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COMPARING THE IMPACT OF THE INTERNET AS A SUPPLEMENT IN A HIGH SCHOOL PRECALCULUS/TRIGONOMETRY COURSE TO A MORE TRADITIONAL COURSE

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Abstract

This study is conducted in a large Midwestern city in a Precalculus/ Trigonometry course for junior and senior level students. Two sections are compared with respect to the use/non-use of different technology resources. The experimental class is held in a computer lab using the Internet and technology resources offered by the textbook. The control group is taught using traditional means of mathematics instruction. The control group outperformed the experimental group on all the mean of the six common exams. However, only four of the six differences on the common exam scores are statistically significant at the 0.05 level. Furthermore, the experimental group express positive opinions towards the use of technology in the classroom in a survey offered at the end of the course.

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Introduction

Looking through the beginning of a current mathematics textbook both students and teachers can find a list of supplemental materials made available by the publisher. Teachers can find books such as an instructor's resource guide, books containing answers to problems in the text, examples for labs, and books containing test banks. Students can find solution guides to odd exercises, videotapes, and supplemental worksheets. The most current textbooks offer teachers and students another resource: interactive websites and CD-ROMs. This comes with the great growth in technology and the accessibility of computers and the Internet in the home, public library, and schools. Technology is being added into the curriculum, but will these new resources and use of technology have an effect on student performance?

While there are no studies that look at the impact of web-based supplemental material with Precalculus students, there are studies discussing the impact of web-based material and other electronic mediums on student learning mathematics. In a college trigonometry course, Robison [7] studied the difference in performance between students who were given lab assignments using a series of computer-animated graphs and students who were assigned the labs using a stationary series of graphs. She found that there was not a significant difference in the mathematical achievement at the 0.05 level but noted that her students perceived their future careers would require the use of technology. The students viewed that the addition of technology to the curriculum was positive and necessary.

In a study done in a high school statistics course, Christensen and Stephens [2] compared the performance of a "traditional" course and a course taught with Microsoft Excel. Although the experimental group using Excel outperformed the traditional class, there was no significant difference at the 0.05 level. Although there was not a significant difference, the students reported very positive feelings towards the use of the software in a survey administered at the end of the course.

Stephens and Konvalina [9] performed a similar study comparing "traditional" instruction and instruction using the software program

MAPLE in two intermediate algebra and two college algebra courses. The experimental classes, those using MAPLE, in both the intermediate and college algebra courses outperformed the classes using traditional instruction, but each difference was again not significant at the 0.05 level. In an instructor evaluation, both professors received the best results they ever received in over twenty years of teaching from the classes using the supplemental technology.

Kramarski and Mizrachi [5] compared the impact of online versus face-to-face instruction with or without metacognitive guidance among 7th grade students. They found that in general among several mathematical topics, the online/meta students outperformed the face-to-face/meta students, who out performed both online and face-to-face (no meta) students. Also, while rarely significant, the online students outperformed the face-to-face students in almost every category.

Stephens [8] integrated Microsoft Excel in an intermediate algebra course and offered grade booster points for extra projects using the Excel program. Although the sentiment towards the computer program and assignments were positive, there was not a significant correlation between the students' grade on the Excel assignments and the score on the final exam.

A study performed at an urban high school district by Koedinger et al. [4] compared results on standardized mathematics exams. The experimental group was exposed to instruction with an intelligent tutoring for algebra computer program. The study found that this experimental group outperformed the control by 15% on the standardized test and by 100% on topics specifically targeted by the computer program.

Levine and Wasmuth [6] compared a class that integrated laptops into an Algebra 1 class to a more traditional class. Both classes had access and exposure to some technology (graphing calculators and Excel). The laptop class used web-based simulations and a software program called Scientific Notebook (a Computer Algebra/Word Processor combination). In general the laptop group expressed their opinion that the software used was beneficial to their learning. Levine and Wasmuth report that the laptop group outperformed the control group by 6% points

on a post test. However, the authors fail to point out that the control group outperformed the experimental group on the pretest by 5% points.

A study performed by Elliott et al. [3] also compared performance between a Precalculus class that received traditional instruction and another Precalculus class that used a supplemental computer program called AquaMOOSE. Unlike the previous studies, this experimental group did not outperform the traditional group, although the difference was not statistically significant.

The purpose of this current research is to compare the performance in high school level Precalculus/Trigonometry courses, one class taught with traditional instruction and one taught using the supplementation of the Internet resources provided by the textbook. Is there a relationship between academic performance and the use of technology in the classroom? We also wished to determine the students' opinions regarding the use the Internet resources at the end of the course.

Course/Instrument Details

Precalculus and Trigonometry (Precalc/Trig) is a two semester course with Precalculus taught during the first semester and Trigonometry taught in the second. The students in the study were placed in either the control group or the experimental group. Both classes were issued the same textbook and had access to the same set of graphing calculators.

The control group was taught using traditional classroom methods. A chalkboard or overhead was used for notes and daily instruction. Graphing calculators were used during lecture, student work time, and exams. Students were assigned daily homework problems from the textbook.

The experimental class was conducted in a computer lab; each student had access to their own computer. The lab was equipped with an overhead projector used during daily lecture and a projector used to display the instructor's or a student's work from any computer.

The experimental group used the technology resources supplied by the textbook. These resources included a CD-ROM and the textbook

website on the Internet. The CD-ROM contained the entire textbook along with a graphing calculator, practice quizzes, guided examples, and animation of examples not found in the text. The CD-ROM was distributed to each student at the beginning of the course along with the student textbook. On the textbook's website, guided notes and practice quizzes for each section were available. The website did not have any passwords or login requirements. The website could be accessed by the students at any personal computer. During classroom instruction the CD-ROM and animated examples were used throughout the year and at least two practice quizzes using the textbook's website replaced a book assignment each unit.

Throughout the course, every Precalc/Trig student in the school district is required to take six CRT exams (Criterion Reference Test) covering content standards set by the district. These common tests were written by teachers within the school district. Briefly exam 1 deals with graphing polynomial and rational functions, exam 2 applies the properties of logarithms/exponents to problems settings, exam 3 uses series and sequences along with evaluation of limits to solve problems, exam 4 applies right triangle trigonometric identities including the laws of sines/cosines to solve problems, exam 5 expands the material from exam 4 to circular functions dealing with radians, and exam 6 deals with polar coordinates, equations, and conversion to rectangular ones. The Kuder-Richardson-21 reliability for the tests came out to be respectively .77, .75, .85, .75, .67, and .87. Students in the experimental group were not allowed to use any form of technology during the CRT exams other than a graphing calculator provided by the instructor. The control class was allowed to use the same set of graphing calculators.

Subjects, Instruments, and Analysis

The two classes of Precalculus/Trigonometry consisted of 41 students: two tenth graders, nine eleventh graders, and fifty twelfth graders. The control group had twenty-three students (1 sophomore, 3 juniors, and 19 seniors), the experimental group (Internet resources) contained eighteen students (0/3/15). All students were average to above average mathematical ability.

Both classes were given the same daily assignments from the textbook, common in-class exams, and CRT exams. The six CRT exams were given throughout the school year: two exams during the first semester and four exams in the second semester. A 5-point Likert scale opinionnaire (see Table 1) was administered at the end of the course in the experimental group to determine student attitudes towards the technology used in their course.

Table 1. Survey items from opinionnaire

Question #	Actual Question
1	I used the TEXT RESOURCES outside of the classroom.
2	I felt that the INTERNET problem sets were good practice.
3	I preferred working the INTERNET problems rather than textbook problems.
4	I did not like working the INTERNET problems. They were not good practice and did not help in my understanding of trigonometry.
5	I feel that the TEXT RESOURCES were useful in completing daily assignments.
6	I did not like the TEXT RESOURCES. They tended to confuse me and my understanding of the topics discussed in class.
7	The TEXT RESOURCES made it easier to complete daily assignments.
8	I enjoyed the INTERNET assignments in the trigonometry class.
9	I feel that the TEXT RESOURCES helped prepare me for quizzes and tests.
10	I would recommend including more INTERNET projects/ assignments for future Trigonometry/Precalculus classes.

Results

Independent sample *t*-tests between the control group and the experimental group on the six CRT exams and the mean of all six CRT scores are shown in Table 2. In all cases the hypothesis of equal variances was retained. When comparing the mean scores on the six CRT exams, the control group consistently scored higher than the experimental group. The differences between the means would only be considered significant at the 5% level on four of the exams: CRT 1 (p-value of 0.018), CRT 3 (p-value of 0.005), CRT 4 (p-value of 0.014), and CRT 6 (p-value of 0.017). The respective effect sizes were 0.80, 0.90, 0.76, and 0.74, all high moderate or strong effects (Cohen [1]). With respect to the mean CRT score for each student, the control group had a mean score of 13.797, and

11.296 in the experimental group (supplemental Internet resources). The differences are significant with a *p*-value of 0.009 and an effect size of 0.77, a strong effect.

Table 2. Comparison of means by independent samples *t*-tests

Means	CRT1	CRT2	CRT3	CRT4	CRT5	CRT6	TOTAL
Control	15.652	15	13.696	13.478	12.522	12.435	13.797
Internet	13.278	14.778	9.722	9.667	11.111	9.222	11.296
***p*-value**	0.018	0.86	0.005	0.014	0.198	0.017	0.009

Table 3 shows the contrasting opinions of the second experimental class using the supplemental Internet and computer resources. The feelings of this class were strongly in favor of using the resources. A high percentage of the class found the resources useful when completing daily assignments, preparing for quizzes and tests, and felt the resources offered good practice problems in addition to those assigned in class.

Table 3. Percentage of responses in each category from the opinionnaire

Survey Item #	Strongly disagree	Disagree	No opinion	Agree	Strongly agree
1	10	11	16	47	16
2	5	11	0	79	5
3	5	37	21	21	16
4	32	47	11	5	5
5	5	10	11	53	21
6	16	58	11	10	5
7	0	16	10	42	32
8	0	16	26	53	5
9	0	21	16	63	0
10	5	16	21	42	16

Conclusion

Similar to most previous studies the students believed the web-based activities helpful. However, contrary to what most previous studies using

electronic sources discussed above had found (usually with non-significant results), the results of this study show that the group using the electronic supplemental material did significantly worse at learning the content than the more traditional class. Specifically, the data indicates a significant difference in performance on a majority of the CRT exams and the overall test average in favor of the class receiving traditional instruction. However, this course was using web-based instruction, whereas the previous studies used software programs such as MAPLE, Excel, and cognitive tutors.

Although the differences were not significant on all of the exams, the Internet class consistently scored below the other class. This class enjoyed the use of the Internet in the classroom and a majority of the class recommended continued use in the future. The instructor noted that the use of the Internet in the classroom often proved to be a distraction rather than an aid to instruction. Students would often hurry though in-class assignments to use the Internet for personal enjoyment and "click" through the Internet assignments until they found correct answers, not working towards understanding. On the other hand, students who were absent from class or needed to review material from previous chapters to take a retest found the use of the textbook's website to be a wonderful tool.

In conclusion, there is some evidence provided in this study that the traditional group learned the Precalculus content better than the experimental group. The results of this study indicate that teachers should carefully consider when (and how) to use web-based material in the classroom. In our drive to constantly modify and stay current with our curriculum, we may embrace changes to our curriculum that do not necessarily help our students. Future research could look at how web-based material might be better designed to avoid the "click till you get the right answer" syndrome noted by the teacher, especially among the supplemental material typically supporting high school mathematics textbooks. Finally, a more comprehensive qualitative study to analyze exactly how students spend their time during courses using web-based material rather than just the observations noted here would be useful.

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