True Exploration and Visualization of Geometry with Technology[1]

Gustavo Valencia
Early College High School
Department of Mathematics
2510 Pecan Building R
Harlingen, Texas, 78550
gustavo.valencia@hcisd.org

Taeil Yi
University of Texas at Brownsville
Department of Mathematics
80 Fort Brown
Brownsville, Texas 78520
taeil.yi@utb.edu

Abstract
Current levels of secondary students' mathematical performance suggest that the United States is not preparing the general population with the levels of mathematics knowledge as the rest of the world. Research has documented a tendency of students to answer mathematics problems with apparent disregard for the reality of the situations described by the text of these problems. The problem may not be cognitive, but rather the teaching style and or culture of the classroom where problems are presented in stereotypical fashion, with the assumption that a solution involving the application of one or more of the basic arithmetical operations to the numbers mentioned in the text is all that is required. When students take standardized test many of them simply add, subtract, multiply and or divide these numbers with a calculator in hopes of finding the answer in the choices provided. In this article we present the results of a study on learning outcomes between traditional style of learning and technology project based instruction. We will discuss types of technologies used and how technology project based instruction was integrated into the geometry class. We have developed a web-based course, using different technology tools to facilitate the learning process to reveal the sample group's understanding of different mathematical concepts. This was a qualitative study involving thirty-four mathematics students from a public high school, Early College High School, in Harlingen, Texas. The data was gathered from student surveys, interviews and pre and post test scores. The instructional tools used in this study are online lessons and assignments produced with a Livescribe Smartpen[4] to create animated PDF documents, PowerPoint video files using Camtasia Studio[5], GeoGebra[6] files and student produced videos and projects. The findings revealed that students who used technology project based instruction gained a deeper understanding of mathematics in a positive way.

Introduction

There is no doubt that there is a decline in student's achievements, level of understanding, and interest in mathematics in the United States.[1] Although there are many factors for this lack of interest and ability, the purpose of this article is to provide a possible teaching tool to address the problem of disinterest and comprehension. Today's instructors at public high schools are faced with a growing amount of responsibilities including, ever-changing timelines, standardized testing, and pressures from administrators, parents, and the general public. With these conditions, many teachers feel pressure to transfer knowledge by direct teaching. This article is based on the learning outcomes of two geometry courses at the high school level. We have developed a possible solution to aid the instructor, and at the same time, draw in the interest of the students with the aid of technology. With the use of some affordable and free software, we were able to generate interest in our technology savvy students while improving their knowledge of mathematics. As educators, we must improve our student's problem solving skills to ensure their abilities and understanding of mathematics. Evidence of this is seen when students are presented with real world math problems, and they are unable to solve these problems logically.[2] They need to be able to decipher the problem, visualize and organize data, explore possible

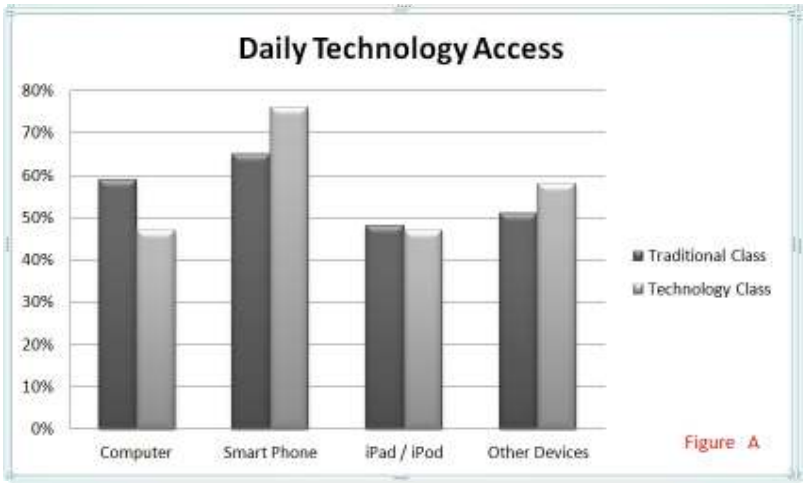
[1] *Supported by PPOHA grant (P031M090045) from DoED*.

alternatives, and verify the solution. This article will show how technology project based instruction can help students develop mathematical knowledge that allows them to solve problems and explore new ideas, in and out of the classroom.

Methodology

Early College High School (ECHS), is located in Harlingen, Texas, the southernmost part of the state. The city has a population of about 65,000 residents. The school's population is 378 students from grades 9 through 12. ECHS is a high school with a bold approach to education. The school is based on the principle that academic rigor, combined with the opportunity to save time and money, is a powerful motivator for students to work hard and meet serious intellectual challenges. The school was designed so that low-income youth, first-generation college goers, English language learners, minority students, and other young people underrepresented in higher education can simultaneously earn a high school diploma and an Associate's degree or up to two years of credit toward a Bachelor's degree—tuition free. The school has two geometry classes with 17 students in each. Both classes have a mixture of males and females, freshmen and sophomores, but predominately Hispanic. One of these classes was taught in a traditional setting of classroom lectures and the other class was taught with the aid of technologies such as video lectures, GeoGebra web pages or lab worksheets, and interactive Livescribe PDFs. As part of the study, these classes followed the same timeline, curriculum, and were taught by the same teacher.

Both classes were asked to complete a technology survey to create a base line of the student's access and comfort level with technology. At ECHS all students have access to Wi-Fi, of which some connect with either own personal laptops, iPads, iPods, or other devices and the student's ratio of laptops in their math and English courses is one to one. After the completion of Algebra I, each student is issued a TI-84 Plus calculator. The results of the survey showed that as many as 65% of the students in the traditional class used some form of technology daily outside of the school day, while 76% of the technology class did. The types technologies used daily varied but they showed a high level of comfort by the students in accessing information, see figure A. One-Hundred percent of both classes stated they used technology during the school day for academics. The survey revealed that both classes had similar levels of abilities and access to technology. The classes were administrated a pre-test, two and a half weeks into the curriculum. Of the 20 questions asked only 2 were multiple choice and only 3 of the topics had been covered in class or were prior knowledge from Algebra I. The class average score for the traditional class was a 12.6 and the technology class scored a 13.2, both based on a 100% scale. The results were expected to be low due the amount geometry curriculum covered at the time of the test. Eighteen weeks later the post test was administered.



During the time between the pre and the post tests, each class covered the same topics over the same time period, but in different ways. For example one of the early topics taught was about the vertical angle theorem. In the traditional class this was presented to the students as a definition and examples using algebraic expressions were shown on the whiteboard. Students added this information to their notes and were asked to remember this as a statement of fact, a process of steps to be used later. Students were then given an assignment on vertical angles while the teacher filled the gaps with struggling students one at a

time. The same lesson was then presented to the technology class. These students started the lesson with a GeoGebra lab activity. Through this activity the students were lead to the self discovery of the theorem verses the information being given to them directly. GeoGebra is a free open source dynamic mathematical software.[6] It allows the students to visualize the problem simultaneously in algebraic and geometric formats, see figure B. These interactive off or online lessons are designed to lead the students to form their own conjectures about the topic. At varies times students are then asked to share their ideas and come up with their own definitions. These results are then compared to the actual theorems or axioms found in their text book. Students are also encouraged to find counter-examples or prove the conjectures false if possible. This technology class also adds this information to their notes along with one or two examples. This exploration and visualization has been the key element to their deeper understanding of both algebra and geometry concepts. The students in the class are also then asked to complete a shorter version of the same assignment. Once or twice a week these students were also asked these questions. What did I learn today? What prior concepts did I use today? Below are some portions of conjectures formed by the students or statements of prior knowledge in the technology class.

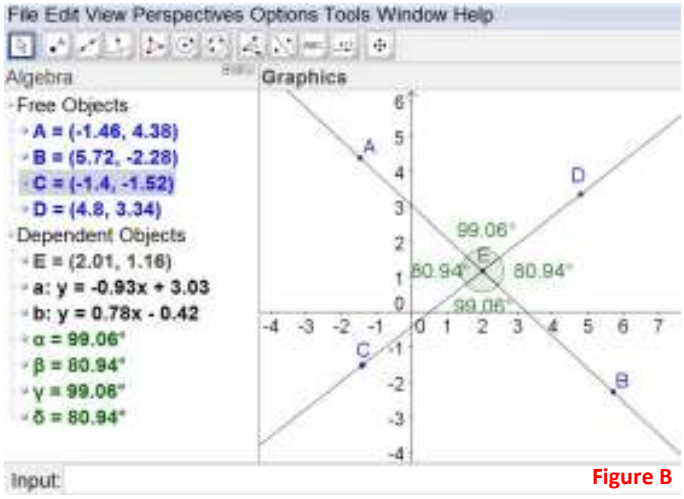


Figure B

" adjacent angles are supplementary"
"the angles opposite of one another are congruent"
"there is one negative and one positive slope of the intersecting lines"
"we used lines today, which continue, and not segments"
"the lines AB and CD intersect at point E"

Other differences are how lessons were taught using Microsoft PowerPoint presentation, students listen to them using their own earphones and at their own pace. Students were shown how to play, pause, and replay sections they did not understand, while adding notes to their notebook. Students could revisit any of these lessons during the school day or at home online. These presentations were created using Camtasia Studio[5], some had embedded videos of problems solved with a Livescribe Smartpen[4], others included GeoGebra web links that would assist the student in getting a clear visualization of the problem. This method of delivering the lesson allowed the teacher time to work with struggling students individually and at the same allowed the other students to explore and learn with the aid of technology. Another advantage is it allowed students who were absent to complete lessons on their own. The two math teachers at ECHS offer tutoring afterschool in the following subjects, Algebra I, Geometry, College Algebra, College Pre-Calculus, Calculus 1, and on any type of standardized state or national math test. Therefore having the geometry lessons online allows these teachers the option of tutoring a geometry student online while assisting another math student at the same time. The geometry students in this case do not require as much individual time, if any at all, with the teacher. After interviewing the students from the technology class, many of them found the LiveScribe Smartpen animated PDF problem example files very helpful, see figure C. These LiveScribe PDF files can be played much like a video file.


Figure C

They provide step by step instructions to solve problems. The benefit of the program is it allowed the student to visualize and hear how to step up and solve these problems as the instructor would in class. If a student had a question about a homework problem or just a question in general, they could also email the instructor and then later receive an attached file with the answer to their question. These types of files could also be accessed online. Many of the students stated they used these files before exams and it helped them recall the lessons and reinforced their understanding and clarified any doubts they had. One student stated during their exit interview, "*it's like having the teacher teach you how to setup the problem and walk you through it again, especially the parts we covered weeks ago".* These file were given to the students which they were also able to keep on their personal electronic storage devices. (See [7] to find all these files we have developed.)

Result

Half way through the geometry course the students took the post test and a district wide developed benchmark test. In addition, some students were randomly selected from each class and interviewed. The district wide benchmark was given to all geometry students in the Harlingen school district. The topics on this test were outlined by the district's vertical and curriculum team to access the student's knowledge of material covered from day one to the halfway point of the school year. The data showed that the district's student average score based on a 100% scale was a 56, while the ECHS traditional class was at 71 and the technology class was at 87. The class grade book average, based on a 100% scale, at the time of the post was an 83 for the traditional class and a 92 for the technology class. The results of the post-test can be seen in figure D. The data shows the number of students, out of 17, who answered each question correctly. The post-test results graph clearly shows that the technology class performed better on all test items, even those covered months ago. For example test item number 15 was a concept taught at the beginning of the school year. During the post interview process one of the questions asked was "Explain which activity or technology used in class helped you learn the most?" Below are some of the most common responses from each class after the post-test.

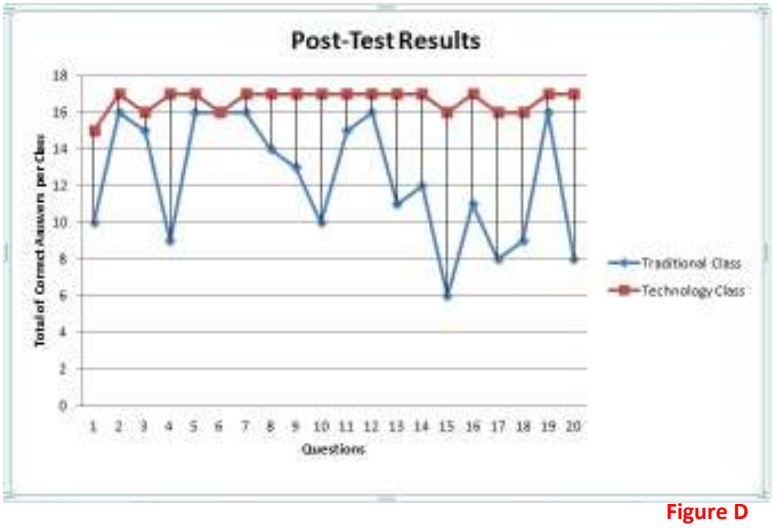


Figure D

Technology Class

"I think I was able to remember things better because we would see the picture on GeoGebra"
"I think what helped me the most was writing my thoughts down from the activities we did in class"
"what helped me were the videos that showed each step"

Traditional Class

"what helped me the most was keeping all of my notes and reviewing them before the test"
"I guess what helped me was when you would help me in class and show me how to answer the question"
"using the calculator made it easier, it helped me a lot"

At the beginning of the course the students were also asked to write about their likes or dislikes of their previous math courses. In the past 5 years of doing this assignment, the results have been very predictable, on average about 86% of students have rated their math courses as the most disliked. Yet even at the midpoint of this course, a majority of the students from the technology class have stated how

much they enjoy math for the first time and their parents have also expressed their delight in the student's success and change in attitude for their math course.

Conclusion

This study has shown by using technology we can increase the student's interest in mathematics, empower them to become independent learners, and provide them with the experiences they need to solve problems and test their ideas. Through the use of dynamic technology project based instruction, such as the vertical angle assignment discussed earlier, we have significantly increased our student's abilities and more importantly their understanding of geometry concepts. The technology used in this study created a learning environment that allowed the students to explore, visualize and discover both geometry and algebra concepts. This environment allowed the students to venture into the unknown and learn which lead to their formations of conjectures and in depth class discussions.

Future Plan

We have begun to develop a website with most of the lessons taught in class. This site will soon be a collaboration of best practices by Harlingen school district geometry teachers to assist them and students alike, the site can be accessed online.[7] Our plans also include the development of additional sites for other high school math courses.

References

[1] 2009 PISA Report http://www.pisa.oecd.org/dataoecd/31/28/46660259.pdf
[2] Developing the STEM Education Pipeline
http://www.act.org/research/policymakers/pdf/ACT_STEM_PolicyRpt.pdf
[3] A Quiet Crisis in Educating Talented Students http://www2.ed.gov/pubs/DevTalent/part1.html
[4] LiveScribe Smart Pen Website http://www.livescribe.com/en-us/?gclid=CL7Hwd_Owa4CFRPktgodNiMrDQ
[5] Camtasia Studio Website http://www.techsmith.com/camtasia2-1111.html?gclid=COnV1fbOwa4CFUljTAodB1rLDw
[6] GeoGebra Website http://www.geogebra.org/cms/
[7] The Geometry Project (Harlingen CISD website)
http://www.hcisd.org/cms/lib4/TX01001784/Centricity/Domain/1515/index.html