# Do Online Homework Tools Improve Student Results in Principles of Microeconomics Courses?

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## Introduction

Recent technological advances in education have made it possible for instructors to use new tools in their attempt to enhance student interest and improve understanding of economics principles. A substantial body of economic education literature has examined the effectiveness of these tools in influencing student performance. Generally, these studies compare student performance (measured either in course grades or standardized test scores) between a control group and a test group. In the last decade or so, these new tools have tended to focus on different aspects of computer technology and whether or not use of the technology enhances student learning. Along these lines, Agarwal and Day (1998) found that use of the Internet in economics instruction had a positive effect on student learning as measured by improvement in the Test of Understanding in College Economics (TUCE) scores in both graduate and undergraduate economics courses. Similarly, Sosin et al (2004) suggest that TUCE scores of students in classes using extensive technology showed a small but significant improvement over those students in classes using little technology. Ball, Eckel and Rojas (2006) reported that Wireless Technology Systems (WITS), which they developed, improved final grades in lecture orientated principles of economics classes. These authors state "…evidence mounts that interactive exercises improve teaching effectiveness…" (page 446). They go on to mention that instructors who want to explore new technology should try the online homework system, Aplia.

In spring 2008, an instructor at Saint Mary's College who had been participating in an ongoing study using the TUCE to assess student performance began using Aplia rather than instructor assigned and graded (traditional) homework in his principles of microeconomics classes. In questionnaires given at the end of each semester, this instructor found that students prefer online homework to traditional homework. Over the course of two semesters, of the 58 students who completed the questionnaire, 90 percent said Aplia had a positive effect on their understanding of class material and 73 percent preferred Aplia to traditional homework. These results are similar to those of Smolira (2008) who administered a questionnaire to 50 undergraduate students in two introductory finance classes. The results of this questionnaire showed that 84 percent of students found online homework helpful in their understanding of finance and 64 percent of students preferred online homework to traditional homework assignments.

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While it does appear from the results of these and other studies that many instructors and students believe computer technology enhances student performance, there is, however, a vocal minority that disagrees. One prominent spokesperson for this contrary viewpoint, Oppenheimer (2003) has been very skeptical of computer technology. He believes that this technology leads to diminished interpersonal skills and creativity in primary and secondary students.

This paper contributes to and extends the literature by reporting the results of an empirical study investigating the effect on student learning of an online homework tool, Aplia, compared to the more traditional instructor assigned and graded homework.

The paper is organized as follows: Section II describes the scope and procedures used in the study including our theoretical model and data description. Section III presents the analysis and results obtained. Finally, in section IV we present conclusions and suggestions for further research.

## II. Scope of Study and Procedures

1. Description of Study

The study was conducted over three semesters: fall 2007, spring 2008, and fall 2008 and included seven sections of Principles of Microeconomics courses taught by a single professor in the Economics Department at Saint Mary's College of California. The professor taught each of the seven sections as similarly as possible using the same textbook, covering the same material, and giving similar exams. The only planned difference in the courses was the type of homework assigned.

In fall 2007, traditional instructor assigned and graded homework (IAG) was used in three sections of the Principles of Microeconomics course. Students were required to complete four homework assignments consisting of end-of-chapter problems and questions from the text. Each of the four assignments covered from one to several chapters. The assignments were graded by a teaching assistant and returned to students along with an answer sheet. Because the instructor was already using the TUCE to measure improvement in student performance, the results achieved by students in these sections were used as a benchmark to ascertain if students' enthusiasm for Aplia translated into improved performance.

In spring 2008 and fall 2008 semesters, the Aplia online homework system was used instead of IAG. Aplia, an online software company developed by Stanford economist Paul Romer in 1999, specializes in interactive economics homework which has been used in over 850 institutions by more than 900,000 students. Aplia is tailored to several different textbooks and uses a number of different types of questions pertaining to material in specific chapters. Using Aplia, students completed homework assignments online on a weekly basis. The assignments were keyed to the chapters of the textbook covered in class each week. Questions included multiple choice, fill-in-the-blank, as well

as interpretation and manipulation of graphs. Specific deadlines were established for completing each assignment. In spring 2008, questions were automatically graded by Aplia at the time of the deadline (GAD). After the deadline, students could return to the questions and review the feedback as to which parts of each question they got right or wrong, as well as an explanation of the correct answer. For each graded problem set, there were optional practice assignments for which answers and explanations were provided.

Prior to the fall 2008 semester, Aplia converted to a Grade-It-Now (GIN) format. Students may try a Grade-It-Now problem up to three times. When students are satisfied with their answer to a question, they submit their answer and receive immediate feedback. After reviewing the feedback, students have two options. They can either move on to the next question or try another version of the question they just attempted. The new version has the same basic structure as the prior question but with a different setup or numbers.

The fourth edition of the Test of Understanding in College Economics (TUCE-4) was administered as both a pre-and post-test to students in all sections of the Principles of Microeconomics courses. The pre-test was given to each student during the first week of class. The same exam was embedded as a post-test for the multiple choice portion of the final exam for the course. The goal of this process was to provide a consistent evaluation mechanism for measuring student performance to ascertain if the method of homework assignment used affected performance.

## 2. Theoretical Model

Our theoretical model is based on an educational production function, similar to the model used by many other researchers in economic education. In this production function, the output is student knowledge in economics and the inputs are student ability as measured by high school GPA and SAT scores along with demographic characteristics such as gender and ethnicity. Finally, we hypothesize that use of online homework results in improved student performance compared to the use of traditional homework.

## 3. Data

Over the three semesters, a total of 171 students participated in the study. Of these, 77 were assigned IAG homework and 94 used Aplia. Forty-six students were in sections in which GAD was used and 48 were assigned GIN homework. The majority of students enrolled in the various sections of the Principles of Microeconomics course are business or economics majors. The students were told about the study and its purpose, and were included in the study only if they authorized access to and use of institutional data including gender, high school GPA, SAT scores and ethnicity.

Students included in the study took both the pre- and post-test, agreed to participate in the study, and passed the course. We excluded those students (two in fall 2007 and two in

fall 2008) who received a grade of 'F' in the course. None of these students completed more than half of the homework assignments. Therefore, we believed that the type of homework assignment would not affect their TUCE scores.

4. TUCE

Developed more than 40 years ago by the Joint Council on Economic Education, the Test of Understanding in College Economics (TUCE) has been used extensively by instructors and researchers in the economics profession. The test was designed to serve as a measuring instrument for controlled experiments in the teaching of introductory economics at the college level and enable instructors of particular introductory courses to compare the performance of their students with that of a national sample of students in other colleges and universities.

Broad content categories are incorporated into the TUCE as a means of insuring "adequate coverage of the basic elements of 'typical' college principles courses so that the *total raw score* can be deemed to measure *general* understanding of basic economic principles" and "discriminate among individual students on the basis of their ability to understand and apply selected concepts and principles." (Saunders, 1991, p.2). The comparative effectiveness of courses in achieving the objectives measured by the TUCE can be ascertained by comparing the scores of students with the percentile distributions of the scores of students used to develop norming data for the TUCE. While the TUCE was not designed to evaluate the achievement of individual students, the test can be used in this way. The TUCE-4 Microeconomics test consists of 30 multiple choice questions covering six content categories and representing three cognitive categories.

As stated by Walstad and Rebek (2007), the TUCE has two main objectives: (1) to offer a reliable and valid assessment instrument for students in principles of economics courses; and (2) to provide norming data for a national sample of students in principles classes so instructors could compare the performance of their students on a pretest and a posttest with this national sample.

## III. Analysis

A. Comparison of Means

Table 1 shows the average TUCE scores achieved by students using the three homework methods. The improvement in average scores ranges from 5.35 to 5.48 points and the differences in scores between the pre- and post-tests are all statically significant at the .01 level. The results indicate that improvement in student performance using the three different methods of homework is similar. We next examine and compare each of the homework types in more detail.

**TABLE 1**

**Pre- and Post-Test Mean Scores on the Microeconomics TUCE for Saint Mary's College Students, by Semester and Type of Homework Used**

| Three Semester Comparisons, Excluding Those Who Received 'F' Grades | | | | | |
|---|---|---|---|---|---|
| **Semester and type of homework used** | **Pre-test mean score** | **Post-test mean score** | **Difference in pre-and post-test scores** | **t value** | **Number of observations** |
| Fall 2007 IAG | 9.14 | 14.51 | 5.36 | 13.3984 | 77 |
| Spring 2008 Aplia GAD | 8.20 | 13.67 | 5.48 | 9.8409 | 46 |
| Fall 2008 Aplia GIN | 9.65 | 15.00 | 5.35 | 8.5198 | 48 |

An unpaired t test was used to compare the three homework formats. The unpaired t tests determine whether or not the improvement in results achieved using the three homework methods are statistically different. The unpaired t test results are as follows:

| **Homework Method** | **t value** |
|---|---|
| IAG vs.GAD | .1703 |
| IAG vs.GIN | .0134 |
| GAD vs.GIN | .1474 |

These results show that there is no statistically significant difference in improvement in TUCE scores for the three different types of homework employed because none of the t statistics obtained were significant, even at the 10 percent level. This result, therefore, does not support the hypothesis that online homework leads to an improvement in student performance relative to use of instructor assigned and graded homework (IAG). However, the results do indicate that student performance is not affected adversely when online homework is used instead of IAG.

B. Regression Analysis

Because improvement in student performance was found to be statistically the same using either Aplia or traditional homework methods, we turned to regression analysis as a means of ascertaining factors that influence improvement in student performance between the pre-and post-test TUCE.

Our first Ordinary Least Squares (OLS) regression incorporates other student data along with the homework style used. The model used is as follows:

Improvement in Student Performance=Change in TUCE score =

$A+B_1*PRETUCE+ B_2*SATMATH+B_3*SATVERB+B_4*HSGPA+ B_5*GENDER+B_6*ETHNIC +B_7*APLGAD+B_8*APLGIN$

PRETUCE = the student's pre test TUCE score

SATMATH = the student's math SAT score;

SATVERB = the student's verbal SAT score**;**

HSGPA = the student's high school grade point average;

GENDER = a dummy variable equal to 1 for female students, 0 otherwise

ETHNIC = a dummy variable equal to 1 for non-Caucasian students, 0 otherwise

APLGAD = a dummy variable equal to 1 for Aplia GAD, 0 otherwise

APLGIN = a dummy variable equal to 1 for Aplia GIN, 0 otherwise

The results of this model are presented in Table 2. Only two of the independent variables have statistically significant coefficients - - PRETUCE and SATMATH. The negative sign of the PRETUCE coefficient indicates that each one point increase in a student's pre-test score is associated with nearly a one-half point decrease in the post-test score. That is, higher pre-test scores presumably reduce the amount that students can improve between the pre-and post-test. In the extreme case, a student who scored 100 percent on the pre-test could not improve his/her score on the post-test. Also, a 10-point increase in a student's math SAT score was found to be associated with a 0.1 point improvement between the pre- and post-test.

**Table 2**

**Regression Results For All Students, Excluding Those Who Received 'F' Grades**

| | *Coefficients* | *Standard Error* | *t Stat* |
|---|---|---|---|
| Intercept | -1.353828 | 2.585416 | -0.523640 |
| PRETUCE | -0.476268 | 0.115772 | -4.113851* |
| SATMATH | 0.014281 | 0.005155 | 2.770531* |
| SATVERB | 0.001074 | 0.005441 | 0.197437 |
| HSGPA | 0.731865 | 0.530078 | 1.380674 |
| GENDER | 0.169158 | 0.617283 | 0.274036 |
| ETHNIC | 0.669492 | 0.631855 | 1.059566 |
| APLGAD | -0.144703 | 0.762096 | -0.189875 |
| APLGIN | -0.327806 | 0.738187 | -0.444069 |
| R Square | 16% | | |
| Observations | 143 | | |

**Significant at the .01 level*

To further refine our analysis in an attempt to determine whether the type of homework used has differential impacts on students who receive higher grades in the course, we conducted a similar analysis for the 48 students who received either an A or B in the course. These results are presented in Table 3.

**Table 3**

**Regression Results For Students Receiving A and B Grades**

| | *Coefficients* | *Standard Error* | *t Stat* |
|---|---|---|---|
| Intercept | -1.6966988 | 5.2298242 | -0.3244275 |
| PRETUCE | -0.4150511 | 0.1651288 | -2.5134986* |
| SATMATH | 0.0144176 | 0.0085300 | 1.6902297 |
| SATVERB | -0.0022961 | 0.0093640 | -0.2452065 |
| HSGPA | 1.4445100 | 0.7285156 | 1.9828127* |
| GENDER | 0.8177744 | 1.0136604 | 0.8067538 |
| ETHNIC | 0.2832636 | 1.0525557 | 0.2691198 |
| APLGAD | 1.0021363 | 1.3623054 | 0.7356179 |
| APLGIN | 1.9198168 | 1.1567907 | 1.6596060** |
| R Square | 27% | | |
| Observations | 48 | | |

** Significant at the .05 level*

***Significant at the .10 level (one tail test) because the null hypothesis is that Aplia does not improve test scores and the alternative hypothesis is that Aplia does improve test scores.*

This regression suggests that students who received A and B grades and were assigned Aplia GIN homework improved their TUCE scores by nearly two points over those students who used IAG homework. Similar to the results for all students, the PRETUCE variable was found to be statistically significant. Also, HSGPA was found to have a positive impact on improvement in TUCE scores.

Because we were primarily concerned with whether use of Aplia improved test scores rather than the effects of the specific type of Aplia used, in Table 3A we show results combining observations from use of both types of Aplia. Students receiving A and B grades and who used either form of Aplia, improved their scores about 1.6 points more than students who used IAG homework.

**Table 3A**

**Regression Results Combining Both Types of Aplia For Students Receiving A and B Grades**

| | Coefficients | Standard Error | t Stat |
|---|---|---|---|
| Intercept | -2.0795241 | 5.1639788 | -0.4026980 |
| PRETUCE | -0.3956554 | 0.1615275 | -2.4494610* |
| SATMATH | 0.0156531 | 0.0082764 | 1.8912962 |
| SATVERB | -0.0034506 | 0.0091454 | -0.3773013 |
| HSGPA | 1.4438663 | 0.7235751 | 1.9954615* |
| GENDER | 0.8874767 | 1.0015921 | 0.8860660 |
| ETHNIC | 0.3728759 | 1.0371380 | 0.3595239 |
| Aplia Combined | 1.5905558 | 1.0427218 | 1.5253885** |
| R Square | 27% | | |
| Observations | 48 | | |

* *Significant at the .05 level*

** *Significant at the .10 level (one tail test)*

## IV- Conclusions, Implications, and Suggestions for Further Research

This study investigates whether use of online homework assignments leads to improved student performance in principles of microeconomics courses compared to use of traditional homework assignments. Results of the study suggest that while students significantly improve their understanding of microeconomics principles over the course of a semester as measured by the TUCE, this improvement does not appear to be affected by use of different homework methods. Moreover, the only statistically significant predictors in our overall (all students, excluding those who received a grade of 'F') model were students' pre-test TUCE scores and SAT math scores. However, this model explained only 16 percent of the improvement in TUCE scores.

These results were not what were expected considering the enthusiasm many students and professors appear to have for the Aplia method as reported in their evaluations and the positive results of new technology methods as reported in similar research. However, there are still some interesting conclusions that can be drawn from the study. Most importantly, it appears that the students participating in the study improved their understanding of microeconomics principles as measured by the TUCE even if the homework method assigned did not affect this improvement.

The fact that $R^2 = 16$ percent implies that unless improvement between pre- and post-TUCE scores is highly random, some important explanatory variable or variables have been omitted. We believe that there are numerous variables other than those readily measurable that could explain this improvement. These include the text used, student effort including attendance, class size, and teacher/student and student/student interaction both in and out of the classroom. Becker (1997) notes the importance of this type of interaction when he states, "Small classes, in which students are actively engaged in the learning process through discussion and small group activities, encourage persistence and appear to be conducive to learning…". (page 1370). It is therefore likely that homework is only a relatively small piece of the learning puzzle, especially at liberal arts colleges like Saint Mary's where the total undergraduate student body is about 2500 and typical classes have fewer than 25 students. It is possible that for larger class sizes, in which students do not have significant access to and interaction with instructors and other students, they would rely more on homework to learn course material. In these institutions, the type of homework assigned could affect student improvement.

Students who received grades of A and B and who also used Aplia improved their scores about 1.6 points more than did those students who used the instructor assigned and graded homework method. Perhaps this is due to a combination of more effort, interest or ability on the part of these students.

Finally, while this study shows that online homework is not more effective in improving TUCE scores for all students than traditional homework, it also suggests that student performance is not adversely affected by using online homework. While some instructors (Oppenheimer, 2003) believe that technology diminishes the student-teacher relationship and is therefore detrimental to student learning, results of this study do not support that

view. Moreover, the Aplia online homework method takes much less time to administer than traditional homework and can be assigned more often which keeps students continually engaged throughout the term. It also allows instructors to use their time more effectively preparing for class and presenting other activities that enhance learning, including current events, case studies, experiments, review sessions and meeting with individual students;

The results of this study have implications for future research. Some additional areas of future research could include:

- Does average class size make a difference? Students at institutions in which introductory courses routinely have several hundred students enrolled in each course, and for which interaction between students and instructors is minimal, might benefit more from use of online homework systems such as Aplia than students at institutions for which class sizes are much smaller and there is greater interaction between students and instructors with increased personal attention for each student.

- Determining the effects of homework method on performance of students with different learning styles.

- Examining how methods of measuring student learning other than the TUCE, such as essay questions and writing assignments, are affected by the use of different homework systems.

- Including attendance (as a measure of student effort) as an independent variable in the regression analysis.

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