequate practice without the graded homework incentive.

In terms of student learning, we detected no significant difference between the grading policies for questions in the high levels of Bloom’s taxonomy which are the types of questions that were not covered in either the assigned homework problems for grade or the in-class exercises. However, questions in the low level Bloom’s taxonomy (similar to the assigned homework problems and in class exercises) were answered better by the students in the no homework and one out of three homework grading policies supporting the conclusion that its not the grading policy but the amount of practice that influences student performance.

In summary, similar to the previous work in this area<sup>[4,8]</sup>, we found no conclusive evidence that grading homework improves student performance. Our results also indicate that subjecting

students to practice problems either in class or as homework significantly affects student performance especially for students with weaker academic standing. Furthermore, student performance in problems similar to the ones that they have practiced is better than the ones they were left on their own to practice.

## **Future Research**

Even if there does not seem to be convincing evidence that graded homework improves student performance, faculty use graded homework as an early indicator of how the overall class is doing and students' level of understanding. Therefore, the faculty may be reluctant to eliminate grading homework.

Research literature provides interesting results regarding the correlation between performance in homework and performance in a course. Wankat<sup>9</sup> provides a correlation analysis of 120 chemical engineering students' performance on homework and learning, where learning is measured by the total points earned in all of the tests in a sophomore chemical engineering course. The analysis results in  $R^2=0.2919$  which is not exceptionally high but does show a positive correlation between performance on homework and learning as measured in this study. Most recently, Fernandez, Saviz and Burmeister conducted a study<sup>8</sup> to examine the correlation between individual student scores on homework, quizzes, tests and final examination. Their analysis included four different courses taught by 3 different faculty and showed a weak correlation between homework and quiz, test or final exam scores and much stronger correlation between quiz, test and final exam scores.

In light of our findings and the results from [8] and [9], the next logical question to ask is, should we invest scarce TA time in grading quizzes and/or frequent tests rather than homework problems? In this manner, not only we will get early indication of how the students' are doing, but possibly this information will better correlate to overall course performance than homework, and frequent tests may encourage students to get more practice and therefore improve student performance.

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