Is Assigning Homework Prior to Lecture More Effective in Statistical Learning than Assigning Homework After Lecture?

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Abstract

This session presents the results of two teaching methods for introductory statistics - in one class students submitted homework prior to lecture and in the other class students submitted homework after lecture. It is hypothesized students assigned homework before lecture demonstrate higher statistical learning than students assigned homework after lecture.

Motivation for Study

Business students at Lamar University are required to take two semesters of statistics which are offered at the junior level. The first course covers descriptive statistics, basic probability, discrete and continuous probability distributions, sampling theory, estimation, and introduction to test of hypothesis (single population mean and single population proportion). The second course covers: a review of estimation and tests of hypothesis, expands hypothesis testing to include single population standard deviation, two population means, two population proportions, two population variances, ANOVA models, nonparametric models for two or three populations of quantitative data, chisquared models for categorical data, simple/multiple linear correlation/regression analyses, and time series.

In Fall 2000, I taught three sections of the first statistics course. The average on the first examination was 53 with 58 percent of the students failing the examination. Because students were provided three sets of multiple choice examinations as a study guide, I refused to curve grades. Immediately, students started dropping the course. By the end of the semester, 78 percent of the students either dropped or failed the course. The department chair called me to his office and asked me to "lower the bar without watering down the course." According to the chair, students' major complaints were the difficulty of the midterm examinations.

The Study

For Spring 2001, I redesigned the course. Instead of administering quizzes between the three major midterm examinations and requiring a comprehensive final examination, the course was redesigned by grading homework, administering MORE quizzes, eliminating all midterm examinations, and requiring a comprehensive final examination.

I felt I was both "watering down the course" and "lowering the barrier" because I was lowering performance standards to accommodate students at the expense of learning. I decided I needed to do something in the course to give the lower expectations meaning. I decided that one of the two sections of the first semester course would work homework before my lecture. The other section would work homework after my lecture. The syllabus stated:

> The syllabus contains the reading assignment for each class period. Students in both classes are expected to read the assigned pages BEFORE attending class. During this semester there will be two approaches of assigning homework. For Section 1 (10:10 am), the problems appearing with the assigned reading are to be worked BEFORE attending the class lecture. For Section 2 (11:00 am), the problems appearing with the assigned reading are to be worked AFTER attending the class lecture (however, students in this section are expected to have read the assigned reading). It is hypothesized that students in Section 1 will perform higher on the average on quizzes and the final examination than students in Section 2. During the semester, Professor Drapeau will collect ten homework problems. Students in Section 1 need to bring homework to class on Wednesday and Friday and one Monday (March 5). Students in Section 2 need to bring homework to class of Friday and Monday and one Wednesday (March 7). Professor Drapeau will not accept late homework. Each homework problem selected will be graded on a base of five points. Although Professor Drapeau will be more lenient in

grading homework from students in Section 1 than from students in Section 2, students in both sections must clearly show their work. Students who merely copy the solutions in the back of the textbook will not receive full credit. To maximize homework points, write the formula, substitute numbers, and show the final calculation. For problems in Chapters 7-10, draw pictures which clearly identify the appropriate probability. To Professor Drapeau, it is more important for students to show the process of solving a problem than to generate the final answer. If more than ten homework problems are collect, the best ten homework problems will contribute fifty points to your semester grade.

In addition to ten homework assignments, the syllabus scheduled twelve quizzes. The syllabus stated:
Twelve quizzes will be administered during the session. These quizzes are scheduled for Monday classes. The scheduled dates of these quizzes appear on the syllabus. Each quiz will consist of true/false questions, short answers, simple problems, and/or computer printouts. When the quiz is simple problems, you must show your work to obtain full credit. If you only provide the answer -- only part of the solution -- you will receive only partial credit. Each quiz will be worth 20 points. The best ten of the 12 quizzes will be used for your semester quiz score. The quizzes contribute 200 points to your final course grade. On the day of the quiz, the first 25 minutes of class time will be used to answer questions over material covered during the previous week. The second 25 minutes of class time will be used to work the quiz. Calculators are permitted on quizzes.

I decided to maintain the comprehensive final examination. The syllabus stated:
A comprehensive final examination worth 150 points will be administered on the date as specified by the University. Necessary formulae will be provided by the student bringing a HELP SHEET to the examination. For the final examination, the HELP SHEET will consist of both sides of TWO 8.5x11 inch sheet of paper. You may write anything on the HELP SHEET, but everything on the HELP SHEET is to be HAND WRITTEN. ANY ATTEMPT TO USE MORE THAN TWO, TWO-SIDED HELP SHEET WILL BE CONSIDERED CHEATING. **A STUDENT REFERRING TO THE HELP SHEET AS A "CHEAT" SHEET WILL LOSE THE PRIVILEGE OF USING A HELP SHEET.** IF YOU FORGET YOUR CALCULATOR OR HELP SHEET, YOU WILL COMPLETE THE EXAMINATION WITHOUT THE RESOURCE; YOU MAY NOT USE YOUR NEIGHBOR'S CALCULATOR OR HELP SHEET.

A comparison of the course structure for Fall 2002 and Spring 2001 appears in the Table 1.

Table 1
Comparison of Traditional vs. Modified First Semester Statistics Course

Activity	Fall 2000	Spring 2001
Homework collected/graded	None	10 assignments (collected 11) 50 points
Quizzes	Best 7 of 8 100 points	Best 10 of 12 (actually 10 of 14) 200 points
Midterm Exams	3 300 points	None
Comprehensive Final	1 200 points	1 150 points
Total Points	600 points	400 points

The Research Hypothesis

Intuitively, students in Section 1 (pre-lecture homework) would be expected to perform better than students in Section 2 (post-lecture homework) because they had to carefully read the text and work assigned homework before I lectured on the material. I would expect that this "pre-preparation" would (1) develop critical thinking skills, (2) facilitate comprehension of statistical concepts and (3) provide learning to perform better on quizzes and the comprehensive final examination. This reasoning suggests a one-tail test: H_0: $\mu_1 \leq \mu_2$ and H_0: $\mu_1 > \mu_2$ where means are compared for homework, quizzes, and each component of the comprehensive final examination.

Statistical analysis used Oneway ANOVA and the General Linear Models of SPSS. Both these models test the null hypothesis that all means are equal with the alternative that at least one mean is different. With only two samples, the direction of difference can be determined by comparing the two sample means. It must be noted that these statistical models are based upon probability samples. Students in these two classes were actually convenience samples. The assumption, regardless of how weak it may be, is that these convenience samples are as representative of the two populations as are random samples. A level of significance of 0.05 was selected.

Findings

Table 2 presents the analyses of five Oneway ANOVA analyses comparing the difference between the two sections in mean performances on homework, quizzes, and each component of the comprehensive final examination.

Table 2
Oneway ANOVA
Mean Performances on Assessment Instruments
BUAL 3310, Section 1 and Section 2

Variable	Homework (11)	Quizzes (14)	Final Exam Part I (True/False)	Final Exam Part II (Problems)	Final Exam Both Parts
Maximum Points	55	280	50	100	150
Section 1 (n_1=15)	32.9	175.5	29.4	44.3	73.7
Section 2 (n_2 = 14)	22.5	168.4	31.4	45.2	76.6
P-value	0.016	0.632	0.336	0.881	0.694

Section 1 (pre-lecture homework) generated a higher average on homework and quizzes but a lower average on both parts of the comprehensive final examination than did Section 2 (post-lecture homework). If these two small samples are treated as probability samples, then the only difference which is statistically significant at the 0.05 level of significance is the mean homework grades between the two sections. As noted in the syllabus (and as practiced in class during the semester), I graded homework from Section 1 more leniently than homework from Section 2. Therefore, the statistical difference could be easily attributable to the way I graded homework from the two sections.

Although there is no statistically significant difference between mean performances on each of the two parts of the final, the performance on the final examination was disastrous! Part I of the comprehensive final examination consisted of 25 true/false questions testing theory. If students marked a question false, they had to correct the statement to make it true. Out of 50 possible points, the mean grade was 29.4 points (58.8%) in Section 1 and 31.4 points (62.8%) in Section 2. Part II of the comprehensive final examination

consisted of problems worked longhand for which partial credit was assigned. Performance on Part II was worse than on Part I; out of 100 possible points, the mean grade was 44.5 points (44.5%) in Section 1 and 45.2

point (45.2%) in Section 2. For the combined parts, the mean grade was 73.7 points (49.1%) and 76.6 points (51.1%) in Section 2. It was obvious that the weekly quizzes only encouraged short-term learning, so students were not prepared to take a comprehensive final examination. Because performance on the comprehensive final examination was so poor, the higher number between semester percentage prior to the comprehensive final examination and semester percentage after the comprehensive final examination was used to assign semester grades. For all but one student, performances on the comprehensive final examination reduced semester percentages, so course grades were based upon performances entering the comprehensive final examination. The one student who improved his semester percentage was failing before and after the comprehensive final examination.

Realizing that performance could be influenced by aptitude, GPA was used as a measure of aptitude and a Oneway ANOVA was performed on GPA of students in both sections. This analysis is presented in Table 3.

Table 3
Mean GPA of Students in BUAL 3310, Section 1 and Section 2

	Mean GPA
Section 1 (n_1 = 15)	2.74
Section 2 (n_2 = 14)	2.94
P-value	0.384

The mean GPA of students in Section 1 is lower than the mean GPA of students in Section 2. Assuming the samples to be probability samples, the difference is not statistically significantly at the 0.05 level of significance.

Realizing that performance could be influenced by the amount of time students work on jobs outside of school, a Oneway ANOVA was performed on the hours worked per week (HWPW) of students in both sections. This analysis is presented in Table 4.

Table 4
Mean Hours Worked Per Week for Students
in BUAL 3310, Section 1 and Section 2

	Mean HWPW
Section 1 (n_1 = 14)	35.6
Section 2 (n_2 = 14)	26.9
P-value	0.153

The mean HWPW of students in Section 1 is higher than the mean HWPW of students in Section 2. Assuming the samples to be probability samples, the difference is not statistically significantly at the 0.05 level of significance.

Five linear models analyzing the difference in means of each of the five assessment instruments were run using GPA as a covariate; these are referred to as Model 2. Five linear models analyzing the difference in means of each of the five assessment instruments were run using HWPW as a covariate; these are referred to as Model 3. Finally, five linear models analyzing the difference in means of each of the five assessment instruments were run using both GPA and HWPW as covariates; these are referred to as Model 4. Table 5 presents the results of these analyses.

Table 5
Mean Performances on Assessment Instruments Section 1 and Section 2
Model 1 – Compare Only Performance Model 2- Performance Adjusted for GPA
Model 3 – Performance Adjusted for Hours Worked Per Week
Model 4 – Performance Adjusted for GPA and Hours Worked Per Week

Variable	Homework (11)	Quizzes (14)	Final Exam Part I (True/False)	Final Exam Part II (Problems)	Final Exam Both Parts
Section 1[1]	32.9	175.5	29.4	44.3	73.7
Section 2[2]	22.5	168.4	31.4	45.2	76.6
Model 1 P-value	0.016	0.632	0.336	0.881	0.694
Model 2 P-value	0.001	0.115	0.452	0.561	0.825
Model 3 P-value	0.026	0.619	0.569	0.600	0.768
Model 4 P-value	0.001	0.001	0.738	0.112	0.220

[1] **n_1 = 15 for Models 1 and 2, n_1 = 14 for Models 3 and 4**
[2] **n_2 = 14 all models**

As with the Oneway ANOVA, the General Linear Models consistently found the difference in mean performances on homework between the two sections to be significantly different. Using a five percent level of significance, mean homework of Section 1 was higher than mean homework of Section 2. However, as previously explained, grading of Section 1 homework was more lenient than grading of Section 2 homework. Model 4 – comparison of means adjusted for both GPA and HWPW – indicated mean quiz grade of Section 1 to be significantly higher than the mean quiz grade of Section 2.

As noted in the discussion of the Table 2 analysis, mean performance on each part of the comprehensive final examination in Section 1 was lower than in Section 2; however, at the five percent level of significance this difference was not statistically significant. As previously noted, students were not prepared to take a comprehensive final examination.

Summary and Conclusions

This study was motivated by the need to "lower the bar" without "watering down the course." Students in one section of the first junior level business statistics course were required to work homework before class lecture while students in another section of the same course were required to work homework after class lecture. Assessment measures included (1) 11 homework assignments, (2) 14 quizzes, (3) a comprehensive final examination consisting of 50 points of true/false questions and 100 points of problems worked long-hand. Although the two sections represent convenience samples, they were "assumed" to represent all students who take the first statistics class. Therefore, statistical analysis was performed using Oneway ANOVA and General Linear Models; level of significance was set at 0.05. Four models were tested: (1) simple comparison of means on the five performance measures, (2) comparison of means adjusted for GPA, (3) comparison of means adjusted for HWPW, and (4) comparison of means adjusted for both GPA and HWPW.

Homework was the only performance measure that was statistically significant on all four models. Students in Section 1 preformed statistically higher, on the average, than students in Section 2. As previously noted, grading of homework in Section 1 was more lenient than grading of homework in Section 2.

Quizzes were statistically significant for the model which compared mean performance adjusted for GPA and HWPW. Mean performance in Section 1 was higher than mean performance in Section 2.

Performance on each of the two parts of the comprehensive final examination was lower by students in Section 1 than by students in Section 2. However, the difference was not statistically significant for any of the four models. As previously noted, weekly quizzes only focused on short-term learning and did not prepare students for a comprehensive final examination. The average grade on the comprehensive final examinations in both sections was around 50%. It is apparent that "lowering the barrier" was achieved but "without watering down the course" was not achieved.

Limitations of the study include (1) use of statistical models for nonprobability samples and (2) small sample sizes. Additional analysis will include (1) impact of the number of courses students took and (2) impact of number of college math courses completed before taking the first business statistics course. Including these additional explanatory variables may identify differences in performances between the two sections.