

Practice. Practice. Practice. Do Homework Management Systems Work?

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Practice is an essential component in learning any new skill. For learning the quantitative disciplines at the university level, web-based homework management systems provide the means for extensive practice with immediate feedback, which research suggests should lead to increased student learning (Palocsay & Stevens, 2008; Titard, DeFranceschi, & Knight, 2014). Do web-based homework management systems improve student learning, as measured by exam scores, for adult learners in an online course? Does the use of simple Microsoft Excel-based homework templates relate to improved student exam scores? This natural experiment divided a sample of 2431 online students in an entry level university economics course into three treatment groups to look at the relationship between homework support and exam scores. Results suggest that practice provided by a web-based homework management system is correlated with increased student learning as evidenced by increased exam scores.

INTRODUCTION

How do you get to Carnegie Hall? Practice. It's true for musicians and the literature suggests it is equally true for students hoping to master quantitative disciplines at the university level. Web-based homework management systems provide a means for extensive practice with immediate feedback, which should lead to increased student learning (Palocsay & Stevens, 2008; Titard et al., 2014). Do web-based homework management systems improve student learning, as measured by exam scores, for adult learners in an online course? Does the use of simple Microsoft Excel-based homework templates relate to similarly improved student exam scores?

Previous studies are far from unanimous in their support of web-based homework management systems. Supporters contend the flexibility of extensive practice and immediate feedback lead to improved student performance (Arora, Rho, & Masson, 2013) as well as increased student enthusiasm and motivation (Halcrow & Dunnigan, 2012). Opposing studies found web-based homework systems stimulate student guessing behaviors and lead to grade inflation (Rhodes & Sarbaum, 2015). Other studies showed no significant difference in student exam scores between traditional paper based homework or the newer web based homework systems after controlling for students' previous math experience (Hauk, Powers, & Segalla, 2015). Would the results be similar for adult learners in a fully online environment?

LITERATURE REVIEW

Any discussion of previous findings on the effectiveness of web-based homework management systems must first begin with a definition of the term. The web-based homework management system under consideration in this study is a system created by a major textbook publisher with thousands of users around the world. More broadly, web-based homework management system refers to a system that is accessible from any standard internet browser, that includes password authentication, transmission of assignments to students, collection of student answers, and automatic grading and recording (Bonham, Deardorff, & Beichner, 2003).

Even with the term carefully defined, the very question of learning effectiveness itself remains ambiguous. This study relied upon student performance on exams as a measure of learning because in this course the exams were the only summative as-

essment of learning. Two dominant themes emerge in the discussion of the effectiveness of homework management systems. Does the use of a web-based homework management systems increase student learning as reflected in improved exam scores? Is any increased student learning superficial in nature or does it include deeper understanding of the content?

Improved Exam Scores. The literature is crowded with studies showing web-based homework management systems increase student learning as measured by improved exam scores. Titard et al. (2014) found that exam scores in their undergraduate accounting course increased with the use of a web-based homework management system. Furthermore, a t-test comparison of means showed that exam scores increased more for students who scored at least 70% on homework completed through the web-based homework management system than for students who scored less than 70% on the homework. The study concluded that this increase was due to learning attributed to the web-based homework management system.

Bowman, Gulacar, and King (2014) measured time spent on homework through a web-based homework management system used in an introductory chemistry class. They found a positive correlation between time spent using the web-based homework management system and both exam grades and course grades. Halcrow and Dunnigan (2012) found similar results in their research on students studying calculus. Yet for all the studies showing increased student learning with the use of web-based homework management systems, the results were not absolute (Bowman, Gulacar, & King, 2014; Fatemi, Marquis, & Wasan, 2015; Fish, 2015; Rhodes & Sarbaum, 2015). The opposing studies generally conceded that web-based homework management systems tended to increase homework scores but questioned whether students truly mastered the material in the process.

Superficial Learning or True Mastery. While exam scores are a convenient measure of the level of student learning, true mastery of the material is more difficult to measure, and the literature is more mixed in its support of web-based homework management systems as a means to true mastery.

Arora et al. (2013) found that undergraduate engineering students did better on exams in the first course in the sequence with the use of web-based homework management systems. These students continued to perform better on exams in subse-

quent courses in the engineering sequence, indicating a high level of concept mastery and retention.

Kontur, de La Harpe, and Terry (2015) took these findings a step further in another similar study of undergraduate engineering students. They found that exam scores for high aptitude students improved with increased homework practice through use of a web-based homework management system. Conversely, exam scores for middle and low aptitude students remained unchanged or even decreased with increased homework practice and use of the web-based homework management system. A study of undergraduate operations management students showed similar results (Fish, 2015), suggesting the students had not truly mastered the material.

One theory as to why students may not master the material when using web-based homework management systems focuses on guessing behavior. Web-based homework management systems often allow multiple attempts on each problem to allow for practice.

But with those multiple attempts comes the ability to guess at the problems without negative consequences.

In a study of 100 economics students, Rhodes and Sarbaum (2015) showed that multiple attempts in the web-based homework management system sparked guessing behavior. By gaming the homework management system, students could earn higher homework scores without spending additional time on the homework. This led to improved student homework scores without increased student learning, resulting in grade inflation.

This guessing behavior was also observed by Kortemeyer (2009) and was found to be associated with gender. Through student interviews, Kortemeyer found male students in this study of undergraduate physics students, were more apt to engage in guessing behaviors than the female students. As a result, exam scores increased for female students but remained the same for male students in the study.

A study of physics students looked at the difference in outcomes when students were allowed various numbers of attempts on each question (Kortemeyer, 2015). The research showed that problem solving became unproductive after the first attempt, and that an increase in the allowed number of attempts was associated with a reduction in the homework completion rate. Bowman, Gulacar, and King (2014) also found that although there was a positive correlation between increased time spent on homework and use of the web-based homework management systems and exam scores, those results reversed when multiple attempts were allowed. Multiple attempts on homework questions correlated negatively with exam scores and student course grades.

Ultimately, the literature remains ambiguous on this question with findings varying even within specific disciplines. The reasons for the lack of consensus in previous findings are likely complex, relating to characteristics of the students themselves, and are beyond the scope of this study. By looking exclusively at adult learners in a fully online environment, this study provides

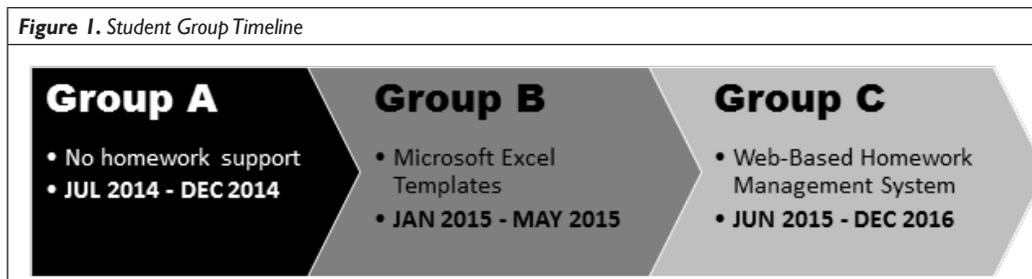
additional insight into the effectiveness of web-based homework systems for this growing student population.

METHODS

This exploratory analysis was based on a natural experiment in which a sample of 2431 online students in an entry level university economics course was divided into three groups to look at the relationship between homework support and exam scores. Changes in the curriculum dictated by the university over a 2-year period dictated the makeup of the groups, with each group receiving a different level of homework support.

Group A received no formal homework support. Group B got simple Microsoft Excel templates. Group C got an online homework management system with custom e-textbook. Changes in support related to changes in curriculum and were introduced at a discrete date rather than being phased in, as seen in the timeline in Figure 1.

Figure 1. Student Group Timeline



The course that was the focus of this study is a fully online introductory economics course with adult learners ranging in

age from 16 to more than 70 years old. The class, which covers both microeconomics and macroeconomics topics, is 7 weeks long. The sample of 2431 students used for this study included every student enrolled in the course from July 2014 to December 2016.

The university from which the study sample was taken relies upon a centrally controlled curriculum for all its courses, so all course materials for all sections were identical. All courses were taught by one of two instructors. A comparison of exam scores, homework grades, and course grades found no significant difference in student outcomes for the two instructors.

The methodology for this study relied upon analysis of variance and regression analysis to develop inferential statistics to allow comparison of results among the three treatment groups. The process began with a comparison of means for exam scores and homework scores among the three treatment groups based on descriptive statistics alone. This was followed by a t-test analysis to confirm that the observed difference in means was statistically significant, across all groups. For further detail on the progression of learning results through the series of curriculum changes pairs of groups were compared using a t-test. Finally, regression analysis was used to better define the relationship between homework scores and exam scores, the measure of student learning in this study.

RESULTS

This study found that student learning, as measured by exam performance, increased as additional formal homework support was added to the curriculum. Contrary to some previous studies, this research found no evidence of grade inflation as students were allowed additional attempts at the homework assignments. As expected, the mean scores for homework increased with use

of the web-based homework management system, but the mean scores for exams increased by a slightly larger margin. What follows is a discussion of specific results for each of the research questions that guided this study.

R₁: Is there a significant relationship between the use of web-based homework management systems with custom e-textbooks and improved student learning as measured by exam scores for adult learners in a fully online environment?

As seen in Table 1, the treatment group using the web-based homework management system showed a mean exam score of 68.24%. This compares to a mean exam score of 55.29% for students who were not using the web-based homework management system. An independent samples t-test was conducted to compare exam scores for students with the web-based homework system and without the web-based system. As seen in Table 2, there was a significant difference in the scores for students with the web-based system (M=68.24, SD=20.75) and without the web-based system (M=55.29, SD=25.9); $t(1367)=-12.44, p<0.001$.

Group A+B			
Exam Grade		HW Grade	
Mean	55.29%	Mean	66.00%
Median	61.58%	Median	79.83%
Count	820	Count	405
Group C			
Exam Grade		HW Grade	
Mean	68.24%	Mean	78.92%
Median	72.62%	Median	86.25%
Count	1611	Count	1611
Group A+B: No homework management system Group C: Web based homework management system			

Groups	N	Mean	SD	t-cal	t-crit	df	p
Group A+B	820	55.29%	25.90%	12.44	1.96	1367	<0.001
Group C	1611	68.24%	20.75%				
Group A+B: No homework management system Group C: Web-based homework management system							

Homework grades increased from a mean score of 66% to a mean score of 78.9% with the addition of the web-based homework management system, as seen in Table 1. An independent samples t-test was conducted to compare homework scores for students with the web-based homework system and without the web-based system. As seen in Table 3, there was a significant difference in the scores for students with the web-based system (M=78.90, SD=22.29) and without the web-based system (M=66.00, SD=33.94); $t(1189)=-9.87, p<0.001$.

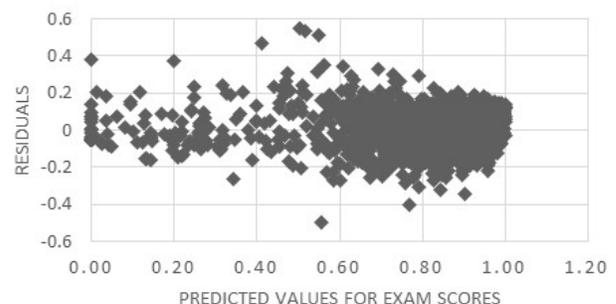
As seen in Table 4, variance in homework scores explained 74.52% of variance in exam scores with use of the web-based

homework management system compared to 69.04% without the system. Figure 2 shows the regression residuals for Group C clustered around the middle of the plot through all predicted exam values with no discernible pattern.

Groups	N	Mean	SD	t-cal	t-crit	df	p
Group A+B	820	66.00%	33.94%	9.87	1.96	1189	<0.001
Group C	1611	78.90%	22.29%				
Group A+B: No homework management system Group C: Web-based homework management system							

Group A +B	
Regression Statistics	
Multiple R	0.8309
R Square	0.6904
Adjusted R Square	0.6900
Standard Error	0.1889
Observations	406
Group C	
Regression Statistics	
Multiple R	0.8633
R Square	0.7452
Adjusted R Square	0.7451
Standard Error	0.1048
Observations	1611

Figure 2. Regression Residuals Group C



R₂: Is there a significant relationship between the use of simple Microsoft Excel-based homework templates and improved student learning as measured by exam scores for adult learners in a fully online environment?

The results above suggest that the use of web-based homework management systems is correlated with increased student learning as measured by exam scores. But could similar results

be achieved with simple Microsoft Excel-based homework templates? To answer this question exam scores for Group A, where students had no homework support, were compared to Group B where students used Microsoft Excel homework templates. Both exam scores and homework scores increased substantially with the addition of Microsoft Excel-based homework templates. As seen in Table 5, mean exam scores increased from 50.28% for Group A to 60.31% for Group B. Results of an independent samples t-test showed the difference in exam scores was statistically significant for students with the Microsoft Excel templates ($M=60.3$, $SD=22.15$) and without the template ($M=50.38$, $SD=28.22$); $t(781)=5.71$, $p<0.001$.

Table 5. Descriptives Group A Versus Group B

Group A			
Exam Grade		HW Grade	
Mean	50.28%	Mean	54.25%
Median	57.98%	Median	65.83%
Count	414	Count	414
Group B			
Exam Grade		HW Grade	
Mean	60.31%	Mean	77.92%
Median	63.10%	Median	90.16%
Count	405	Count	405
Group A: No homework support Group B: Microsoft Excel templates			

The effect was more evident in homework grades, where the mean score for homework grades increased from 54.25% for Group A to 77.92% for Group B. Results of an independent samples t-test showed the difference in homework scores was statistically significant for students with the Microsoft Excel templates ($M=78.92$, $SD=30.27$) and without the homework template ($M=54.25$, $SD=33.27$); $t(813)=10.69$, $p<0.001$.

Although scores for both homework and exams increased from Group A to Group B, the relationship between homework scores and exam scores weakened. As seen in Table 6, regression analysis showed that variance in homework scores explained just 62.34% of variance in exam scores for Group B, compared to 74.9% of variance for Group A. It should be noted, however, that both the mean score for homework and the mean score for exams were less than 60%, and therefore failing grades.

DISCUSSION

The results of this study show that increased homework support is correlated to increased student learning as measured by exam scores. Web-based homework management systems that allow for multiple attempts and repeated practice produced the highest mean homework scores (78.92%) and the highest mean exam score (68.24%) of the three treatment groups. Additionally, variance in homework scores explained the greatest percentage of variance in exam scores (74.52%) for students using the web-based homework management system compared with other treatment groups. This strong relationship suggests that use of the web-based homework management system correlates to increased student learning as measured by exam performance.

Table 6. Regression Analysis Homework Grades (IV) versus Exam Grades (DV)

Group A	
Regression Statistics	
Multiple R	0.861938905
R Square	0.742938676
Adjusted R Square	0.742314741
Standard Error	0.143277221
Observations	414
Group B	
Regression Statistics	
Multiple R	0.78957419
R Square	0.623427402
Adjusted R Square	0.622495292
Standard Error	0.13628454
Observations	406
Group A: No formal homework support Group B: Microsoft Excel templates	

It is noteworthy that although homework scores reached 78.92% using the web-based homework management system, that is still relatively low considering that students were allowed three attempts at each question. Of students who missed the first question attempt, 9.68% did not continue to a second attempt. Likewise, of students who missed the second question attempt, 11.31% did not continue to a third attempt. It is not clear why students would choose not to take advantage of all attempts to achieve the best possible score. This behavior could be explained by Kortemeyer's (2015) findings that after the first attempt problem solving becomes unproductive and was associated with a reduction in the homework completion rate. It could also be related to poor time management causing students to "run out of time" for additional attempts.

Though the mean homework score for Group C using the web-based management system was the highest of the three treatment groups, it was not significantly different from the mean score Group B using simple Microsoft Excel-based templates. The web-based homework management system allowed for multiple attempts, with explanation of the problem after each attempt. The Microsoft Excel-based templates signaled a correct answer by changing the cell color, but offered no explanation or support. The difference in student performance on homework for the two groups was statistically insignificant. This suggests that offering multiple attempts through the web-based homework management system did not stimulate guessing behaviors or result in grade inflation. It should be noted, however, that the increase in mean exam scores with the addition of the web-based homework management system was significant, and that homework scores explained a significantly higher percentage of variance in exam scores.

This contradicts findings from previous studies that found web-based homework management systems to be associated with guessing behaviors, grade inflation, and superficial learning leading to poor exam performance (Bowman et al., 2014;

Fatemi et al., 2015; Rhodes & Sarbaum, 2015). Neither guessing behaviors nor grade inflation was seen with the addition of the web-based homework management system in this study. This difference in findings may be explained by the fact the web-based homework management system in this study presented a different version of the problem with each attempt, reducing the opportunity for guessing. It may be further explained by the adult population from which this study sample was drawn, who may be less inclined to guessing behaviors. However, common reasons for guessing behaviors such as anxiety, frustration, and performance goals would apply to students of any age (Baker, Walonoski, Heffernan, Roll, Corbett, & Koedinger, 2008).

The study population could also explain the findings of this study which indicate the dramatic need for formal homework support. Homework and exams were due on the same day in this class, so there was no opportunity to review homework feedback before attempting the quiz. This makes immediate homework feedback an essential component of student learning, as evidenced by the dramatic increase in mean exam scores with the addition of the web-based homework management system. Additionally, because there are no prerequisites for this course, and due to the university's open admissions policy for the online student population, students come to the course with wildly varying levels of preparation and ability. The web-based homework management system that allows for multiple attempts can help to mitigate those differences.

LIMITATIONS AND OPPORTUNITIES FOR FURTHER STUDY

The quantitative methodology for this study provided its greatest strength but also its most glaring weakness. This study provides new insight into the relationship between web-based homework management systems and student learning as measured by exam performance. However, the reasons for students' actions and reactions in working with the web-based homework management systems was not addressed. Since learning is an activity of the person, and not of the system, a qualitative study to provide more understanding of student actions and reactions is a logical next step.

Opportunities for further study in this area are many. Of particular interest are studies that look at student demographics, studies that look at time spent on homework, and studies that explore how these factors affect low performing students compared to high performing students.

Student demographics offers a rich source of data for further explaining the effects seen here. Gender, age, previous experience with the content area, and previous grade point average may all be factors that contribute to the results seen in this study. Understanding how and to what extent each contributes would increase the usefulness of these findings.

The web-based homework management systems track time spent on assignments for each student. A study exploring the relationship between time spent on homework and either homework scores or exam scores would shed additional light on the finds of this research.

High performing students are different from low performing students in many ways. Research that explores how these differences interact with the effects seen in this study would be a valuable contribution to the field. Further understanding is needed into the role that homework support plays for each of these

student groups, and how each group might be better served by adjustments to the overall system.

The findings of this study confirm that the use of web-based homework management systems is correlated with increased student learning, as measured by exam performance, for adult online learners. Given the rate of expansion of online education, these results provide a springboard for further studies to better define ways to increase student learning among the newer, and increasingly important population of online adult learners.

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