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The Geometer's Sketchpad Research Summary

Introduction

The Geometer's Sketchpad (GSP) is a comprehensive mathematics software system used for creating, exploring, and analyzing many mathematical concepts in the areas of algebra, geometry, trigonometry, calculus and many other areas. The Geometer's Sketchpad is a dynamic platform in which a user is able to construct or graph various mathematical concepts and then manipulate them. Unlike other computer software, the Geometer's Sketchpad is dynamic so that the images can be changed and transformed right before the user eyes without having to start over or erase and redraw any of their images. The images also retain the same geometric relationship between them as they were constructed although they are in a changing state. Users can manipulate these images or graphs to look at all situations instead of the specific situation in which they initially constructed or graphed. "Dynagraphs allow a student to easily explore variables and functional dependency by changing the input of a function and seeing how that change affects the function's output." (Kenrose, 2009)

As well as being dynamic, the Geometer's Sketchpad provides measurement and calculation functions. Measurements can be taken such as length, arc length, angle measure, area, etc… to be displayed on the screen. The value of the measurements also change dynamically as the image changes which is another way for users to see the geometric relationships between the images and how they either remain the same or if they change proportionally or perhaps that there's no relationship at all. A feature of the Geometer's Sketchpad calculator is that a user does not have to enter any values into the calculator; they are able to just click on a value that has

already been calculated. If the image is changed, that value changes concurrently as well as the calculation so no calculations ever have to be redone.

The Geometer's Sketchpad allows user to explore simple as well as highly complex theorems and relations in mathematics with the ability to record the user's constructions as scripts. A useful aspect of scripting the constructions is that users can test whether their conjectures work in general or if they have just discovered a special case. It is easy to use and can encourage a process of discovery in which students visualize and analyze a problem and then making conjectures before attempting a proof. As a result of different explorations, he (Purdy) found that his students had been led to a deeper understanding of the problem and its solutions. (Bakar, 2009)

History of the Geometer's Sketchpad in the Classroom

Before the invention of the Geometer's Sketchpad and even still used to this day, the best form of dynamic geometric learning took place with the geometric tools such as the compass and the straightedge. Students were instructed to constructed different geometric forms with these tools and then analyze them to discover the relationships that occur within the images. The problem with this was that if a student wanted to analyze another situation of the same object, they had to start all over again or erase some of their previous constructions which was time consuming and messy. These tools were used since the ancient Greeks to explore mathematical ideas so there use and implementation is still valid but with the ever evolving use of technology in the classroom, there had to be a better way to integrate these geometric into the mathematics curriculum. That's where the Geometer's Sketchpad steps in.

The Geometer's Sketchpad can trace its origins back to the 1980s with the Visual Geometry Project. The project, funded by the National Science Foundation, and researched at Swarthmore College under the direction of Dr. Eugene Klotz and Dr. Doris Schattschneider. The program was named in honor of Ivan Sutherland's Sketchpad which was a groundbreaking work in interactive computer graphics in the early 1960s. Key Curriculum Press became involved as the program's publisher where they termed the phrase dynamic geometry to describe the program's interactive geometric imagery. The Geometer's Sketchpad underwent years of testing before it was released as a Macintosh version in 1991. The first Windows version was released in 1993. Through years of development, a new version was released in 1995 that expanded the program from Euclidean and transformational geometry to include analytical geometry. In 2001, yet another version of the Geometer's Sketchpad was released to extend the program from dynamic geometry to the teaching and learning of algebra as well as calculus. The program is used by 10s of millions of students throughout the world. "The use of 'The Geometer's Sketchpad' participation will allow students to realize the active construction of knowledge, a deeper understanding of what they have learned the content, and effectively resolve the difficulty." (Use of Geometer's Sketchpad…, 2008)

Today, the Geometer's Sketchpad is one of the most widely used technologies used in education. Many textbook and supplemental activity companies have developed workbooks specifically designed to incorporate the Geometer's Sketchpad in the curriculum for both educational and pedagogical purposes. A large-scale assessment of technology trends in American education, conducted by researchers at the University of California, reports that mathematics teachers across the country find Sketchpad to be the most valuable software for students. The Geometer's Sketchpad has also been translated into many languages and is used in

countries such as Canada, China, Singapore, Russia, Korea, and others where it is incorporated right into the national curriculum. Not only has the Geometer's Sketchpad won numerous industrial awards; it has also been featured in presentations given by notables such as Bill Gates and John Sculley.

Summary of Research

Numerous studies have been conducted to explore the effectiveness of the Geometer's Sketchpad in the mathematics classroom, especially in the subject of geometry, in recent years. A lot of the effort focused on providing teachers and students with good examples of how to use the Geometer's Sketchpad in mathematics. Some studies have been conducted concurrently with other technologies such as the graphing calculator to gauge the entire effectiveness of technology in the mathematical classroom.

One study was conducted by Lester (1996) to investigate the effectiveness of the Geometer's Sketchpad on the achievement of geometric knowledge on high school studies. The results of Lester's study showed that the mean of the post-test scores for the experimental group using the Geometer's Sketchpad was significantly higher than the mean post-test scores for the control group who learned the traditional method with the textbook. Lester (1996) also found there was a significant change in attitude towards geometry among the students who used the technology.

Yousef (1997) took this one step further by conducting his own study to investigate the effects of the Geometer's Sketchpad software on the attitudes of high school students towards geometry. The study showed that the scores of the pre-test and the post-test of students in the experimental group were significantly higher. As well as Lester, Yousef(1997) also found that

there was a significant difference between the control and experimental groups in the gains of the scores from the pre-test to the post-test.

Although there have been many studies done in the area of the Geometer's Sketchpad and its effectiveness, there are two studies that will be the primary focus. One is from Teoh Boon Tat and Fong Soon Fook (2005) with their study of the effects of Geometer's Sketchpad and graphic calculator in the Malaysian mathematics classroom. The other study is the effect of using the Geometer's Sketchpad on Jordanian students' understanding some geometrical concepts as conducted by Dr. Farouq Almeqdadi (2005).

Tat and Fook (2005) used tested both the effectiveness of the Geometer's Sketchpad and the graphing calculator by developing four modules for students to learn about quadratic functions. There were 2 familiarization modules and 2 treatment modules. The familiarization modules enabled the students to become familiar with the various features of the Geometer's Sketchpad and the graphing calculator to be able to explore quadratic functions. Both modules employed the discovery approach in the learning of quadratic functions.

The students were given pre-tests and post-tests that consisted of 25 multiple choice questions and were carried out for 40 minutes each. The pre-test was given 2 weeks before the familiarization modules were implemented. The post-test was conducted 10 minutes after the treatment modules were administered.

The study concluded that the Geometer's Sketchpad and the graphing calculator contributed just as well to the study of quadratic functions. Neither of tools was better than the other so you have to look as the other factors when using the different technological platforms. The Geometer's Sketchpad helped in the visualization of the quadratics more but not

significantly. The cost of both the Geometer's Sketchpad and graphing calculators is high but to different parties. Graphing calculators present the higher cost to students while the Geometer's Sketchpad presents a higher cost to the Ministry of Education as they have to pay for all of the account licenses. Other factors that Tat and Fook (2005) mentioned were that the Geometer's Sketchpad could handle geometry, transformations, and iterations extremely well while the graphing calculator excelled in the fields of statistics and matrices.

In Almeqdadi's study (2005), he studied a group of 52 9^{th} grade male students. He split them into 2 groups, consisting of 26 students in each group. One group would be a control group while the other is the experimental group. Both groups would be taught by the same teacher with the control group using only the book for the experiment while the experimental group would use both the book along the Geometer's Sketchpad. At the end of the experiment, both groups took a post-test that focused on the perimeter and area of polygons such as rectangles and triangles.

Almeqdadi (2005) found that the mean of the post-test scores for the experimental group was significantly higher than that of the control group. The mean of the experimental group was 68.6538 while the mean of the control group was 41.5385(Almeqdadi, 2005). One would think this would show that using the Geometer's Sketchpad is more than 1.5 times as effective as the traditional book method but one has to look closer as Almeqdadi's results. The standard deviation of the experimental group was 21.0978 while the standard deviation for the control group was only 15.0844(Almeqdadi, 2005) meaning that while the scores may have been lower for the control group, the scores were less spread out than that of the experimental group.

Conclusions

Studies have shown mixed results about the effectiveness about the use of the Geometer's Sketchpad in the mathematics classroom. Many studies have shown that groups of students who use the software score higher on tests as compared to groups of students who learn by traditional methods such as using the textbook. Post-test scores do show a significant difference in most studies leading to the conclusion that it is in any mathematical educator's best interest to incorporate the Geometer's Sketchpad into the curriculum.

A closer look at the studies does not necessarily support that idea. When looking at the standard deviation of post-test scores, students in a group who used the Geometer's Sketchpad as part of their curriculum has a much higher deviation meaning that their scores were much more spread out so while the mean of their scores might have been higher, it was because there were certain students who scored much lower than other members of the experiment. A reason overall scores were higher in experimental groups was that students who used the software were more motivated and had a better attitude towards geometry than students who learn by traditional methods. Studies also show even when compared to other mathematical technologies such as the graphing calculator, the Geometer's Sketchpad does not offer any significant advantages.

The Geometer's Sketchpad and other technologies use in the classroom are however widely encouraged. They increase the attitude towards mathematics and help with the visualization of many mathematical concepts. The National Council of Mathematics Teachers(NCTM), the loudest and most respected voice in mathematics education today, encourages their members to use any and all technology they can to enhance concepts and motivate students.

Recommendations made to these studies include tracking students throughout their school careers in their use of the Geometer's Sketchpad. Time was taken in many of these studies to learn how to use the controls of the program. It would be a benefit to the studies to use these same students in future studies so that more time can be dedicated to the mathematical concepts and not just how to use the program. Another recommendation would be to use consistent versions of the program. With the ever evolving and changing state of the Geometer's Sketchpad, some versions may have features that are more beneficial to students than other versions so it is difficult and unfair to compare different studies when they are not using the same materials.

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