Educational Technology in a Mathematics Classroom to Improve Student Understanding

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Abstract
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Educational Technology in a Mathematics Classroom 2

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Dedication

This manuscript is dedicated to my father, Daniel Alan Schutt. In his loving memory I wrote this with the knowledge of his eternal pride and belief in me. He knew that I could accomplish anything that I put my mind to and was determined to master.
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Educational Technology in a Mathematics Classroom to Improve Student Understanding

Educational technology "can make mathematics an active laboratory experience" (Day, 1996, p. 134). Students use graphing calculators, computers, and other technology for data organization, manipulation, comparison, and analysis. Using these types of technology and asking students to do these activities highly promotes student involvement in their learning. However, even in the giant push for the use of technology, it is only a tool to enhance that learning, not the main focus of the learning (Day, 1996).

Even though schools are joining the twenty-first century in terms of their technology availability in the schools, it cannot be used properly in classrooms when teacher understanding and support is still back in the twentieth century. In order to make educational technology useful in our schools, the schools must have high quality infrastructure, hardware, software, professional development, maintenance, and long-term support (Ficklen & Muscara, 2001). Once all of this is in place, students will benefit from all types of technology that are offered to them.

Being a teacher in a high school mathematics classroom, I have found that the most important piece of technology that students will use is the graphing calculator. This paper will first show how the graphing calculator and many other types of technology, including the Tablet PC, software, and interactive websites can be used in the mathematics classroom. Secondly, the research that I conducted in my classroom will show how effective the use of the graphing calculator may be in student learning and comprehension.
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Review of Literature

Due to the constant changing and increased use of technology in the world today, teachers and students must now rethink how technology should be used in our schools (U.S. Department of Education, 2005). The first section of this review of literature will explore new hardware available such as how the graphing calculator has stormed mathematics classrooms. The Tablet PC and Interactive Whiteboards are now emerging as very useful educational tools. Several computer software programs, such as Microsoft’s PowerPoint and Excel, Geometer’s Sketchpad, and Inspiration are making their homes in our classrooms as well and will be the focus of the next piece of this literature review. Then a look into online websites such as UnitedStreaming.com and ExploreLearning.com will complete the literature review.

Graphing Calculators

For the past 30 years, the calculator had been the brunt of much controversy in the world of mathematics. With the introduction of graphing calculators, that world is now trying to figure out how to make this technology more useful and beneficial to students (Ellington, 2003). Since 2001, New York State has required that students taking the Math B Regents exam use the graphing calculator and those students taking the Math A Regents exam use at least the scientific calculator. The graphing calculator was to be available to students taking the Math A Regents exam, however they must have been trained to use the technology correctly (NYSED, 2002). The New York State Education
Department (2002) said, "graphing calculators are instrumental in the teaching and learning of mathematics" (p. 1). The Math B curriculum has extensively used the graphing calculator as an integral part of the daily lessons and other work (NYSED, 2002).

In the new millennium, the graphing calculator has been highly supported, however in the past the calculator in general was not always considered the student’s best friend. As a matter of fact, teachers in the early 1980s felt that a calculator had negative affects on student achievement and attitude. Researchers such as Ellington (2003) and Harskamp, Suhre, and Van Streun (Duprey & Howard, 2004) used these concerns to investigate if the teachers’ beliefs could be supported. However, what they found was that there was no negative affect on student learning and it did not influence their attitudes towards math positively or negatively (Ellington, 2003). Even today, teachers that were not taught mathematics with technology were less inclined to use it because they still believed that the way they were taught was the way that they should teach their own students. The idea that calculators make students lazy and unwilling to help themselves do a problem on their own is still out there (Quinn, 1998).

The graphing calculator was introduced in the late 1980s and the National Council of Teachers of Mathematics wanted teachers to be able to use the graphing calculator effectively in a mathematics classroom. NCTM (Ellington, 2003) said that this technology was an "emergence of a new classroom dynamic in which teachers and students become natural partners in developing mathematical ideas and solving mathematical problems" (p. 434). Again, more research was called for and pertained to how the new calculators would affect student learning and attitude toward mathematics.
The studies compared groups of students that used a graphing calculator and other groups of students that used a scientific calculator. The results showed that students improved their mathematical understanding of graphing, making connections between those graphs and their functions, visualizing on a multi-dimensional level, problems solving, and computation (Ellington, 2003). Posttests during other studies showed that students that regularly used a graphing calculator attempted more problems and receive the most points. These researches felt that graphing calculators had a positive impact on student achievement and conceptual understanding (Duprey & Howard, 2004). Ellington (2003) believed that the calculator should be used in all mathematics classrooms in the precollege levels and that the use of it during class should increase every year as the student goes through their schooling. Teachers were to create lessons that involved the integration of calculator use and investigations on a regular basis. They definitely should have been used to help promote problem-solving instruction in the middle and high school years which would result in more success in student performance and positive attitudes toward the subject.

However after the research, Duprey and Howard (2004) still found mixed results regarding if the calculator truly helped to improve student achievement and understanding. They (Duprey & Howard, 2004) were mainly concerned about “the time spent learning the calculator” that educators needed to train students and then the “fear of calculator dependency” by the students (p. 15). It is true that in order to improve student use on that graphing calculator, they must be trained to use it. This time had to come out of class time or students were required to have a special math lab in order to learn the uses. Another major concern was that in poorer districts, families and / or the school
district could be unable to afford to purchase the graphing calculators (Duprey & Howard, 2004).

Hvizdos and Gosse (2003) discussed a great way to allow students to be introduced to the graphing calculator. It was by having them participate in a scavenger hunt. This scavenger hunt should be designed to give the students an overview of how to navigate through the menu structure and abilities.

Wong (1999) stated that some of the most important uses of the graphing calculator included solving and graphing linear and quadratic equations and inequalities and transformations of functions. Edwards (2003) took this idea even further when dealing with systems of linear equations. He preferred to solve the systems using matrices and showed his students how to do this through a geometric perspective.

Another useful feature of a graphing calculator was not just graphing equations, but graphing statistical graphs and doing other statistical analysis. Students could create histograms, box and whisker plots, as well as other very useful graphs through the statistics-plotting area. If a student was interested in seeing multiple statistical graphs at one time, they could use the ZoomStat function and then in the WINDOW menu, alter the size so that the graphs are not overlapping each other (Coons, 1999).

The latest graphing calculator released from Texas Instrument was the TI-84 Plus Silver Edition. It had “more than 1.5 megabytes of FLASH ROM memory” (TI, 2005). Also, the operating system could be upgraded and had twice the “processor speed of the TI-83 Plus” (TI, 2005). Due to this great power, it had thirty application programs already loaded on the calculator for educational purposes as well as an additional ninety-four applications that could be downloaded from the internet to the calculator. Also, the
new calculator had a USB port that gave the user the ability to connect to any computer, presentation equipment, or other calculators to share what they were doing with others (TI, 2005).

Texas Instrument released hardware and software applications that could be used to enhance the graphing calculator’s abilities. Such items included the NoteFolio App that allowed students to connect a keyboard to the graphing calculator to take notes or write essays which can then be transferred to their computer (Thatcher, 2003). Brown (2005) described that “today’s measurement probes, software, and connecting hardware — collectively known as “Probeware” — allows users to quickly gather highly accurate data points” (p. 9). Vernier teamed up with Texas Instrument and created the EasyTemp probe and EasyData software for the TI-84 Plus (Brown, 2005). Calculator-Based Laboratories, otherwise known as CBLs, was a data collecting device which connected to the graphing calculator that was able to model data linearly, exponentially, logarithmically, et cetera. The CBL could have sensors such as motion detectors, colorimeters, pressure sensor, microphone, or a pH sensor (Goetz, 1998). Another collection device was the Calculator-Based Research, CBR, which focused mainly on motion data in the real world. This data included distance, velocity, and acceleration. (Texas Instrument, 2005)

Tablet PC

Several schools nationwide have been involved in pilot programs that provided students with one of the latest technologies: the tablet PC. Some of these schools
included the University of Virginia (Roach, 2004), East Stroudsburg University (Amirian, 2004), and Bishop Hartley High (Barton & Collura, 2003). The later school was the first high school in the United States of America to provide an entire graduating class, a group of 140 students, with the tablet PC. Not only were they allowed to use it in school, but for their own purposes outside of school. These students treated the technology with the utmost respect and all were returned in pristine condition at the end of the school year (Barton & Collura, 2003). The main purpose of the projects was to “improve student learning, enhance faculty productivity based on easier integration of technology into instruction, and a better understanding of how digital materials can be designed effectively” (Roach, 2004, p. 36).

Roach (2004) described this devise “as a compact, portable device” and “about the size of a typical spiral notebook” (p. 36). It had the Windows XP operating system that could be found on any desktop or laptop computer. The main difference, and main use of a Tablet PC, was that it had the ability for students to write on the glass screen with a special pen. This was useful when taking notes due to a program called Microsoft Windows Journal; the hand written notes would then be turned into a text document for future use. Students had the option of using an assortment of highlighters and writing tools to help make their notes as detailed and usable as possible (Barton & Collura, 2003). If students would rather have typed certain portions or all of their notes, keyboards and mice were also available to use with the tablet (Amirian, 2004). At the time, the keyboard was attached to the tablet by being hinged or on a swivel from the main device (Foster, 2005). When students needed to refer back to their notes to study, they could use a search engine on their tablet to search their own documents for certain
information. A program called “Snippet” allowed students to copy and paste images from other locations, such as the Internet, into their notes to make them as comprehensive as possible. Another feature was that users could dictate to the tablet and it would convert the dictation into text (Barton & Collura, 2003).

Students involved in these programs were able to access information on their classes from their classrooms, homes, or elsewhere as long as they had an internet connection (Roach, 2004). East Stroudsburg University had their classes create web sites that allow their students to obtain class notes and other materials to download (Amirian, 2004). Bishop Hartley created the Homework Online site, which allows students to access notes, assignments, and presentations that their teachers had posted. Teachers could also post an audio recording that could help those students that were auditory or hearing-impaired (Barton & Collura, 2003). Roach (2004) said that the downloading feature was also helpful during classes when students were “able to access online exercises and simulations” or other materials to enrich the lesson even further (p. 36). Since students could access these items online, they were not restricted to using the tablet during certain time frames. They could use it based around their schedules, especially if they were on sports teams or had after school jobs (Barton & Collura, 2003). Since the tablets were all connected to one central computer at the school, if a student was to loose their tablet, all of their information was backed up on the main system (Barton & Collura, 2003). Due to the wireless ability of the tablet, the information exchange of multiple types of information between students and teachers made their lives very easy instead of having to physically meet together (Galuszka, 2005). Since students were allowed to use
the tablet on their own time, it also had the capabilities of using multimedia such as videos and music, as well as the instant messenger (Amirian, 2004).

Roach (2004) quoted a short, but amazing quote from Linda Zecher, the vice president of the U.S. Public Sector for Microsoft: “Innovation demands collaboration” (p. 36). This technology allowed students to work together collaboratively in real time to accomplish classroom tasks on the tablet. However, in order for students to work collaboratively and make it work, they each needed their own tablet. Amirian (2004) found that if students in a group shared a tablet, they were less successful. If several students were crowded around a single small screen, it was hard for them to see everything that happened on the screen since the viewing angles were very limited.

For teachers, they could have students take quizzes, exams, surveys, et cetera through the tablet and then send them immediately to the teacher via an online drop box (Amirian, 2004). This allowed the teacher to bring their tablet home in order to grade these online exams. In order to create an even more personalized grading system, the text program allowed the teacher, or any other user, to input comments and critiques (Barton & Collura, 2003). Once done grading these items, they could then send them back to the students electronically (Amirian, 2004). Teachers could also communicate with their students in real time, which could help give students one-on-one attention and help in a different manner (Roach, 2004). It was also helpful for teachers when a student was absent. The student could simply download the notes in PowerPoint form or handwritten notes created and posted by the teacher. Also, teachers could do a quick poll using the tablet to see who was on task and understanding the materials that were being worked on.
The simple bookkeeping duty of taking attendance could also be done quickly using this technology (Amirian, 2004).

In a mathematics classroom, tablets could also be used while the teacher was giving notes in PowerPoint or other forms using a wireless projector (Amirian, 2004). Students could input any side notes into the presentation and save it for themselves (Barton & Collura, 2003). Also, it was very helpful to simply draw in mathematical symbols. Many times a word document did not have the more complex mathematical symbols and if they did, there are multiple steps and buttons to click on to get to the particular symbol that the user was looking for. Typing in formulas had never been easier (Barton & Collura, 2003). If students had a hearing or visual impairment, modifications were easily made for these students by changing contrast, color, text size, audio recording, and audio playing capabilities (Amirian, 2004).

The future of tablet PCs is uncertain. Many goals have been laid out, but depending on if the educational world catches the Tablet PC fever, who knows what will happen. Possibilities that are in the works include having textbooks made digitally so that they could be accessed through the tablet, instead of carrying around the extra weight and bulk (Barton & Collura, 2003). It is believed that eventually this new technology will replace laptop computers. In Austin, Texas, Huston-Tillotson College professors believe that undergraduates seeking to go into teaching should have the requirement of learning how to use the tablet in order to get their degree due to their easy use, mobility, and multiple other benefits (Galuszka, 2005). Galuszka (2005) also stated that there was the potential that the tablet is simply a fad and that educators were wasting their time. Physically, the machine is evolving; Bill Gates said “the next generation tablet on which
the display screen partially separates from the rest of the machine and slides from a horizontal to a vertical position to reveal a keyboard underneath" (Foster, 2005, p. A.1). Since the Tablet PC is a relatively new technology and still in development, it will take years of refinement, but it will eventually be the primary computer used in education (Foster, 2005).

**Interactive Whiteboards**

The interactive whiteboard was described by Clyde as "a specially designed whiteboard" (2004, p. 43) with a computer and digital projector that connected to the computer. Images were projected onto the screen and could be altered using special pens or by touching the screen. Each company that sold the interactive whiteboards had teaching software and electronic resources on CD- or DVD-ROM to accompany the hardware (Clyde, 2004). These companies and their specific interactive whiteboard included SMART Technology Inc.'s SMART Board (SMART Technologies, 2005), Promethean Inc.'s ACTIVboard (Miller, 2005), InterWrite's SchoolBoard (Byrd, 2005), and Quartet's IdeaShare Board (Ludia Inc., 2002).

During classes, the interactive whiteboard had the capability of using special electric pens that replace chalk and dry erase markers. Teachers and students used the pens to write directly on the whiteboard over the images that were projected. After writing and making notes on the whiteboard, users had the ability to save and print what they had done. Also, it could have been used in word documents or posted on a web site for future access (Clyde, 2004). Whiting (2005) stated that since the whiteboards were
large enough for all to see clearly, then students were “actively engaged with the screen itself”. Mini-whiteboards also referred to as portable tablets, wirelessly connected to the main whiteboard. Having students use the mini-whiteboards allowed the teachers to have students involved in multiple interactions at once and could show any individual student’s work on the main whiteboard for others to view (Byrd, 2005). Also, the interactive whiteboards additionally had “hand-held polling devices for instant classroom voting” (Byrd, 2005, p. 11) where the entire class was able to vote on the correct answer.

After two years of research from 2002 to 2004, Keele University (2004) suggested that mathematics teachers should purchase “ready-made interactive whiteboard designed software – since it takes time to prepare all your own” (p. 35). These software packages include EXP Maths by Nelson Thornes, Interactive Teaching Programs by Department for Education and Skills, and Interactive Mathematics by Association of Teachers of Mathematics (Keele University, 2004). The researchers from Keele University (2004) also suggest other software packages such as Cabri-Geometry, Geometer’s SketchPad, Autograph, Omnigraph, MswLogo, PowerPoint, Excel, and Word were very effective while using the interactive whiteboard technology.

From 2003 to 2004, six teachers from Bracknell Forest Primary School conducted research on the use of the interactive whiteboard in their classrooms. The authors, Knight, Pennant and Piggott (2005), stated that the teachers discovered three main themes during this time: the technology “had a positive impact on motivation and engagement” (p. 11), it “appeared to contribute to raising self esteem for some pupils” (p. 11), and that it “offered pupils the opportunity to revisit images of prior learning” (p. 11).
Whiting (2005) found that students with special needs, along with average learners and students that should have been classified, improved a great deal when working with the interactive whiteboard. Students who were reluctant to write became more “involved in the writing process,” those that had difficulties in processing “were performing math computation,” and students with Attention Deficit Disorder “were paying attention and participating in lessons” (Whiting, 2005).

Knight, Pennant, and Piggott (2004) also identified five contexts on how the interactive whiteboard could be used. The teacher could have been a demonstrator or modeler. If the teacher were in control, they would share the use of the technology with the students by inviting them to the board to help. The students could also be in control by having the teacher guide them through the work. Finally, students could be working with the technology independently. The authors (Knight, Pennant, & Piggott, 2004) stated “models of teaching and learning that are more open and social are more likely to result in the interactive whiteboard offering a unique feature to the classroom” (p. 16). When using this technology, teachers were more aware of a greater variety of teaching and learning methods available to them which influences the way that they teach and engage their classrooms (Knight, Pennant, & Piggott, 2004).

Microsoft PowerPoint

According to Tomei and Balmert (2000), an interactive lesson must be “visually-based, behavior-oriented,” “contain self-paced instructional content appropriate for students,” offer “specific, logical, systematic lessons that foster individualized instruction
and sequential learning,” and “is student-initiated and student controlled” so that it
“places a good deal of the responsibility for mastering the material directly in the hands
of the learner” (2000, p. 69).

Tomei and Balmert (2000) also studied a nine-step design model that was created
by Jerrold Kemp to help them learn how to create an interactive lesson. The steps
included: selection of a topic, identification of types of students that were taught,
identification of “the specific behavior-based elements that students must master” (p. 70),
preparation of the behavioral learning objectives, organization of “the instructional
progression” (p. 70), creation of assessment tools, creation of PowerPoint presentation,
conduction of the assessment, and the location of additional resources that may be needed
for the lesson (Tomei & Balmert, 2000).

While creating the PowerPoint presentation, the user could use four features that
would help the presentation to be most beneficial to students. These four features were
“Action Buttons, Hidden Slides, Kiosk Browser and an Assessment Slide” (Tomei &
Balmert, 2000, p. 70). The Action Buttons allow the user to progress to the next slide,
movie and / or sound clip, or other information. The Hidden Slides were used “to see
certain slides only under particular circumstances” (Tomei & Balmert, 2000, p. 70).
These slides can be used for assessment purposes so that students can not see answers
and explanations when they should not. A Kiosk Show is self-running and can be used to
show an unattended presentation that restarts automatically when finished. Assessment
slides must be appropriately sequenced in the presentation from beginning to end and be
able to give some sort of instantaneous feedback. A summative or final assessment is
highly recommended. This type of assessment must come at the end of the presentation
and prove to the instructor that the learner has mastered the appropriate skills (Tomei & Balmert, 2000).

Geesaman (2000) used PowerPoint to create a Jeopardy game to review a mathematics unit. She had a computer that was connected to a large television to present to her classroom. The main screen consisted of four categories with four buttons each that were labeled with their point value for the difficulty of the questions that were asked. After clicking on the point value buttons, students were taken to a question slide that included the question. If an equation was needed on the question slide, Geesaman was able to insert it into the program using Microsoft’s Equations Editor. Each team of students was to answer the questions on a team whiteboard so that each group had the opportunity to earn the points. The Final Jeopardy question allowed each team to secretly decide on its wager and answer the question (Geesaman, 2000).

Ebert revisited the article by Geesaman in 2002 with his own spin on reviewing in the mathematics classroom. He created a multiple choice review game where each question included the use of three different slides. The first had the question and the four multiple choice answers. The correct multiple choice answer brought you to a slide that congratulated the student on their good work and advanced them to the next question. However, if the student had chosen a wrong multiple choice answer, any of those three would have brought the student to the third slide that stated the answer was incorrect and gave the student suggestions on how to solve the problem. Each review that Ebert created was made up of twenty questions that could be posted on the school’s network server or on the internet for student use in the future. An idea that he thought of was to have students create these types of review games for a small project (Ebert, 2000).
Spreadsheets

According to Henle (1995), the spreadsheet was “a general-purpose tool for manipulating rectangular tables of mathematical quantities. It is organized into rows and columns of cells” (p. 321). These cells were able to house text, data, or formulas. The formulas were able to contain “standard arithmetic, logical, and string operations as well as functions” (p. 321). Since spreadsheets were dynamic (Richgels, 2005), they also had the ability to create bar, line (Henle, 1995), histograms, and circle graphs (Richgels, 2005). These charts could be shown in two or three dimensional form (Henle, 1995). Not only did spreadsheets create graphs and charts, but they also were able to calculate statistical data such as the mean, median, mode, and totals (Richgels, 2005).

Henle (1995) said “like any good mathematics software, a spreadsheet encourages experimentation” (p. 322). Suggested ways of experimenting were discovering how Fibonacci numbers, Pascal’s triangle, and Sierpinski’s gasket worked (1995). Richgels (2005) believed that “the software frees the students from the manual construction of graphs to a higher level of thinking and interpreting of data and graphs” (2005, p. 6).

Horton, Phillips, and Kenelly (2004) said that there are several advantages of using a spreadsheet over other graphing devices. The first is that “they provide greater flexibility” (p. 284) so that “users are not restricted by the choices of models available in their software. They can create a model of any type” (p. 284). Secondly, “spreadsheet give a greater opportunity for estimation” (p. 284). A third advantage was that “spreadsheets can help students develop an understanding of error in the mathematical models” (2004, p. 284). The example they gave was how in regression models it the
equation of the line was the line of best fit, not the line of exact fit. The last advantage that Horton, Phillips, and Kenelly (2004) stated was that spreadsheets have the ability to be printed easily in order for the user to have a hard-copy. Henle (1995) also gave advantages of using a spreadsheet. It was easy to use so that students could quickly figure out the basic features and start using them immediately. The user would not be misled by thinking that they had created the entire graph because the spreadsheet only took a sample of the function. The graph could be re-plotted if new endpoint were given. The plot could have been could have been customized in color and format. The chart could have been copied into other documents such as a drawing program or a word processor. Also, the spreadsheet could be saved and used again at a later date.

**Geometer's Sketchpad**

Geometer's Sketchpad was originally designed at Swarthmore College during the 1980's as a supplementary program to teach high school geometry (Doyle, 2004). According to Satterfield (2001), the program allowed “students to construct precise figures and manipulate them interactively, helping them to develop mental models for thinking about geometric shapes and their properties” (p. 184). At the high school level, Doyle (2004) said that the program “has been recognized as a model of seamless integration of software, curricula, and pedagogy possibly unequaled in any other area of K-12 education” (p. 17) and that it “remains the best approach to the application of computer software in an educational setting” (p. 17).
This dynamic tool allowed students and teachers to visualize and explore several mathematical concepts (Garofalo & Bell, 2004). The program had the capability to present quadrilateral concepts, symmetry, transformations (Satterfield, 2001), theorem proofs, (Garofalo & Bell, 2004), lengths, areas, circumferences, trigonometry (David, 1991), and many other topics from algebra, geometry, precalculus, and calculus (Garofalo & Bell, 2004).

The program had many strengths that included versatility, ease of installation, excellent for cooperative learning (Satterfield, 2001), increase in student motivation and interest, improvement in student reasoning processes, understanding of difficult geometric concepts (Lange, 2002), supported “drawing and manipulation of lines and two- and three-dimensional figures” (David, 1991, p. 34), and included over thirty completed sketches that students were able to use immediately (David, 1991).

Taylor (1992) described what she believed to be an excellent way of introducing Geometer’s Sketchpad to a mathematics class. First, she taught students how to set up for the exploration by creating an acute triangle. From there she had the students to an exploration on the differences between acute, obtuse, and right triangles. Using these triangles, she had them measure the angles using the built in measuring function. The creation of the measurements allowed her to have the students find out the sum of the angles of a triangle. To expand on this idea, she had students find “the sum of the measure of the angles of a five-pointed star” (1992, p. 189). The final exploration were on the differences between scalene-, isosceles-, and equilateral-triangles using the measuring function and areas of these triangles (Taylor, 1992).
Inspiration

Doe (1999) described Inspiration as "a visual learning tool that helps students organize their thinking by developing graphic representations of ideas" (p. 72). The platform allowed its users to brainstorm, categorize information, and organize these ideas (Jones, 2002). The ideas could have been in web, chart, pictorial (Schneider, 2000), or outline (text only) forms (Jones, 2002). These forms could be created from using multiple tools such as drawing tools, standard word processing, other specialized tools and palettes (Doe, 1999), and even audio recordings (Jones, 2002). The web, or diagram, form is the most flexible because of an extensive amount of symbols and shapes to be used to represent concepts. These concepts are linked using arrows or a Rapid Fire feature (Schneider, 2000). Also in the web form, ideas could be hyperlinked to other files and internet sites (Jones, 2002).

Inspiration inspires students to learn and be creative through these visual techniques of representing ideas and concepts graphically. These types of activities allowed students to deepen their sense of understanding and promoted the development and thinking of ideas. They also helped to increase retention of material and to improve learning and organizational skills (Doe, 1999).

UnitedStreaming.com

UnitedStreaming was a video-on-demand library (McCaffrey, 2003) with the largest collection of videos (McQuin, 2003) of over forty-five hundred available online
videos (Reed, 2005). Users were able to stream the video or download the file for future use. After downloading the video, the user may watch the video as is, insert it into a PowerPoint presentation, and even edit it to their specific needs (McQuin, 2003). There also was an extensive image library that included educational photographs and clipart (Reed, 2005). This resource is available to anyone at anytime and anywhere (Reed, 2003).

McCaffrey (2003) described a study that was conducted in several classrooms in Virginia. The studies showed that UnitedStreaming led to more attentive, knowledgeable, and higher-achieving students. Due to the increase in student interest and curiosity, the study “concluded that multimedia presentations are more effective than traditional lectures” (2003, p. 34).

Frank Boster completed a study on incorporating “standards-based video clips into lessons developed by classroom teachers” (Reed, 2003, p. 14). Boster stated that students who had instruction that incorporated video streaming “showed dramatic improvement in achievement” (Reed, 2003, p. 15-16). Also available from the site were teachers’ guides, activities for students, quizzes, and other resources for educators (Reed, 2003). In the same article, Reed (2003) discussed how important professional development was for teachers. The training needed to include practical and technical applications as well as suggested uses of the resources available to get them in-order to get started.

The U.S. Education Department had a set of National Educational Technology goals. In Reed’s (2003) article, he stated that these goals were to have informational technology in all classrooms, all teachers using it, all students having the skills to use it,
continued research and evaluation to make it even better, and for it to “transform teaching and learning” (p. 18).

When teachers used UnitedStreaming, their students gained reinforcement of reading and lectures, help in development of base knowledge, enhanced comprehension and discussion, diverse learning styles were reached, and the teacher became more effective. The videos enhanced classroom instruction because they helped teachers to plan ahead, prepared the teacher by previewing videos, expectations were made clear for students, the teacher was able to determine the length of the video, students were encouraged to participate, and activities were connected to real-world experiences (Pasnik & Honey, 2005). According to the Software Information Industry Association, multimedia resources like UnitedStreaming advanced “learning in phonological awareness, vocabulary development, reading comprehension, and spelling” (Pasnik & Honey, 2005, p. 21). It also helped “with problem solving and hands-on, experimental activities” (Pasnik & Honey, 2005, p. 21), improved conceptual understanding of mathematical topics through real-world examples, and fixed misconceptions in students’ thought processes (Pasnik & Honey, 2005).

For beginning users, Talmadge (2005) suggested that they look into the Learning Tools section to see what resources are available. For the intermediate users, he suggested that they begin to incorporate the videos into their lessons by inputting them into PowerPoint presentations. For the very advanced users, he believed that they were able to create their own videos to use.

Since UnitedStreaming delivered copyright free videos of high quality content, it was necessary for schools to acquire a site license. Each of the sit licenses cost one
thousand dollars each year in order for school districts to have unlimited use of the resources (McCaffrey, 2005).

ExploreLearning.com

"ExploreLearning is an international, innovative, and interactive online educational software developer" (Virginia Piedmont Technology Council, 2005). It had a large library of interactive simulations that were excellent for math and science teachers. The simulations were called Gizmos. The Gizmos were easy to use, flexible to support the multitude of teaching styles, and made learning fun for students. There were over four hundred Gizmos available (Proquest Information and Learning Company, 2005b). These manipulatives were developed for student use in grades six through twelve and were extremely powerful for teachers to teach and students to learn. They were aligned to all state and national standards (Proquest Information and Learning Company, 2005a).

Proquest (2005b) gave a useful tip for the first time visitor to the online software. They stated that there was an eight minute introductory movie to understand how the site worked and what the Gizmos were. There were also five other "movies that show how you might teach a specific lesson using Gizmos" (Proquest, 2005b).

Apple (2005) believed that the "inquiry-based learning" Gizmos had the following benefits: covered a multitude of topics, not a lot of time needed to teach students how to use it, aligned to national and state standards, easy to use with all major textbooks, assessments were included, used research proven strategies, useable anytime and anywhere, and supported in many technology settings. The VPTC (2005) brought to
light another benefit that ExploreLearning has also joined with McDougall Littell and created two e-texts for Algebra.

ExploreLearning.com was developed by Dave Shuster and launched in 2002 (VPTC, 2005). In March of 2005, Proquest Information and Learning purchased the online simulation source. The main objective for the site was to help "learners make sense of complex scientific and mathematical principles" (Proquest Information and Learning Company, 2005a). Al DeSeta, the President of Proquest Information and Learning of K-12, said "As the need for math and science literacy support grows, we will provide quality products to help support learning" (Proquest Information and Learning Company, 2005a). The site has earned awards that include the Diamond Award in Mathematics and the E-Learning Innovation Award. Also, they have been included in the Eisenhower National Clearinghouse's Digital Dozen three times (Proquest Information and Learning Company, 2005a).
Methodology

I chose to do my action research centered on the Conics unit in the Math A curriculum because it used the graphing calculator in depth. This unit was taught in the Geometry course in December of 2005 and January of 2006. The topics that were covered were a review of factoring, graphing a parabola based on the x-intercepts and axis of symmetry, graphing a parabola on an interval, transformations of parabolas, solving systems of equations graphically of a parabola and a line and also a circle with a center at the origin and a line, and solving systems of equations graphically of a parabola and a line.

There were three Geometry classes that I used to do my action research. Classes are on a block schedule. There were four blocks a day that were each eighty-five minutes long and each section of the Geometry classes met every other day. One section met during first block, the second during second block, and the third during fourth block. The Geometry course was set up to be the second year of high school mathematics. The type of students that were in these classes ranged from accelerated freshmen to a third year senior. I had a total of sixty-one students between all three classes.

Mainly, I created the lessons on my own, but discussed ideas with another Geometry teacher who was a veteran teacher of thirty-four years. The lessons consisted of typed notes in skeleton form so that students had an easier and more organized way of taking notes (see Appendix A for a sample of a note-taking worksheet). During the lessons, students also completed a graphing calculator activity to learn how to use the x-y table (see Appendix B for this activity). Students were also given an assignment sheet on the first day of the unit that allowed them to know all of the assignments that they would
need to complete and what topics that those assignments covered. I gave the students one quiz based on the first three lessons of the unit (see Appendix C for quiz). When I was completed with teaching the unit, I gave the students two review packets to review for the test. The test was created in the 2003-2004 school year by three other teachers that taught Geometry that year. During that particular school year, as a department, we worked on created tests for every unit in the Math A curriculum so that all teachers gave the same tests (see Appendix D for test). Using the test that the mathematics department created for the Conics unit, and a quiz that I created on my own, I identified which questions should have been answered with the graphing calculator, by hand, or either way. I analyzed how the students answered and if their answer was correct or not in order to compare the effect that the graphing calculator had on their learning. This information allowed me to see if the students had used the graphing calculator effectively in order to help themselves to succeed on the test.
Results

After the Conics unit was completed, I used the unit test to prove if the graphing calculator was an effective aid to the students after the amount of time spent using the technology. Questions one, five, seven, eight, nine, ten, fourteen, and fifteen could have been solved using either the graphing calculator or by hand. Questions eleven and thirteen could have been partially solved using the graphing calculator, but were more geared toward solving completely by hand, where as questions two, three, four, six could only be solved by hand. Lastly, question twelve could have been solved using the graphing calculator but the problem specifically said to solve algebraically. I chose to look specifically at the questions that could have been solved either way. I also chose to look back at the quiz taken during the unit to see if there were any similarities or discrepancies.

Question one from the unit test gave the equation of a parabola and asked the students to find the turning point or vertex. Fifty-four students, out of the sixty-one total, answered correctly using the graphing calculator. One answered correctly by hand using the axis of symmetry formula taught to them. Six students answered the question incorrectly. Therefore, 89% were able to effectively use the table function on the technology to find the vertex.

Question five asked the students to solve a set of system of equations that included a parabola and a line. Since the question did not identify which way that students needed to solve the problem it was open to their discretion. Twenty-one students answered this question correctly using the algebraic method. Another twenty-
five students answer the equation correctly but did not show work. They could have obtained their answer by using the graphing calculator or by guessing correctly. The last fifteen answered incorrectly. Therefore 41% or less effectively used the technology to help them find the points of intersection.

Question seven gave the students an equation of a parabola and asked them to identify what the graph of the parabola looked like. Students could have entered in the equation into the graphing calculator and used the graph function or they could have remembered the rule that if the equation was in the form \( y = -x^2 \) then the parabola would open downward and there was only one choice that open downward. Fifty-six students answer the question correctly. The five students that did not answer the question correctly all chose the other graph of a parabola that opened upward. Therefore at most 92% of the students used the technology because some of the students were able to remember the rule.

Question eight asked students to find the roots of a parabola given the equation. Students were mainly taught to solve this type of equation by factoring, setting the factors equal to zero, solve for \( x \), and finally create a coordinate with a \( y \) value of zero. Most students attempted this by hand, however eight students attempted the question using the table function on the graphing calculator. One student was able to successfully answer the question using this method (see Figure 1D) and a second one was able to identify one of the roots, but did not expand the table enough to find the other root. The other six students found the table but similar to the last student discussed, did not expand the table enough to find either root. This shows that 86% of the students that attempted to use the technology were not as effective as they should have been.
Question nine gave the students the equation of a parabola already in factored form and the students needed to identify not only the x-intercepts, or roots, but also the y-intercept. All but three attempted the question by hand. These three used the table function of the graphing calculator. Two of the three had tables where they would be able to identify the three intercepts, however neither of the students identified the intercepts (see Figure 2D for one example of a complete student table). The third student was missing one row that would have included the second x-intercept; however he only identified the y-intercept and not the x-intercept that was shown in the table. Therefore the students who attempted to use the technology were effective in their ability to find the information but did not know how to use it which did not make it an effective tool for them.

Question ten asked the students to graph a given parabola on a certain interval. Fifty-three of the students were able to enter the equation into the calculator correctly to find the points. However, of these students, nine of them found points in an incorrect interval or did not correctly plotted the points on the graph paper or graph it at all. Of the eight students that did not find correct points, five forgot to place the negative sign in front of the equation, one tried to factor to find points, one of them I was unable to decipher what she did, and the last did not even attempt the problem. Therefore 72% were successful in the effective use of the technology to find the correct points in the given interval. Another 15% effectively found the points, but did not read the directions for the correct interval.

Question fourteen asked the students to graph a parabola, find its axis of symmetry, reflect that parabola over the x-axis, and find the vertex of the new parabola.
At this time, I will only discuss the students’ successfulness of finding the correct points to plot the initial parabola. Fifty-five of the students were able to find a correct table of values in order to correctly graph the parabola. Of the six that answered incorrectly, one student did not input the negative sign before the $x^2$ when typing the equation into the y= screen therefore obtaining an incorrect table of values. Three of the incorrect answers were left completely blank and two has incomprehensible work written down. Therefore 90% were able to use the technology effectively to find a set of points in order to correctly graph the parabola.

Question fifteen described the path of a ball that was thrown in the air in the form of a parabola. Students were asked to find out after how long the ball reached it maximum height and what that maximum height was. Students were mainly taught to do this by hand by using the axis of symmetry formula to find the time and plugging that value back into the parabolic equation to find the height at that given time. Students were exposed to using the table function on the graphing calculator to find the turning point. Since the answer to this problem was a decimal it would have been difficult for students to answer if they did not remember how to use the table setup function. Forty-three students were able to answer the question to get either full credit or partial credit. Of these students, one student was able to manipulate the table setup function to have the x-values increase by 0.25 in order to find the turning point on the graphing calculator (see Figure 3D). Eighteen students received no credit; of these two knew to use the formula for axis of symmetry but did not plug the information in correctly and made other mistakes in the evaluation to receive no credit. Eight of the students that received no credit had work that was incomprehensible and another eight left the problem completely
blank. Therefore the students were not able to effectively use the technology because they were not trained to alter the table setup.

After analyzing question fifteen on the unit test, I chose to look at the first question on the quiz that I had given to my students because it was the same question, but with a different equation. This time the answer were integers and easier to find in the table function. Three of the students, 5%, did use the table function to effectively identify the time when the ball reached its maximum height and what that maximum height was.
Discussion and Conclusion

After analyzing the results of the Conics Unit test, I saw to what extent I had instructed the students to solve the different types of problems algebraically or using the graphing calculator. More importantly, I saw how effectively they used the technology to aid themselves. After the exam, we held a class discussion on each of the problems that I discussed previously. For each of those questions some of the students openly offered feedback on why they answered the questions how they did.

I think that since 89% the students solved question one using the graphing calculator that they were effective in their use of the technology. After the discussion, many of the students said that they knew how to solve it both ways, but that it was easier to solve it using the graphing calculator. Even though it may have seemed easier, the students still needed to know what a vertex was and how to find it using the technology.

Along the same lines, I also felt that I did well in teaching the students how to identify what a parabola would look like using either the rule or the graphing calculator since 92% of the students were effectively able to use the technology to aid them in finding the picture of the parabola. Also, on average, 89% of the students showed that they could effectively enter the equation of a parabola into the calculator and find appropriate points in order to graph the image of the parabola. This was seen in questions ten and fourteen. In question ten the students were given the interval to find and then in question fourteen they had to identify the correct interval themselves.

Even though I did not stress how to use the graphing calculator to find x- and y-intercepts, solve systems of equations, or manipulate the table setup function, some
students did attempt to use the technology for these types of problems. However, the majority of the students did not know how to effectively use and comprehend the information that the technology gave them. I think that this is something I need to work on with my students more in order to make the graphing calculator a more useful tool to them. In future school years, on the day that I teach how to do each of the topics by hand, I must also have an activity for the students to explore how to use the technology to aid in answering the equations.

Since few students were able to use the technology to find the intersection point of a parabola and a line, I will need to teach them how to use the intersection function when the conics are graphed. Along with this concept, I will need to show them how to read the table to see where the conics have common points. Students also need experience looking at a table and being able to identify the x- and y-intercepts. Finally, I know of a simulation that can be used to demonstrate the ball throwing type of questions; I can use this in order to better visualize the problem and so that the students understand that the maximum height and the time at that height is really the vertex. Along with this, which can be seen in other situations as well, I need to have the students learn how to change the amount that the x-value increases by in the table for those cases where the vertex is not at a coordinate with integers.

I believe that Quinn’s (1998) statement about students using the calculator as a tool to be lazy and not understand the mathematics is false. The students still need to understand not only the concept of what the mathematics is asking of them but also how to manipulate the tools at their fingertips to help them find the answer; in a way, the students need to know more mathematics in order to use the technology. Ellington
(2003) shares the same beliefs as I do; that not only student achievement will increase, but so will their conceptual understanding instead of simply knowing what formulas go with which types of problems. Doing this only make the students robotic in nature to just plug information into an equation and get an answer. The graphing calculator is a very effective tool if students use it appropriately.

I will continue doing research in my classroom and how the graphing calculator affects student learning. The next topic that I will focus on is how the technology can help students in their understanding of statistics. In this unit I will teach my Algebra students about the different types of central tendency, bar, line, and circle graphs, scatter plots, histograms, and box and whisker plots; almost all of which students would be capable of creating or calculating using the graphing calculator’s many abilities.

The high school that I teach at has recently found CBL 2s tucked away that are now available to be used. I am also interested in experimenting with these and how they can be used in any of the units that I teach. I will be researching to see if they will be useful to and enhance my students learning and comprehension of mathematics.

In conclusion, I do believe that the use of the graphing calculator is a useful and effective tool to students and their learning. After the research that I have done through the many articles and the classroom research with my own students, I have a deeper understanding and appreciation as a teacher of how the graphing calculator can affect my teaching and classroom activities. Duprey and Howard (2004) are correct in that using the technology may take more time in the classroom, but in the end the students will enjoy the hands on learning, appreciate having the multiple ways of solving a problem,
and will truly understand all parts of what I am asking of them. If this can happen they will have a deeper comprehension and appreciation for the mathematics taught to them.
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Appendix A
Sample of Notes – Graphing Parabolas for a Given Interval

Name: ________________________ Date: ________________

Notes - Graphing Parabolas on an Interval & Transformations with Parabolas

1. \( y = x^2 - 8x + 15 \) on \( 1 \leq x \leq 7 \)
   a. Graph parabola

   
   b. Reflect parabola over the \( y \)-axis
2. \( y = -x^2 + 6x - 1 \) on \( 0 \leq x \leq 6 \\
a. \text{ Graph parabola}

b. \text{ Translate parabola 4 units to the right and 3 units down}
Appendix B
Graphing Calculator Activity

Name: ___________________________ Date: ________________

Graphing Calculator Activity:
Parabola Values

Steps:
1. Turn GC on.
2. Hit the y= button
3. Type in equation. The “x” button is located next to the “ALPHA” key.
4. Hit the yellow “2^nd” key.
5. Hit the “WINDOW” key. Because we hit the yellow “2^nd” key, we are actually using “TBLSET” which is above “WINDOW”.
6. The cursor should be flashing on the line that says “TblStart=”. Enter in a “0” if it is not already there.
7. Hit “ENTER”.
8. The cursor should be flashing on the line that says “ΔTbl=”. This means, what do you want your intervals to increase by. Enter in a “1” if it is not already there.
9. Hit the yellow “2^nd” button again.
10. Hit “GRAPH”. Because we hit the yellow “2^nd” key, we are actually using “TABLE” which is above “GRAPH”.
11. This gives you a table of X and Y values.
12. Copy down the values you need for your interval that is given.
13. What is the axis of symmetry?

Examples:

1. \( y = x^2 - 6x + 8 \) on the interval \( 0 \leq x \leq 4 \).

2. \( y = x^2 - 7x + 10 \) on the interval \( 0 \leq x \leq 7 \).

3. \( y = -x^2 + 4x + 12 \) on the interval \(-2 \leq x \leq 6 \).

4. \( y = -x^2 + 3x - 2 \) on the interval \(-1 \leq x \leq 4 \).
Appendix C
Quiz

Name: ___________________________ Date: ____________

Conics – Quiz 1

1. A ball is thrown and has a parabolic path of \( y = -x^2 + 4x + 3 \) where \( y \) is the height in feet and \( x \) is the time in seconds that the ball is in the air.
   a. Find the time when the ball has reached its maximum height.
   b. Find the maximum height of the ball.

2. Given the parabola \( y = x^2 + 4x - 4 \)
   a. Graph the parabola on the interval \(-5 < x < 1\). Make sure that you state the \( x\)-\( y \) chart and label the parabola “a”.
   b. Reflect the parabola from part (a) over the y axis. Make sure that you state the \( x\)-\( y \) chart and label the parabola “b”.

[Graph of a grid with 15x15 squares for plotting]
Name: ____________________________ Date: ____________________________

Conics - TEST

Part 1
Answer all questions in this part. Each correct answer will receive 2 points. Clearly indicate the necessary steps, including appropriate formula substitutions, diagrams, graphs, charts, etc. For all questions in this part, a correct answer with no work shown will receive only 1 credit.

1. The coordinates of the vertex of the parabola \( y = x^2 + 2x + 1 \) are
   a. \((-1,0)\)                       b. \((0,-2)\)
   c. \((1,4)\)                       d. \((-2,1)\)

2. The graphs of \( x^2 + y^2 = 9 \) and \( y = 3 \) are drawn on the same axes, what is the total number of points in common to both graphs.
   a. 0                             b. 1
   c. 2                             d. 3

3. Which equation is the graph of a parabola?
   a. \( y - x = 5 \)                b. \( y - x^2 = 5 \)
   c. \( y^2 - x^2 = 5 \)            d. \( y^2 + y^2 = 5 \)

4. What is the center and radius of a circle with equation \( (x - 4)^2 + (y + 5)^2 = 81 \)
   a. center = \((4,-5)\), radius = 81
   b. center = \((-4,5)\), radius = 81
   c. center = \((4,-5)\), radius = 9
   d. center = \((-4,5)\), radius = 9

5. What are the solutions to the system of equations \( y = x + 3 \) and \( y = x^2 - 3x - 9 \)?
   a. \(((2,-1), (9,6))\)
   b. \((-2,1), (6,9))\)
   c. \((1,-2))\)
   d. \((2,-1), (1,-2))\)
6. Consider a parabola whose axis of symmetry is the y-axis. The point (-2,3) lies on the parabola. Which point also lies on the parabola?
   a. (0,-3)        b. (-2,3)
   c. (2,-3)        d. (2,3)

7. Which graph below best resembles the graph of \( y = -x^2 + 4 \)?

   (a) ![Graph A]
   (b) ![Graph B]
   (c) ![Graph C]
   (d) ![Graph D]

Part 2
Answer all questions in this part. Each correct answer will receive 2 points. Clearly indicate the necessary steps, including appropriate formula substitutions, diagrams, graphs, charts, etc. For all questions in this part, a correct answer with no work shown will receive only 1 credit.

8. What are the roots of \( y = x^2 + 3x - 18 \)?

9. Find the x and y intercepts of \( y = (x + 2)(x - 3) \).
Part 3
Answer all questions in this part. Each correct answer will receive 3 points. Clearly indicate the necessary steps, including appropriate formula substitutions, diagrams, graphs, charts, etc. For all questions in this part, a correct answer with no work shown will receive only 1 credit.

10. Graph $y = -x^2 - 2x + 3$ from $-5 \leq x \leq 1$.

11. Solve the following systems of equations graphically: $x^2 + y^2 = 9$
    $y = x - 3$
12. Solve the following systems of equations algebraically:
\[ y = x^2 - 4x + 4 \]
\[ y = 2x - 4 \]

Part 4
Answer all questions in this part. Each correct answer will receive 4 points. Clearly indicate the necessary steps, including appropriate formula substitutions, diagrams, graphs, charts, etc. For all questions in this part, a correct answer with no work shown will receive only 1 credit.

13. (a) Graph the lines \( y = 4, \ x = -3, \) and \( y = \frac{4}{3}x + 4 \) on the same coordinate axes.

(b) Find the area of the triangle formed by the intersection of the three lines in part a.
14. (a) Graph \( y = -x^2 + 6x \).
(b) What is the axis of symmetry for the graph in part a?
(c) Reflect the graph from part a in the x-axis and label it c.
(d) What is the vertex (turning point) of the graph in part c?

15. A ball is thrown into the air. Its height after t seconds is given by
\( h(t) = -16t^2 + 40t \).

a. How long does it take for the ball to reach its maximum height?

b. What is the ball's height at that point?
Appendix E
Samples of Student Work

8. What are the roots of \( y = x^2 + 3x - 18 \)?

9. Find the x- and y-intercepts of \( y = (x+2)(x-3) \).

Figure 1D – Correct student work for Question 8

Figure 2D – Correct table of values in student work for Question 9

15. A ball is thrown into the air. Its height after \( t \) seconds is given by \( h(t) = -16t^2 + 40t \).

(a) How long does it take for the ball to reach its maximum height? \( 1.25 \) seconds

(b) What is the ball's height at that point? \( 25 \)