

TRADITIONAL VS. ONLINE HOMEWORK IN COLLEGE ALGEBRA

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ABSTRACT

A year long study was conducted in multiple sections of College Algebra by the authors using a system of both traditional paper homework and online homework assignments. The online homework system was Pearson/Addison-Wesley's *CourseCompass* which was integrated with the textbook. This system allows the students multiple attempts at problems with extensive hints and examples while providing instant feedback for every problem. Data was collected from both groups including in-class exam scores, final exam scores, and homework averages. Of particular interest to the investigators was whether one method would help facilitate the understanding and retention of the material better than the other. We present the analysis and the conclusions.

1. INTRODUCTION

As class times are shortened and required material is lengthened, many mathematics professors are increasingly turning to online homework systems such as *CourseCompass* (www.coursecompass.com), *WebAssign* (www.webassign.com), and *WeBWork* (<http://webwork.rochester.edu>). Systems such as these offer the student instant feedback and online help while freeing the professors from the often cumbersome task of grading traditional paper-and-pencil homework. The question addressed in this paper is whether an online homework system facilitates the understanding and retention of the material better than traditional paper-and-pencil homework.

The study was conducted in College Algebra classes during the 2007-2008 academic year at Indiana University of Pennsylvania (IUP), a state university with approximately 14,000 students. College Algebra at IUP is a prerequisite for the calculus and business calculus sequences. Key topics in this course include: linear functions, quadratic functions, polynomial functions, graphing and solving equations, various

applications, exponential, and logarithmic functions. Certain classes of College Algebra used traditional paper homework assignments and other sections used the online homework system *CourseCompass* by Pearson/Addison-Wesley which was bundled with the textbook. The textbook used in all the classes was Beecher, Penna, and Bittinger's College Algebra [2].

2. LITERATURE REVIEW

Although research on the effectiveness of online homework systems has had mixed results, most studies conclude that online homework is as effective as traditional paper-and-pencil homework or is in fact an improvement over the traditional techniques. Safer and Segalla [7] found that students using *WeBWorK* in College Algebra performed as well as those who used the traditional method. Similarly, Bonham, Beichner, and Deardorff [2] found that students using *WebAssign* for homework submission in both Calculus and Algebra had higher test grades than those who used traditional paper-and-pencil homework. They reported test scores of 78% versus 75% in calculus and 82% versus 77% in algebra but they explained that the difference between the test scores for the two methods was not statistically significant.

Hirsch and Weibel [6] found that students using *WeBWorK* in calculus classes at Rutgers University showed a 4% statistically significant improvement on the final exam grade over their peers who were assigned traditional paper-and-pencil homework. Zerr [8] reported that an online homework system created for University of North Dakota calculus students improved student learning. This study also found positive student attitudes for the online homework system and that this resulted in students completing more homework outside of class. Finally, a recent study completed by Heffernan, Mendicino, and Razzaq [5] found that fifth grade mathematics students learned significantly more when using web-based homework than those given traditional homework. They reported an effect size of 0.61 and used this to suggest that school systems should implement such web-based homework systems when feasible.

Our study attempts to show whether there is a statistically significant improvement in student performance using online homework versus traditional paper-and-pencil homework. In the following section we give the details of the online homework system. In Section 4, we explain the method of our study, including student participation and an explanation of the two types of homework used by the students. In Section 5, we provide statistics and explain our hypothesis test.

3. THE ONLINE HOMEWORK SYSTEM

The online homework system used in this study is *MyMathLab* which is a component of *CourseCompass*, a course management system created by Pearson/Addison-Wesley. Access to this online system is bundled with the textbook which was used in the class [1]. A screenshot of a typical problem assigned in College Algebra can be seen in Figure 1.

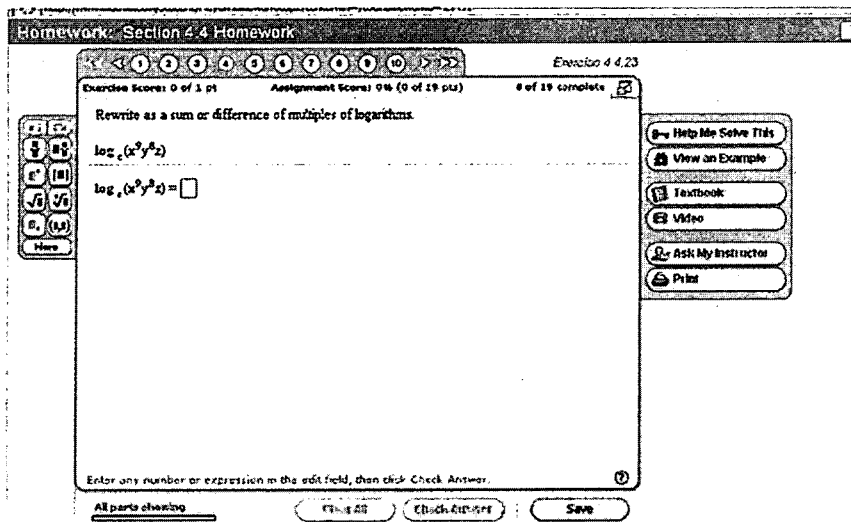


Figure 1: Homework Problem in *MyMathLab*

MyMathLab allows the students three attempts at the exact same problem. If the student needs more than three attempts to do a problem, the computer algorithmically generates a similar problem with different numbers. The online homework system asks the student which score they want to save to the gradebook for each problem they reattempt. It also provides extensive tutorials with step-by-step instructions working out a problem similar to the one assigned. Often, the only difference between the two problems was the numerical values. The tutorial associated with the problem in Figure 1 can be seen in Figure 2. In this example, one can see that the values from the original problem have been changed. The tutorial then interactively asks the students to complete each step, prompting them with explanations of rules and definitions. If the student gets any of the intermediate steps incorrect, the program provides feedback and hints on what they need to do to correctly complete that part of the problem.

Step 1.

To separate the expression into several logarithms, you'll need to use

- A. The Quotient Rule.
 B. The Product Rule.
 C. Both the Product Rule and the Quotient Rule.

Use the Product Rule.

$$\log_c(x^9y^8z) = \log_c(x^9) + \log_c(y^8) + \log_c(z)$$

Step 2.

Use the Power Rule to write the logarithms of powers as products.

$$\log_c(x^9) = 9 \log_c x$$

$$\text{Similarly, } \log_c(y^8) = 8 \log_c y.$$

The given expression can then be written

$$9 \log_c x + 8 \log_c y + \log_c z$$

Step 3.

None of the logarithms in the expression can be further simplified.

$$\text{Therefore, } \log_c(x^9y^8z) = 9 \log_c x + 8 \log_c y + \log_c z$$

Question is complete.

Figure 2: Homework Tutorial in *MyMathLab*

4. METHOD

The data for the study spans two semesters. The paper homework was used during one semester and the online homework system was used the following semester. The three sections of College Algebra using paper homework had a total of 65 students who completed the class. The two sections of College Algebra using the online homework system had a total of 61 students who completed the class. There were slight variations in content between the exams given for the different semesters because of scheduling and holidays. After carefully reviewing the exams, the instructors chose to limit the sample size to only 21 of the paper homework students because they took an identical final exam to those in one of the online homework sections. The instructors felt the level of difficulty of the other version of the final exam was too different to include those students in the sample. There were 31 students in the online homework section.

Traditional paper homework assignments were graded for correctness and completion and were returned to the students with

comments. The students had only one chance to complete these assignments. The online homework system allowed the students three attempts at the exact same problem. If the student needed more than three attempts to do a problem, the computer algorithmically generated a similar problem with different numbers. The online homework system asked the students which score they wanted recorded in the gradebook. This allowed the students to save only their best score for each problem they attempted. With several attempts and extensive online help, many students were able to earn perfect scores on nearly all if not all of their online homework assignments.

Several students expressed their preference for using the online homework system over paper homework. Many explained that they liked being able to do their homework whenever they wanted and still have help via the online tutorials. They also appreciated the multiple attempts at problems to get them correct, often asking for help in class if they could not get the problems so that they could return that night to try the problems again.

5. RESULTS

5.1 Homework Type and Exams

We found the students who used the online homework system performed better on the exams. To statistically examine these results, we set up the following hypothesis test:

$$H_0 : \mu_0 = \mu_p,$$

$$H_a : \mu_0 > \mu_p,$$

where μ_0 = mean exam score for all online homework students and μ_p = mean exam score for all paper homework students. The p -values associated with each of the exams are given in Table 1. Since the p -value for Exam 2 is $0.006 < 0.05$, there is sufficient evidence at the 5% significance level to conclude that the mean score of Exam 2 from all the online homework students is higher than the mean score of Exam 2 from all paper homework students. Similar statements can be made regarding the p -values for Exam 1 and Exam 3 since they are both less than 0.05.

In contrast, the Final Exam had a p -value of $0.0685 > 0.05$. This means there is insufficient evidence at the 5% significance level to conclude that the mean score of the Final Exam from all online homework students is higher than the mean score of the Final Exam from all paper homework students. However, the sample mean difference is about 8% between the online and paper homework groups.

	Exam 1	Exam 2	Exam 3	Final Exam
<i>p</i> -value	0.000	0.006	0.014	0.0685

Table1: *p*-values for the Hypothesis Tests

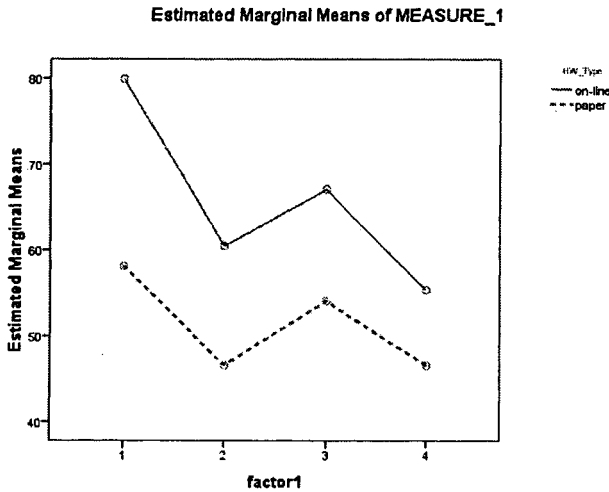


Figure 3: Results by Homework Type

Figure 3 shows the means for Exam 1, Exam 2, Exam 3, and the Final Exam (4) for the students who used online homework and those who completed traditional paper homework assignments. The line segments in Figure 3 are not parallel, which indicates some level of interaction between homework types and the four exams. In comparing the same exams for different homework types, the line segments preserve the same slope regardless of the homework type. This shows that homework types have the same impact (both either increasing or decreasing) on exam grades. Furthermore, observing the gap between the plots of the online homework and paper homework, we see that the gap is decreasing from Exam 3 to the Final Exam (4). In general, the online homework exam averages drop more significantly than the paper homework exam averages, causing the gap between the two means to decrease.

The means for the online homework students' exams were higher than those who completed paper homework assignments. We believe these higher scores are a result of the extensive repetition and assistance the online homework program provides. Students are able to review homework before exams and can reattempt the homework problems without penalty. Students also had every problem graded and therefore knew if their answers were correct. This is in contrast to the paper

homework assignments which had only selected problems graded. Students could not be sure their techniques were correct for solving problems that were ungraded. These advantages over traditional paper homework contribute to the successful mastery of the material by the online homework students.

5.2 Correlation between Homework Grades and Exam Performance

Additionally, we examined the individual scores of the students on the various exams based on their homework types. The scatter plots of the homework z-scores versus the exam scores for both online and paper homework are provided in Figure 4, Figure 5, Figure 6, and Figure 7. The correlation coefficients for both the paper homework students and the online homework students' Exam 1, 2, 3, and Final Exam can be seen in Table 2. The paper homework students' exam scores had a stronger positive linear pattern than the online homework students' exams. This means the paper homework scores provide a better prediction of their exam scores. The paper homework students do not actually perform better on the exams than the online homework students (in fact the opposite is true), but the homework scores are a better measure of their exam success.

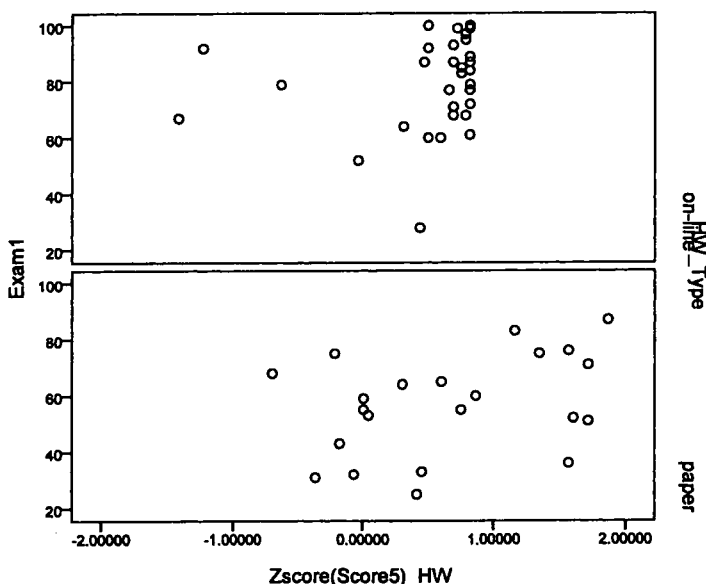


Figure 4: Exam 1 Scores by Homework Type

Although the scatter plots for the online homework students did not fit a positive linear pattern, many had a nearly vertical line of exam scores with a z-score of almost 1. Within this pattern, the exam scores ranged from 20 to 100. We believe this can be attributed to the multiple attempts

allowed on every homework problem and the extensive online tutorials and help. The students may simply be mimicking the steps of the worked-out examples without having any true understanding of the concepts.

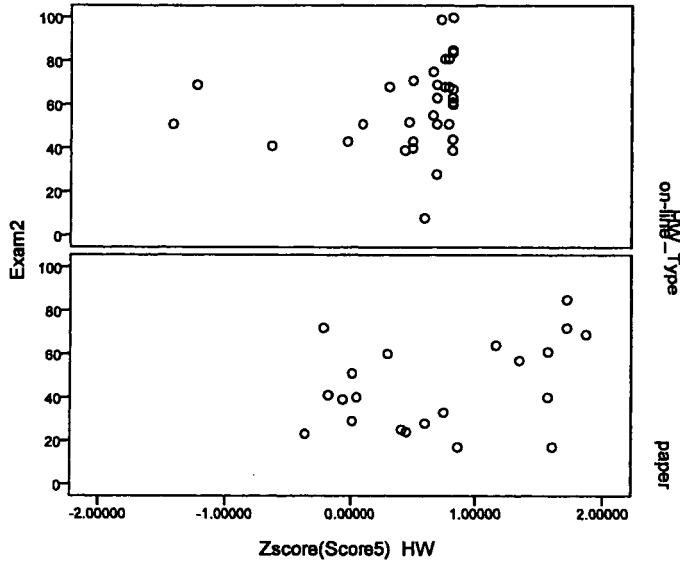


Figure 5: Exam 2 Scores by Homework Type

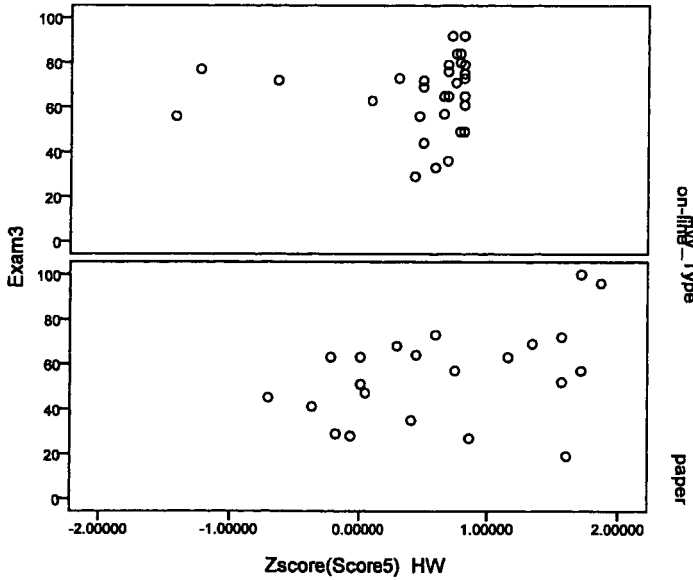


Figure 6: Exam 3 Scores by Homework Type

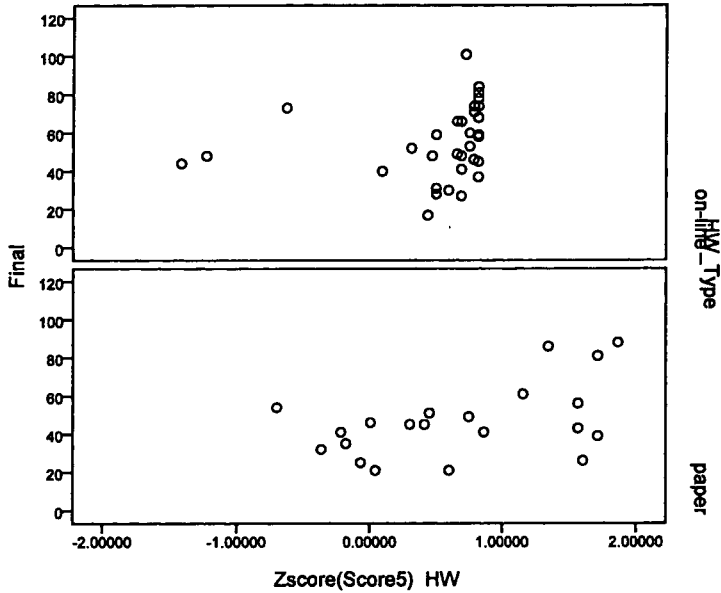


Figure 7: Final Exam Scores by Homework Type

	Exam 1	Exam 2	Exam 3	Final Exam
PAPER HOMEWORK	0.342	0.373	0.421	0.476
ONLINE HOMEWORK	0.154	0.193	0.092	0.180

Table 2: Correlation Coefficients for Exam Grades vs Homework Type

Yet, without the repetition that is allowed in the online homework system, we feel the students overall would not have learned the material as well. We feel being able to redo homework problems and review them interactively was a key factor in the online homework students obtaining higher exam scores than the traditional paper homework students. What we noticed with the paper homework students was that if they had poor homework averages, they had little to no chance of performing well on exams. They did not have the same opportunity to interactively review their homework and get instant feedback as the online homework students did.

6. CONCLUSIONS

Some factors that we would like to address are the fact that the breakdown of material from the exams in the Fall semester differs slightly from the exams in the Spring semester due to holidays and the general difference in semesters. Ideally, we would like to run the study by

switching back and forth between online and paper homework in the same class in the same semester. Unfortunately, this is both impractical from a teaching standpoint and the fact that the students incur a cost to use the online homework systems. To announce that we would not be using the online system exclusively would most likely be met with much disdain. Also, the students in the online homework sections were given the paper homework sections' exams as a sample. Students were not given the solutions and had to work the sample exams to obtain solutions. For this reason, different problems were chosen for the online homework semester exams while the same level of difficulty was maintained.

The online homework students earned higher exam scores than the traditional paper homework students. We believe this is due to the repetition and problem hints available to the online homework students. Additionally, the online homework students could review and reattempt their homework assignments without penalty. They also had scores for every homework problem and were assured their answers were correct. In contrast, the paper homework students only had correct solutions to the problems that were graded and were therefore unsure if some of their problem solving techniques were correct. Also, students' scores on the paper homework assignments were a better predictor of exam performance.

Additionally, we note that the retention rate in the online homework sections was much higher than that of her traditional paper homework sections. The retention rate for the online homework sections was 86% while the retention rate for the paper homework sections was just 58%. Both homework types ended with nearly the same number of students but it is important to note that there were three sections using paper homework and only two sections using online homework.

The instructors recognize that there is no way to verify who is actually completing the online homework. Also, if the online questions are multiple-choice, the students may successfully complete the problem by repeatedly guessing without understanding the concepts. However, the instructors found that online homework helped to streamline the class, eliminating the need to wait for papers to be graded and returned. Students were also able to check their averages in the class at all times by logging in to the online homework system. Most importantly, the student exam scores were higher for the online sections than those of the traditional paper homework sections. This combined with the better retention rate achieved by the online classes makes using the online homework systems, although not without flaws, extremely appealing.

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