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Bringing Technology into the Mathematics Classroom: The Who, What, Why and How

Erin Green
St. John Fisher College

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When you look around, technology is everywhere. It is in toothbrushes, cars, kitchens, banks, stores, etc. It is almost impossible to go a day without using some form of technology. This is because technology has made our lives easier. Things we used to have to do manually can now be done, much easier, using some form of technology. It makes perfect sense that technology would have an active presence in the classrooms of today and tomorrow. To properly integrate into the classroom, technology should be integrated across the curriculum. However, the focus here is in the mathematics classroom.

As technology is becoming more and more prevalent in daily lives it seems only natural for educators to look for ways to include technology in their teaching. St. John Fisher teaches prospective teachers to incorporate technology, because of many of the perceived benefits for the students by doing this. It seems to look good on paper but more convincing was necessary, which is why the question of this research is how bringing technology into the mathematics classroom can benefit students.

Previous research by Funkhouser (2003) and Ruthven, Hennessy, and Brindley (2004) showed several benefits to integrating technology into the mathematics classroom. Some of these benefits were variety in the classroom activities, more student accountability over their own learning, the ability to address different learning styles more easily, and less time required for calculations and graphing activities. It was also pointed out that using technology in the classroom can help create a student centered classroom. Students are more likely to have higher performance levels when they are taught in student centered classrooms than teacher centered classrooms. The literature

also pointed out some challenges to teachers when integrating technology. To a teacher the main goal should be to help students achieve their best. So it would seem, the benefits to the students by integrating technology into the classroom should outweigh the challenges that may be encountered.

Research done by Funkhouser (2003) showed students have a positive attitude toward using technology in their classrooms. Only one study conducted by D'Souza and Wood (2003) showed students were reluctant to use technology because they were not comfortable with it. For this research, student performance and whether or not the students are more engaged in the classroom, when technology is integrated was the focus. The main questions addressed were: would students perform better when technology was used as a tool in the classroom, would technology keep students engaged and on task throughout the lesson, and which method of instruction do students prefer, in the classroom or the computer lab? A piece of the research asked for the student's opinion on technology in the classroom. The results of this study showed the effects of integrating technology into the classroom on student performance, engagement and time on task. If these results had been supportive of integrating technology into the classroom, technology should be used more often as a teaching tool in the classroom. Then these findings would be presented to other skeptical teachers to try and convince them to give technology a try. Since these findings did not support this theory there may have been a failure to integrate the technology properly. In this case, the method for research should be evaluated and revisited, and possibly more research conducted. If there was no fault in the research then technology should only be used when it is absolutely necessary. No

matter the results, more was learned about how bringing technology into the mathematics classroom effects student learning.

Literature Review

With society changing at such a rapid rate to include technology into almost every aspect of our lives it is not surprising that technology is becoming a teaching tool in the classroom with the focus here on the mathematics classroom. "One of the six principles underpinning the Principles and Standards for School Mathematics is the technology principle: Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (Forgasz, 2006, p. 78). The research in this literature review elaborated on these benefits of including technology in the mathematics classroom as well as gave challenges to mathematics teachers who wish to integrate technology into their classrooms.

Research shows while some teachers are very willing to accept this change to their classrooms, there are several teachers who are reluctant to integrate technology into their classrooms. For these teachers the benefits do not outweigh the negatives associated with integrating technology into their classrooms. The literature took a look at different teachers, both in service and per-service, perspectives.

In addition to looking at the teachers perspectives on technology in the classroom, the research took a look at the students perspectives. In the three studies looked at there were contradicting findings, with two of them indicating students found technology use in the classroom beneficial and one indicating students preferred the traditional approach to learning mathematics. One major question answered by these studies was which factors contribute to whether or not students were accepting of this change.

The last thing looked at in this literature review is how to successfully implement technology use in the mathematics classroom. Several studies examined specific

examples of technology integration in the mathematics classroom and the benefits of these examples. These studies looked at what skills students were able to achieve by using technology in the classroom.

All of this research indicated that technology is emerging as a necessary tool in the mathematics classroom. "Today's technology can provide teachers and students with opportunities for teaching and learning that were impossible in the past" (D'Souza & Wood, 2003, p. 287). The literature pointed out that teachers will need to overcome the challenges that it presents and embrace it in order for students to be as successful as they can be. Several examples are shown to help teachers integrate technology into their classrooms.

Benefits

Teachers need to be presented with logical benefits of technology if they are going to be convinced to integrate technology into their classrooms. Studies have been done to show several benefits to integrating technology into the mathematics classroom. It has been stated, "the uses of innovative web-based technology, especially in the assessment, enhance students' activities in mathematics learning when the web-based assessment engine is well designed and appropriately and timely used" (Nguyen, Hsieh & Allen, 2006, p. 252). Using web-based technology will allow students the opportunity for additional practice, and the ability to self-test while saving the teacher time and giving more feedback from the students. While practicing using the web-based tools the students will be helping themselves be successful in the mathematics classroom. Web-based instruction and practice provide teachers with alternative methods of presenting material, while allowing students the ability to control their own learning. "At the same

time, students can engage in meaningful learning rather than memorization to develop their own interest toward mathematics learning" (Nguyen et al., 2006, p. 252). Web-based tools for assessment and practice are one method of integrating technology into the classroom that has benefits associated.

According to Funkhouser (2003), "a review of literature on methods for instruction in mathematics education suggests two useful approaches: constructivism and computer augmented instruction" (Funkhouser, 2003, p. 163). Constructivism is based around the concept of student centered learning. By using computer augmented instruction teachers can create a student centered classroom. In a study on teachers responses to using technology in the classroom teachers shared the thought, "integrating the computer has turned a teacher-centered classroom into a student-centered one, with the teacher acting more as a coach than information dispenser, and with more collaboration and work in small groups going on" (Hadley & Sheingold, 1993, p. 277).

In other studies, additional benefits described by teachers were variety in the classroom, student independence, enhanced classroom experience, enhanced student motivation and self-esteem, and changes in student roles. "Teachers reported pupils taking on specialized technical roles in the classroom and providing support for peers and teachers, leading to a more collaborative style in which teachers shifted towards a coaching and advisory role" (Ruthven, Hennessy, & Brindley, 2004, p. 260). This type of learning environment allowed students the opportunity to have meaningful mathematical discussions with their peers and teachers. (Chua, Wu, 2005).

Funkhouser (2003) attempted to create a constructivist learning environment using computer augmented geometry instruction. He said, "this computer-augmented

environment allowed the students to explore, discover, conjecture, and confirm mathematics in ways consistent with the theory of cognitive psychology" (Funkhouser, 2003, p. 164). He was hoping to "enhance student learning of geometry concepts and promote more positive student attitudes toward mathematics" (Funkhouser, 2003, p. 165). He was only able to show that students who received this computer augmented instruction demonstrated significantly higher levels of performance. As for student attitudes toward mathematics, his study showed students in the traditional classroom setting had more positive attitudes. Therefore no relationship between computer use in the classroom and positive attitudes toward math could be determined from this study.

Following up on Funkhousers' (2003) ideas, D'Souza and Wood (2003) mentioned, "Exploration and independent inquiry, shared knowledge and collaborative learning, efficiency and organization, analyzing and studying information" (D'Souza & Wood, 2003, p. 287) as some advantages of technology. Inquiry is a concept that comes to mind when discussing constructivist learning environments. When learning through inquiry students ask questions to construct knowledge. Chua and Wu (2005) pointed out to create technology based mathematics lessons there are four key components, one of which being explore. While exploring students would use their inquiry skills to construct the own mathematical understandings (Chua & Wu, 2005). The other three components, conjecture, verify, and generalize all require the students to build upon the knowledge they acquired during the explore stage. This fits right into the constructivist theory previously discussed.

Goos, Galbraith, Renshaw, and Geiger (2003) showed how inquiry can be used with technology. Their research showed "how technology can facilitate collaborative

inquiry, during both small group interactions and whole class discussions where students use the computer or calculator and screen projection to share and test their mathematical understanding" (Goos, et al., 2003, p. 73). Also discussed were the four roles technology can play when used in the mathematics classroom, *master*, *servant*, *partner*, and *extension of self*.

Technology becomes *master* when the teachers or students knowledge of the technology is limited to a specific set of operations. Students and teachers who saw computers as having this role, saw technology in the classroom negatively. One comment by a student was "sometimes I don't know how to use the technology which means I can't get anything done" (Goos et al., 2003, p. 78). When the technology is simply used for quick calculations, this is an example of it being a *servant*. In general, the students surveyed seemed to agree that technology as a *servant* is beneficial in the classroom because it saves time on calculations and graphs, reduces errors, and helped check answers.

Technology as a *partner* is used "to increase the power students exercise over their learning" (Goos et al., 2003, p. 79). When teachers used technology as a *partner* they were able to demonstrate material to students in multiple ways. This helped "teachers address the issue of different learning styles" (D'Souza & Wood, 2003, p. 287). Different types of software were used to enhance the learning environments. Using technology as a *partner* also allowed students to present their work in multiple ways, incorporating the theory of multiple intelligences. One student responded, "by displaying things in different ways [technology] can help you to understand things more easily" (Goos et al., 2003, p. 79).

During the course of this study classrooms were observed and in one classroom students were encouraged to display their work for the rest of the class. This "public display of student work facilitated whole class discussion with the student-presenters themselves leading the dialogue and trying out different command lines in response to suggestions from peers in the audience" (Goos et al., 2003, p. 79). Technology was also noted for prompting peer discussions while the students worked in small groups.

Continuing with the roles of technology, the role of *extension of self* was examined. To use technology as a *extension of self* technology would need to be incorporated into one's own mathematical repertoire. For this teachers developed courseware that allowed students to explore concepts on their own. Some students began to see technology as a part of their own brain and used it whenever required, without thought. When teachers and students think of technology as an *extension of self*, technology is very highly integrated into these classrooms. It could be said from this study that the end goal of integrating technology into the classroom is for technology to become an *extension of self.*

Teachers also felt technology in the classroom increased "the productivity of pupils and the quality of work they produced" (Ruthven et al., 2004, p. 265). During one study technology was used to check and correct student work which contributed to a higher quality of work. By incorporating technology into the classroom teachers were enhancing the appeal for the students in the class, "not only in terms of novelty and variety, and of fun and excitement, but by reducing the laboriousness of work" (Ruthven et al., 2004, p. 267). It was also mentioned that technology can allow students to make connections to the world outside of the classroom. One key contribution of integrating

technology is students would be free from the mundane tasks such as calculating and graphing to focus on more substantial issues in the math classroom.

Additional benefits of technology were identified in a study by Papanastasiou and Ferdig (2006) to understand the relationship between technology and mathematical literacy. They showed that while some computer activities improved mathematical literacy, others hampered it. "The overall results of this study have made it clear that the 'passive' or mechanical use of the computer alone does not highly correlate with increased academic growth, specifically in mathematical literacy acquisition, and teachers need to be aware of this" (Papanastasiou & Ferdig, 2006, p. 369). Therefore, indicating technology should be integrated in a meaningful manner.

In an article by Alfinio Flores (2002) benefits of teaching and learning mathematics with technology were highlighted. He stated calculators can be used for conceptual development and not just calculations. He also pointed out how NCTM has expressed the importance of technology as a tool for use in the classroom. "The Technology Principle (National Council of Teachers of Mathematics, 2000) describes how technology can enhance mathematics learning, how it can support effective mathematics teaching, and how it can influence what mathematics is taught" (Flores, 2002, p. 308). The NCTM strongly supports the use of calculators in all aspects of the mathematics classroom (Dion, Harvey, & Jackson, 2001). Also mentioned were benefits of using specific software. "Software that promotes understanding is helpful, especially interactive software that students can use to explore and discover mathematics on their own or solve problems in a different way" (Flores, 2002, p. 308). The internet is another tool that can be used to allow students to extend their learning beyond the classroom.

Orit Hazzan (2003) listed some of positive arguments for integrating technology into mathematics classrooms. His study allowed students to work at their own pace without being dependent on the other students in the class. "Learners can conjecture, check their conjectures, improve their solution without being embarrassed by a mistake, work in teams conducting 'mathematical conversation,' and explore mathematical ideas as far as their curiosity guides them" (Hazzan, 2003, p. 216). He reiterated the idea that using technology lends itself very nicely to different learning styles, while changing the teacher's role in the classroom. When integrating technology the role of the teacher was changed and they became a guide. This created a more student-centered classroom environment.

Computers were also noted to save time especially in the areas of graphing, calculating and solving equations. Hazzan (2003) reiterated the idea of using the computer as a partner which encourages the students to solve problems with more than one solution or in creative ways. "Computers provide a world of mathematical experience, including simulations for raising conjectures and precise tools for investigating them, personal experiences for all pupils and an ability to see, feel, move, construct, and manipulate 'things'" (Hazzan, 2003, p. 220). He also mentioned how useful the computers ability for ongoing feedback both positive and negative is for the students.

Challenges

As with most things, technology in the classroom presents challenges along with the benefits previously shown. The next studies shown looked into some of these challenges to make teachers aware of them. M.R. Khadivi (2006) conducted a study on

computers and mathematical philosophies in educational trends. In this study Mathematica, which is a common mathematical software package, was used and found to provide wrong answers or error messages. Therefore, when incorporating technology into the classroom, it is important to keep in mind the limitations of the technology. Students should be instructed to not rely on answers provided from the technology if it does not make sense with their previous knowledge (Khadivi, 2006).

An important challenge associated with successful integration of technology in the mathematics classroom is how to invest limited time and resources. Additional time is required to plan technology based lessons adding stress to the teachers already tight schedules. Hazzan (2003) pointed out "it takes more time to prepare a lesson in a computer lab (since it requires creativity and finding appropriate tasks) than in the traditional setting" (Hazzan, 2003, p. 217). Showing a need for additional support to the teachers if they are going to properly implement technology in their classrooms. (Flores, 2002) Coffland and Strickland (2004) found as the number of sections tanght increased the amount of technology integrated decreased. Which indicated those teachers teaching more sections had less time to create technology rich lessons (Coffland & Strickland, 2004).

It should be pointed out that integrating technology into mathematics instruction will be quite a change for teachers and can have profound effects. Helen Forgasz (2006) took a look at factors that inhibit technology usage for mathematics teaching. "Computers challenge teachers' technical abilities, place new demands on their time and energy, and require them to adopt significant changes in their teaching strategies" (Forgasz, 2006, p. 79). One way to try to overcome these challenges is through

professional development for mathematics educators. Access to useful information in the areas of technology integration and new teaching strategies through professional development is needed.

Teachers need to be knowledgeable about the technology they are expected to use, whether it be knowledge of computers themselves or the software used on them. "In the U.S., secondary mathematics teachers indicated that they did not use computers because they lacked experience and access to educational software, lacked knowledge about appropriate ways to use computers to enhance mathematics instruction" (Forgasz, 2006, p. 80). In a study conducted by Coffland and Strickland (2004) a direct relationship was established between teacher attitude and their awareness of technology as well as between teacher technology training and teacher computer use. (Coffland & Strickland, 2004)

Another factor which inhibits technology use is the access to or availability of the technology resources. If teachers are expected to use technology in the classroom, it needs to be available to them and the students. Teachers need to have technology available for use in their lessons whenever they wish to use it. Students need to be able to access the technology without time restrictions, especially if using web-based tools. Without a reliable connection to the internet students would not be able to successfully use web-based tools for practice and assessment (Nguyen et al., 2006). To provide students with this technology schools must invest a significant amount of money which leads to another challenge, the cost of technology. Some forms of technology are too expensive, therefore, limiting their availability within schools, especially the poorer school districts.

Going back to the study by Orit Hazzan (2003), some negative arguments for integrating technology were shown. Some students need to have the human interaction they would not receive from the computer. Another drawback is student absences, because if they miss the class it may be difficult for them to catch up with the rest of the class. Students may not gain the desired understandings due to progressing too soon or the allotted time not being enough. Also with the teacher trying to navigate to all of the students, the weaker students who require more attention could suffer. These issues would been to be addressed for successful integration of technology in the classroom.

A major challenge when working with technology was technical problems. Computers do not always work as expected and could take time away from learning mathematics, to diagnose the problem. Hazzan (2003) also mentioned that students could have different abilities when it comes to using the technology. This could be a challenge if they lack prior experience with a particular technology (Hazzan).

Extent of use

These studies gave some challenges to keep in mind when considering integrating technology into the mathematics classroom. Technology in the classroom is not a new concept, but rather has been around for while. The next few studies looked at what extent technology is already being utilized in the classroom. When integrating technology into the classroom it can be used as a tool for communication, research, productivity, or problem solving according to a study done by Barron, Kempker, Harmes and Kalaydjian (2003). Their focus was on technology integration as it relates to the national technology standards. They pointed out "that with the acceleration in the pace of technological innovation and saturation in society, skills such as problem solving, synthesizing

information, and communication via technology are essential for today's students" (Barron et al., 2003, p. 489).

Other studies related to stages of technology integration were also examined. One of these studies used the Levels of Technology Implementation (LoTi) scale to determine the extent technology was integrated into classrooms in the Los Angeles Unified School District (LAUSD). At the time of this study, 1999, only 28% of teachers felt they were integrating techuology into their classroom as a tool for problem solving. Another study looked at the use of computers and internet in the classroom and determined "half of the teachers who had computers or the Internet available in their schools used them for classroom instruction to some extent" (Barron et al., 2003, p. 495).

The purpose of this study was to determine the extent teachers currently use technology in the classroom for communication, research and problem-solving, which are part of the National Educational Technology Standards (NETS) for students. They determined 54% of middle school teachers use technology as a tool for communication, 48% of high school teachers, and 59% of elementary teachers. To tie this use of technology in with mathematics, Papanastasiou and Ferdig (2006) showed that using the computer for communication was associated with having a higher level of mathematics literacy, which is yet another benefit (Papanastasiou & Ferdig, 2006).

When using technology as a problem solving tool, only 23% of middle school teachers, 20% of high school teachers, and 29% of elementary teachers reported having used it. Computer programming skills are related to problem solving skills and can be linked to mathematics skills. These computer programming skills require higher level thinking, also required for mathematics, so it was expected computer programming

students would show a higher level of mathematics literacy. However, this was not the case for the Papanastasiou and Ferdig (2006) study. Students who had more frequency with computer programming showed lower levels of mathematics literacy (Papanastasiou & Ferdig, 2006).

Lastly, 34% of middle school teachers, 40% of high school teachers and 32% of elementary school teachers reported using technology for research. While research is not typically used in mathematics, the Papanastasiou and Ferdig (2006) study found as students became more at ease using the computer for writing papers and used word processing programs more frequently their mathematics literacy scores increased (Papanastasiou & Ferdig, 2006). This showed how integrating technology across the curriculum can benefit mathematics.

These findings were taken one step further and examined based on subject area. One interesting finding was that only 17% of mathematics teachers used technology for problem solving as opposed to 28% for science teachers, 23% for social studies, and 10% for English. As for using technology for research, 24% of mathematics teachers reported using it, 51% of science teachers, 44% of social studies teachers, and 30% of English teachers. No differences were noted across the subject areas for using technology as a communication or productivity tool (Barron et al., 2003). Based on this study it is determined that while technology is being integrated into classrooms as tools for communication, research, and problem solving it not uniform across all grade levels and subject areas.

Middleton and Murray (1999) conducted a study of fourth and fifth grade teachers technology integration using the LoTi scale. The purpose of this study was to determine

if there was a relationship between a teachers technology usage and the students level of academic achievement. "There was a higher level of technology usage reported by fifth grade teachers and the findings indicated that the academic achievement of fifth grade students was significantly higher than those of fourth grade students" (Middleton & Murray, 1999, p. 144). This study confirms technology should be included in all aspects of a students education in order for successful implementation. They also pointed out teachers need to see the importance of using technology as a tool in the classroom in order for them to embrace and use it in their every day teaching.

A specific technology that has been in classrooms for years is the calculator. In recent years the calculator technology used in classrooms has been changing from scientific to graphing. It was shown earlier how calculator use was beneficial but to what extent are they used. In a survey of calculator use in high schools showed that calculators are being used throughout the schools. The data from this study shows most classes allow students to use calculators for testing purposes although it is not determined how many of these questions the calculator should need to be used on. It is speculated that as calculators are more integrated into the classroom the more calculator active questions on assessments should increase (Dion & et al., 2001).

Student Perceptions

While technology in the classroom has been shown to have benefits and challenges, student perceptions related to technology play a vital role in successful implementation. A study was conducted in England by Presland and Wishart (2004) to determine what factors students considered motivating when using an integrated learning system. This study was small as only one school was studied and within this school only

55 students were surveyed. Of all the students surveyed this system was determined motivate students. "This motivation was mostly incurred through: pupils' awareuess that they are making progress, pupils' ability to get high scores for their work, pupils' perceptions of associated benefits upon their English, Spelling, Reading, and Mathematics work" (Presland & Wishart, 2004, p. 667). They also found a link between this software and increased self-esteem.

Allowing students the ability to solve problems using different methods and strategies can create more student participation, more positive attitudes toward mathematics while reducing classroom anxiety. (Nguyen et al., 2006). Web-based assessment and practice is one method to provide this variety for students. To determine the impact web-based assessments and practice would make on the attitudes of students toward mathematics, another study was conducted. In this study students who used web-based practice and assessment were compared and contrasted with those students who used traditional methods for practice and assessment. "Several studies have shown that students who used computer-based learning practice find mathematics more enjoyable" (Nguyen et al., 2006, p. 254).

Students were interviewed during this study to come up with a consensus on students attitudes toward usiug technology to learn mathematics. These students felt the computer was useful in there daily activities. Five students "believed that computer math was much more interesting than paper-and-pencil math since computers made learning fun; and computer provided examples, scoring, and questions solutions to help them learn and review at the same time" (Nguyen et al., 2006, p. 271). The results of this study indicated that students who were taught using web-based assessments and practice

showed some improvement in their attitudes toward math while the other students' attitudes remained the same.

Students using the computer mentioned they enjoyed and preferred the computer activities. There was a perceived notion that there was a greater level readability of the problems on the web-based tools rather than printed handouts or textbooks. Through repeated practice offered by the web-based tools, students gained a greater sense of confidence. They were able to find and correct mistakes sooner to increase their understanding. This study "found that when students engaged in the web-based assessment and practice, they were willing to spend more time on tasks to gain understand and to strive for better achievement" (Nguyen et al., 2006, p. 275). Which are additional benefits to integrating technology into the classroom.

Some students showed resistance toward incorporating technology into mathematics classrooms. D'Souza and Wood (2003) performed a study to determine reasons for this resistance. They took a look at three different types of teaching styles, pen and paper, cooperative groups, and integrated technology (compnters) and evaluated the students perceptions and concerns about each of these techniques. The results of this study contradicted other studies that were done in the past. Most of the students surveyed preferred the pen and paper method mostly because it was easier, more reliable, less time consuming, and computers are too hard to operate. It appeared that students who had used pen and paper methods for their entire educational careers seemed to have pre-conceived notions of using spreadsheets in their mathematics classroom and they were resistant to using this technology. One student made a comment about having to learn mathematics as well as computers and he didn't like that (D'Souza & Wood, 2003). A

few of the students surveyed did express they preferred using computers because computers were fun or the students worked better with computers. The discrepancy between this study and the previous study could be related to computer usages issues. In the previous study no computer usage problems were reported, which could indicate mostly positive responses of the students. (Nguyen et al., 2006, p. 273)

Some of the challenges that students faced when using computers were "understanding their responsibilities as active learners, getting help with individual learning needs, and integrating their computer supported learning with their larger school experience" (D'Souza & Wood, 2003, p. 290). A concern of students when using technology in the classroom was its availability for assessment. If students are not allowed to use the technology for assessment purposes it can be expected they would be resistant to using technology in the classroom (D'Souza & Wood).

One implication as a result of this study is "over time and with adequate technological, pedagogical support and training, changing teaching and learning methodologies to include computer supported learning methods may receive less resistance from students as well as teachers" (D'Souza & Wood, 2003, p. 292). It is also pointed out that if students are to embrace technology in their mathematics classrooms their teachers should explain to them the purpose of using technology.

Teacher Perceptions

Flores (2002) stated, "Teachers are the catalysts for helping students use technology effectively to learn mathematics" (Flores, 2002, p. 308). Therefore it is important to look at their views of integrating technology into the classroom, because it has been indicated in several studies that teachers are slow in integrating technology into

their classroom routines regardless of availability. (Norton, McRobbie, & Cooper, 2000). This was shown in a study conducted at a technology rich private school where eight of the ten math teachers were surveyed on their use of computers in their classrooms. Those conducting this study concluded that technology integration was a low priority for the teachers despite the availability of it.

One teacher felt technology would be best used to reinforce the lessons after being taught using traditional instruction, and only if time permitted. She did not see a benefit to using it to replace her traditional instruction, making her class teacher-oriented. It is pointed out by Goos, et al. (2003) that the extent to which a teacher incorporates technology is based on their beliefs on mathematics and pedagogy (Goos, et al.). Following up on that thought, "it was apparent that (1) her beliefs about the nature of school mathematics were linked to her focus on teaching mathematics as a series of rules to be explained and (2) computers had a limited role in this process" (Norton et al., 2000, p. 96).

Another teacher in this study did not feel that computers could develop higher order thinking skills as effectively as traditional instruction methods. He felt computers would not be beneficial in explaining or illustrating any mathematical concepts to his students. Learner-centered approaches were rejected by this teacher because he claimed students preferred to have him teach them. Based on his beliefs he did not feel computers would be an aid in developing student understanding within his classroom.

There was one teacher who did not agree with the other two teachers interviewed for this study because she believed that computers could provide students with the ability to extend mathematics beyond the classroom. She felt that computers could be used as a

means of presenting information and concepts as well as a tool for calculations. This teachers' beliefs provided for a student-centered classroom where students were encouraged to construct their own understandings. She "believed that computers could help students conceptualize mathematics and empower them to explore practical applications of mathematics" (Norton et al., 2000, p. 101). Unfortunately she was just one out of ten teachers and chose not to rock the boat and attempt to convert others to her methods of teaching.

To conclude this study, it was determined that simply having access to the technology does not imply it will be used effectively. Many teachers believe their traditional instructional methods will provide students with greater levels of understanding, than technology based methods. Unless these beliefs are altered technology will not become a part of their classrooms (Norton et al., 2000). Contrary to this theory is a one found in a study by Forgasz (2006). This theory states "contemporary mathematics teachers appeared generally supportive and confident in wanting to use computers in their classrooms" (Forgasz, 2006, p. 90). More research needs to be looked at to determine which theory is more accurate.

D'Souza and Wood's (2003) study reinforced the theory of teacher's mathematical instruction beliefs influencing their integration of technology in their classroom. They state, "the teacher's concerns or attitudes about the use of computer technology in the classroom are fundamental and influential elements to the process of educational change" (D'Souza & Wood, 2003, p. 286). In order for students to use technology in an engaging manner, teachers must want and have the ability to use technology in their classroom.

These studies looked at in-service teachers perceptions and attitudes. Orit Hazzan (2003) took a look at the attitudes of pre-service teachers toward integrating technology into their future classrooms. He believed prospective teachers saw the knowledge acquired through technology rich lessons was more meaningful than that which was acquired through traditional lessons. Prospective teachers believed technology could aid in learning mathematics but they were slightly concerned with the change in the role of the teacher. The general consensus from the prospective teachers was that technology should definitely be integrated into classrooms while maintaining some of the aspects of a traditional classroom without technology. One teacher pointed out "the computer can supply information, but we may lose its potential if we do not educate our pupils to use that information" (Hazzan, 2003, p. 222).

Another study by Lawless, Smith, Kulikowich, and Owen (2001) also took a look at pre-service teachers' beliefs on technology in the classroom. They looked at what types of instructional mediums the pre-service teachers perceived to be the most beneficial for use in the classroom. In the area of mathematics they felt videos and textbooks should be used. However, pre-service teachers felt "teachers should consider how instruction could be enhanced when using both technological and traditional media" (Lawless et al., 2001, p. 267), which agrees with the theory obtained from Hazzan's (2003) study.

Examples and Lessons Learned

After studying benefits and challenges associated with integrating technology into the mathematics classroom, student and teacher perceptions were examined. Now some examples of integrated technology in the mathematics classroom are reviewed.

"Geometry presents unique challenges for teachers that technology, such as dynamic geometry environment software, may help overcome" (Coffland & Strickland, 2004, p. 349). Robert Hannatin (2004) examined instructional geometry programs to determine the effect on students' ability. Students in his study were exposed to a learning environment which used Geometer's Sketchpad. The students were encouraged to work in collaborative groups to construct their own understandings. For the purposes of his research the students were placed into two groupings, one group completed structured activities and one completed unstructured activities. All activities were the same except the structured group had more instructions as to how to do the activities and in what order.

The results of this study showed low ability students performed better in the unstructured environment which challenges previous theories which indicate low ability students require more structure. The structured environment was shown to provide students with medium to high abilities the opportunity perform at a higher level. The implication from this study was that teachers could create technology based activities which offer students a high level of guidance while still offering students control over their learning (Hannafin, 2004).

Algebra is another area of mathematics that lends itself very nicely to the integration of technology. Technology can be used in the classroom for calculations and problem solving which would allow students in algebra classes to forgo learning to do these tasks by hand and focus on concept development. Drijvers (2004) conducted a study on using a computer algebra system to help teach algebra. This articled pointed out students do not generally think of algebra as being practical for solving problems. He showed computer algebra helped students acquire a better understanding of algebraic

concepts and operations, in general, which helped them better solve problems. The basic algebra notions were extended to provide a deeper understanding (Drijvers, 2004).

The graphing calculator is a teaching tool for both teachers and students because it has opened the door to several new classroom learning activities. Edward Laughbaum (2003) gave two examples of uses for the graphing calculator in teaching algebra. In the first example students are shown how to solve equations on the calculator using different methods. This was useful for different learning styles because some students preferred one method while others another. It showed students there are many ways to solve a problem with none of them being the one correct way to do it. The second example was two separate explorations that the students conducted on their own, outside of class. By assigning these activities outside of class, time was saved in the formal teaching of factoring. And the students were more likely to remember how to factor because the activities required them to do something rather than memorize (Laughbaum, 2003).

In conclusion, integrating technology into the mathematics classroom is not an easy task. Although researchers have mentioned some challenges associated with integrating technology into the mathematics classroom they also mentioned several benefits that quite possibly outweigh those challenges. Other researchers showed some examples and lessons learned when they integrated technology into classrooms. It is important to keep in mind that not all teachers and students will feel the same way about technology. Some will like it and some will not but technology definitely appears to be heading into mathematics classrooms to stay. Remember there is "no single best way for teaching and learning mathematics in general or for teaching and learning mathematics with computers in particular" (Hazzan, 2003, p. 215).

Methodology

The purpose of this research is to determine if bringing technology into the mathematics classroom is beneficial for the students. In order to determine this, specific lessons, some using technology and others not, were developed and implemented into the classroom. Throughout the lessons the students were observed, quizzes and homework were given and evaluated, and students were informally surveyed to evaluate the use of technology.

Participants

For this research project, two eighth grade classes with similar ability levels were used. The first class has 19 students, 9 boys and 10 girls. In the other class there are 18 students, 9 boys and 9 girls. During the course of the lessons students were assigned partners to work with. These partners were determined randomly by the teacher, prior to the lesson.

Materials

Due to the nature of this research involving technology in the classroom, all of the materials required were technology related. The main piece of technology used were the computers in the computer lab. Two different websites, www.explorelearning.com and www.schoolisland.com, were used on the computers to assist the students with understanding the concepts of the lessons taught. In addition to the internet students used MS Excel to model simple interest.

Procedure

Three lessons were chosen based on the timing of this research. The first two lessons were part of the ratio and proportion unit. For each lesson, two actual lessons

were developed, one technology enriched and one with no technology. One class received the technology lesson and the other class received the non-technology lesson. For the next lesson the type of lesson taught to each class was reversed. The last lesson was part of a review unit to prepare the students for their math 8 state exam. For this lesson two different topics were reviewed, one topic was reviewed using technology nad the other without technology. The topic that was taught with technology was reversed for the second class.

Tools for Gathering Data

During each class, no matter the lesson format, student observations were made by two to three teachers within the classroom. Students were observed to determine whether or not they were on task, or engaged. Throughout the units students were given homework assignments and quizzes to determine their performance levels. At the end of each pair of lessons students were asked to fill out a ticket to leave which asked several questions. One question was related to the material covered that day, the other questions were related to their attitude during the lessons, whether they felt more engaged or more on task in the computer lab or in the classroom, and why. The students were also asked which lessons they preferred, the technology enriched lessons or those without technology. For the last lesson the students were also asked two questions related to the previous lessons to determine if any knowledge was retained and to provide more data for analysis. The observations, assignments, quizzes, and tickets to leave were compared between the two types of lessons. If integrating technology into the classroom is truly beneficial to students, the technology enriched lessons would show a higher level of

performance on the assignments and quizzes, more students on task and engaged, and more student preference.

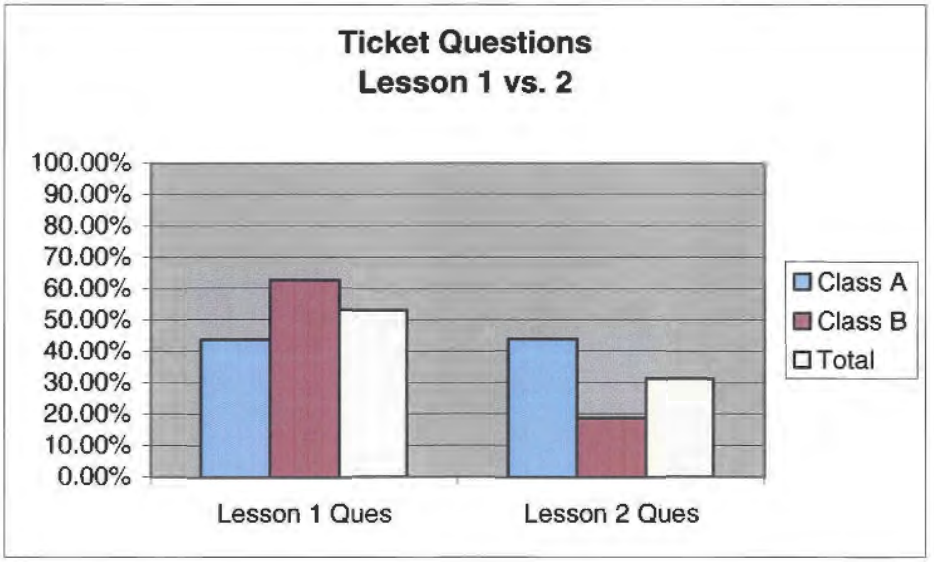
Results

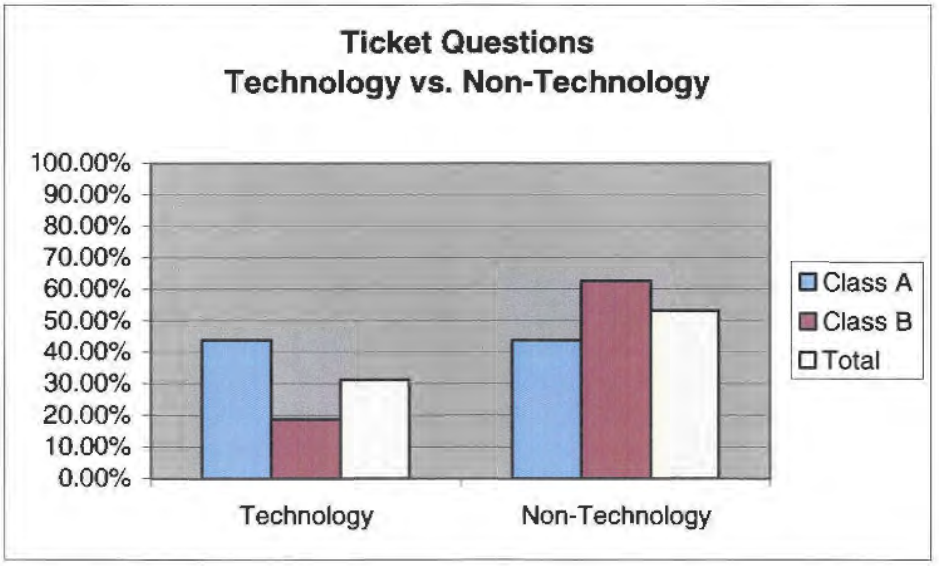
The results of this research, were completely unexpected, and did not show integrating technology into the classroom was beneficial to the students. Student performance did not seem to be better for the technology lessons. The first piece of data reviewed were student grades on a quiz after the first two lessons were taught. The expected results were that students would perform better on the questions related to the lesson they received using technology.

The grades were actually higher for the questions relating to the second lesson, regardless of method. Class A had a class average of 55.56% on the questions from the technology (first) lesson and 64.81% on the questions from the non-technology (second) lesson. Class B's average was 84.31% for questions from the technology (second) lesson and 77.94% for the non-technology (first) lesson. This indicates that the material covered in the second lesson was easier for the students. Another result to point out is that class B outperformed class A on both sections of the quiz. Thus indicating class B may perform at a higher level than class A, which is contrary to the original belief that both classes performed at the same level.

After the second set of lessons students were given a ticket to leave with a question on each of the first two lessons. Following with the results of the quiz, it was expected students would do better on the question related to the second lessou, and class B would do better than class A on both questions. Ironically this was not the case, overall, students performed better on the question related to lesson one (see figure 1). Also class A outperformed class B on the question for lesson two, which contradicts the findings from the quiz (see figure 1).

Figure 1. Ticket Questions Charts.





As part of the second set of lessons students had to complete two assignments, one using the computer and one without the computer. Based on data from the previous set of lessons, students were expected to do better on the assignment without using technology. However, this was not the case, class A's average was 84.71% on the technology assignment and 81.43% on the non-technology assignment. Class B had an average of 93.57% for the technology assignment and 75.29% on the non-technology assignment. This discrepancy could be a result of the students being familiar with the website used for the second set of lessons and not with what was used for the first set of lessons.

Another data source used for this research was teacher observations. Two to three teachers were observing the students to determine if they were on task and engaged during the different lessons. It was expected that students would be more engaged and on task during the technology lessons than the uon-technology lessons. While the students were excited to be in the computer lab, the students quickly became confused in both classes for the first set of lessons. Students did not appear to be more on task or engaged during the technology lessons. One main concern that came up while observing students during the first set of lessons was whether or not the students could take the information from the computer and relate it back to what they were expected to do without the aid of the computer.

During the second set of lessons, class A was on task while in the computer lab, but it took some time to get them engaged in the assignment. Whereas, when they were in the classroom, they were both on task and engaged. When class B was in the computer lab, the students were not as engaged in the assignment as they were in having

conversations with other students. Some students in class B worked through the assignment in the computer lab very quickly and became disruptive to the other students still working. Overall, the teachers agreed the students were more engaged and on task in the classroom, for these lessons.

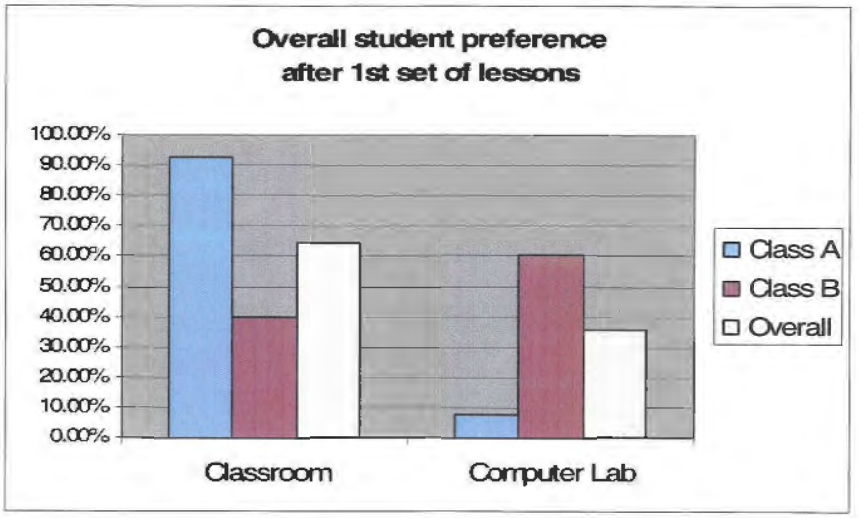
The last piece of data used to help determine if technology is effective in the mathematics classroom was tickets to leave. At the end of each set of lessons students were asked for their opinions on being in the computer lab vs. classroom. Students were asked in which setting they learned better, were more on task, and preferred to be taught. After the first set of lessons, class A responded with the vast majority preferring the classroom and class B slightly preferring the computer lab (see figure 2). Making the overall consensus, after the first set of lessons, that students preferred the classroom over the computer lab.

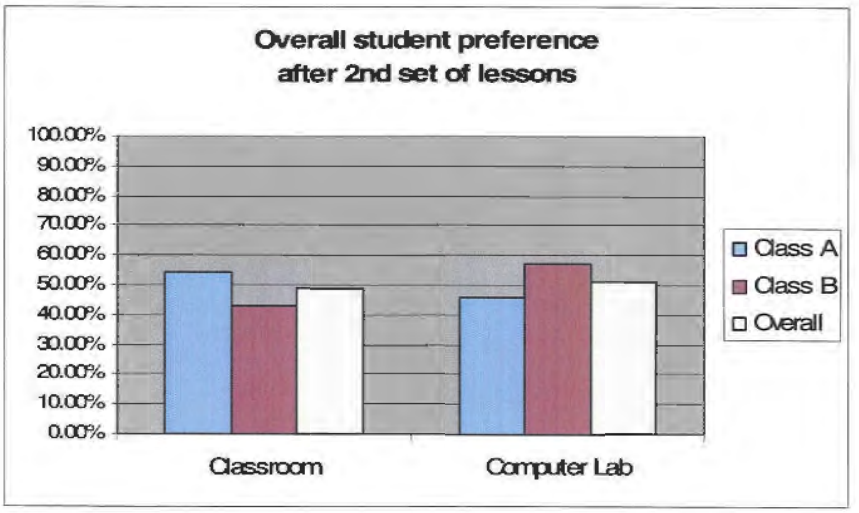
The responses after the second set of lessons were more uniform across both of the classes. Both classes were split 50-50 as to whether they preferred the classroom or computer lab (see figure 2). When combining the results from both surveys, students slightly preferred the classroom to the computer lab, which is not what was expected.

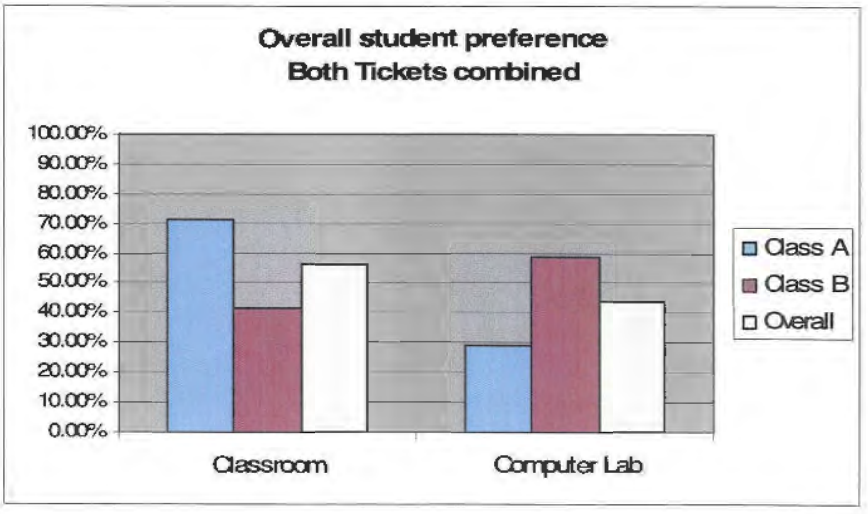
To determine why students would prefer either the classroom or the computer lab, the last question on the ticket to leave asked for comments. One comment made by a student who preferred the computer lab was "on the computer, if you don't know what something means, it will tell you." Another student comment that was made by a student who preferred the classroom was "I pay more attention in the classroom and I am not as distracted."

Therefore, the data for this research shows the opposite of what was expected. While student performance was higher on the assignments from the second set of lessons, the rest of the data does not support integrating technology into the mathematics classroom. Student performance was not consistently improved through the use of technology, they were not more engaged and on task while using technology, and non-technology lessons were preferred by the students.

Figure 2. Tickets to Leave Results.







Discussion & Conclusion

This study has determined integrating technology into the classroom may not be as beneficial to students as previous studies have shown. Based on this research alone, one could say integrating technology into the classroom should be done only minimally. The first question this research was trying to answer was if technology in the classroom would increase student performance. Previous research, especially that of Funkhouser (2003) showed that students would have significantly better performance on the technology based lessons. This research did not show that but rather showed inconclusive data on whether student performance would increase when integrating technology into the mathematics classroom. Grades on the assignments (quiz and ticket to leave) for the first set of lessons were higher for the non-technology questions. However, grades on the assignments from the second set of lessons were higher on the technology questions.

There could be several reasons for the scores to be higher on the technology assignments than the non-technology assignments for the second set of lessons. One possible reason could be the students were familiar with www.schoolisland.com which was used for the assignments. They have gone to this site and done other assignments in the past. The gizmos and Microsoft Excel, which were used for the first set of lessons, were completely new for them. During the first set of lessons students showed high levels of confusion regarding what it was they were supposed to be doing on the computers. Once they started to understand and become more comfortable the time for the activity was up. In the future it might be beneficial to expose students to the same

types of activities using technology throughout the year. That way as they become more familiar and comfortable using technology they will show higher performance levels.

Another reason the students did better on the technology assignment for the second set of lessons could be because the material was not new to them. The second set of lessons was reviewing previously learned material whereas the first set of lessons was introducing material to the students for the first time. This could indicate technology may work better as a means for review than for introduction. Next time it would be better to have all lessons introduce material to the students for the first time to rule out this cause for the discrepancy in grades. Possibly a study could even be done to determine if integrating technology into the classroom is more effective for review or new material.

The next question addressed by this research was whether or not students were more on task and engaged during the technology based lessons. Two to three teachers made observations of each lesson and had input on this and all were agreed that overall, the students were more on task and engaged while in the classroom. There were times when in the computer lab the students all seemed to be engaged in the activity but it was too easy for them to chat with their friends. It was also very difficult for the teachers to manage the class while in the computer lab. The teachers could not always see everyone's screen to make sure they were on task and it was also difficult to get the class's attention to clarify some part of the assignment they were working on. Since there were definite times, although short, when the students were more on task and engaged in the computer lab, it is believed this could be a more regular occurrence if certain things were done to improve the experience.

Students were asked their opinion as to whether they were more on task in the classroom or the computer lab. While class B felt they were more on task in the computer lab for both lessons, the overall consensus shows students were slightly more on task in the classroom than in the computer lab. More students felt they were on task in the computer lab for the second set of lessons which agreed with the teachers findings for those lessons as well. To gain insight into why students chose the classroom or the computer lab, they were asked to explain their choices. One student commented, "I pay more attention in the classroom and I am not as distracted." Another student wrote, "I can stay on task and I learn more things in the computer lab." These comments show the importance of integrating technology in such a way that the students who prefer the classroom get some classroom instruction along with computer lab instruction and vice versa.

To do more lessons like this in the future, steps need to be taken to manage the class better in the computer lab. When discussing the lab setup and how it may have caused students to not be on task, it was thought a better computer lab setup may help eliminate some of the problems. As it turns out there is a better setup computer lab which would allow someone in the back of the room to see each students screen. In doing any additional work in the computer lab it would be highly beneficial to use this other computer lab.

Another solution could be taking the students to the lab on a more regular basis and creating a seating chart. Having a seating chart would help eliminate some of the side conversations that sprang up and students copying off of each other. The teachers involved felt that if the other computer lab had been used, students had more familiarity

with the technology being used for the lessons, and if they were exposed to technology more often, the students could be more engaged and on task in the computer lab than in the classroom. If more activities were done in the computer it would be interesting to see if students started to feel more on task in the computer lab than in the classroom.

The last question addressed by this research was which method do the students prefer, the classroom or the computer lab. This data was the easiest to gather because students are usually eager to tell you their opinion. Based on previous studies, it was expected that students would prefer the computer lab. After each set of lessons students were asked for their preferences and the overall result was 57% prefer to be taught in the classroom and 43% prefer to be taught in the computer lab. In looking at the classes individually, class B actually slightly preferred to be taught in the computer lab and class A preferred the classroom. Using the data from the students, it appears computer lab instruction should be done less than classroom instruction. In doing more research on this topic, it would be a good idea to do more than the two sets of lessons and see if the students start to prefer the computer lab over the classroom or if it continues to stay close to 50/50.

Previous research by Nguyen, Hsieh, and Allen (2006) showed that students had a more positive attitude toward technology in the mathematics classroom when web-based practice and assessment were used. This study also found that to be true. The assignments from the second set of lessons were more of the type practice and assessment then the assignments from the first set of lessons. There were several multiple choice questions the students needed to answer, and if they got a question wrong the computer would give them some advice on why it was wrong and how to get it right. When

comparing the students responses from the tickets to leave for both sets of lessons we see a definite increase in students preference of the computer lab for the second set of lessons. This indicates that using this method whenever feasible could be beneficial to the students overall performance.

In conclusion, based on the results from this study, integrating technology into the classroom does not appear to be as beneficial to the students as the previous research had indicated. Students did not perform better on the assignments for the technology based lessons. They were not more engaged and on task in the computer lab, but rather the classroom. Lastly, the students slightly preferred the classroom over the computer lab. However, more research should be conducted on this topic prior to making any final conclusions because this study had several shortcomings.

The results from this study followed with the findings of D' Souza and Wood (2003). They indicated for technology to be effective it would need to be properly implemented. Due to the timing of this research the topics chosen for the lessons were not necessarily the best for integrating technology. Geometry tends to lend itself very nicely to integrating technology but unfortunately could not be used. When doing further research in this area choosing better topics could completely change the results. Another problem that was discovered halfway through this study was the differing ability levels of the two classes chosen. Originally it was thought both classes had the same ability level, but in the end class B performed at a slightly higher level than class A. This could have skewed the results. Had more time been available, different classes would have been chosen and used.

Without giving it much thought, a different teacher taught the technology lessons for the first set of lessons. Some of the students commented they preferred the classroom instruction because they preferred that teacher. Had the same teacher taught both lessons would students have preferred the computer lab over the classroom? Thus giving different results.

More shortcomings were related to the actual technology being uses. Students were not familiar with the technology for the first set of lessons. One thought was that prior to teaching that lesson give the students a demonstration so they might not be as confused when trying to do the assignment. To try and cut down on the confusion, step by step handouts were given but they were not as successful as hoped. There were also some problems with the computers during the first set of lessons which did not help the confusion. The second set of lessons went much smoother and it was thought this was because the students were more familiar with both the material and the website being used. Next time it would be beneficial to give the students some demonstration on the new technology being used prior to going to the computer lab, since they seem to be more on task and engaged in the classroom rather than the computer lab.

Overall this study was a good one to get started on seeing how integrating technology into the mathematics classroom can benefit students. Given more time it would be possible to go more in depth with the possibility of doing this over the course of an entire year with more than two classes. It would even be possible to take it in a completely different direction and look at how incorporating cooperative learning can benefit students using some of the same research methods used in this study.

While this study does not show integrating technology into the mathematics classroom to be beneficial to the students, it is a limited study and if done differently could have completely different results. Therefore, before choosing to either integrating technology into the classroom or not, one should definitely do some further research on the topic.

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Appendix A

Cover Letter/Consent Form to Parents

Erin Green
St. John Fisher College
3600 East Ave.
Rochester, NY 14618

January 16, 2007

Dear Parents:

My name is Erin Green and I am currently a Graduate student at St. John Fisher College. Mrs. Rich has agreed to assist me with my Master's thesis project. I will be using your son/daughter's classroom for this research. The purpose of this study is to determine the effectiveness of technology in the math classroom and the results will be presented to my graduate class only.

To do this I, with the help of Mrs. Rich, will be developing four days worth of lessons, on two of these days the lessons will incorporate technology (i.e. graphing calculator, computer software) to better assist the students with the material being covered. On the other two days there will be no technology used.

During the course of these 4 days students will be asked to complete an anonymous ticket to leave which will indicate their preference of technology or no technology in the lessons. The students will also be asked to complete assignments/quizzes which will be graded toward their normal homework, quiz and class work grades. These grades will also be used to determine a class average based on technology or non-technology lesson. Any student work retained for the study will be kept anonymous.

I ask that you please return the attached consent form with your child by February 5. If you have any questions or concerns please feel free to contact me at 334-4907 or pugita@rochester.rr.com.

Thank you.

Erin Green

St. John Fisher College
INFORMED CONSENT FORM
(for use with minors)

Title of study: Bringing Technology into the Mathematics Classroom: The Who, What, Why and How

Name of researcher: Erin Green

Faculty Supervisor: Dr. Diane Barrett **Phone for further information**: 585 334-4907

Purpose of study: This study is for my master's thesis project and will incorporate using technology in the classroom to determine how effective technology is in learning mathematics.

Approval of study: This study has been reviewed and approved by the St. John Fisher College Institutional Review Board (IRB).

Place of study: Mrs. Rich's Math Class, Spry Middle School

Length of participation: 4 math classes

Risks and benefits: Students will receive 2 lessons using technology and 2 lessons that do not use technology. Both the technology and non-technology lessons will present the same material for the students. There is the potential that students will learn better from the technology lesson, thus improving performance. Students will be asked to complete an anonymous ticket to leave indicating their preference of technology based lessons or non-technology based lessons.

Method for protecting confidentiality/privacy: Any student work retained for the project will be kept anonymous, all other student work will be returned the students. No students will be directly identified within the project.

Your rights: As the parent/guardian of a research participant, you have the right to:

1. Have the purpose of the study, and the expected risks and benefits fully explained to you before you choose to allow your minor child to participate.
2. Withdraw from participation at any time without penalty.
3. Refuse to answer a particular question without penalty.
4. Be informed of appropriate alternative procedures or courses of treatment, if any, that might be advantageous to you or your minor child.
5. Be informed of the results of the study.

I , the parent or guardian of _____, a minor _____ years of age, consent to his/her participation in the above-named study. I have received a copy of this form.

_____ _____ _____
Print name (Parent/Guardian) Signature Date

_____ _____ _____
Print name (Investigator) Signature Date

If you have any further questions regarding this study, please contact the researcher listed above. If you or your child experiences emotional or physical discomfort due to participation in this study, contact the Office of Academic Affairs at 385-8034 or the Wellness Center at 385-8280 for appropriate referrals.

Appendix B

Sample Lesson Plans

Lesson Title: % of change – Technology based lesson

Monday 2/5

Time	Activity
15 m	Go over HW (rb. p. 114-115: 1-4, 6, p. 262-281)
15 m	Demo (walk through question 1 on gizmo worksheet for increase and decrease) Ask questions like what would it mean to have a 100% increase or Decrease. Follow similar format to non-tech lesson.
30 m	% of change Gizmo (worksheet)/partner work (worksheet)
≈ 20 m	start hw (worksheet)

Reflections:

Lesson Title: % of change – Non-Technology based lesson

Monday 2/5

Time	Activity
10 m	Warm-up (Xavier's Shirt Prob.) – ans. $25
15 m	Go over HW (rb. p. 114-115: 1-4, 6, p. 262-281)
15-20 m	Demo/Lecture - start with 10 pens on overhead, remove some pens, ask class to express this decrease as % - what would it mean to have 100% decrease? - Start with 10 pens again, now add pens, ask class to express as a % - What would it mean to have a 100% increase? - What if we started with only 5 pens? - Review % of change formula and work through examples
20 m	Partners Work (passport bk. p. 388-389: #1, 3, 5, 7, 9, 31, 33) & go over
≈ 15-20 m	start hw (worksheet)

Reflections:

Lesson Title: Large & Small %'s, Simple Interest – Non-Technology based lesson

Wednesday 2/7

Time	Activity
10 m	Warm-up (School Dance Problem)
10 m	Go over HW (wkst.: "Did you Hear about…")
15 m	Glencoe p. 344: mini-lab # 1-7 "Exploring large & small %'s"
20 m	Lecture Burst Express each percent as a decimal 137 % = _____ .7% = _____ Application of %: Simple Interest a) You put $750 in a savings account 5 years ago. With no other activity on this acct, how much interest will you have earned in that time? Use I = prt b) $125 deposited in a certificate of deposit (CD) for 18 months at 5.18% interest annually. What is the new account balance?
≈ 25 m	partner work (Glencoe p. 355-356: 9-23) & Go over ans.

HW: wkst (prop & % probs), review bk. p282-300

Reflections:

Lesson Title: Large & Small %'s, Simple Interest – Technology based lesson

Wednesday 2/7

Time	Activity
10 m	Go over HW (wkst.: "Did you Hear about…")
10 m	Demo (walk through question 1 on gizmo worksheet) Be sure to discuss %'s less than 1 which can not be done on the gizmo.
10 m	Work through the other questions on the worksheet.
30 m	Express each percent as a decimal 137 % = _____ .7% = _____ Simple Interest Excel Application: b) You put $750 in a savings account 5 years ago. With no other activity on this acct, how much interest will you have earned in that time? Use I = prt b) $125 deposited in a certificate of deposit (CD) for 18 months at 5.18% interest annually. What is the new account balance?
≈ 20 m	partner work (finish the worksheet)

HW: wkst (prop & % probs), review bk. p282-300

Reflections:

Appendix C

Sample Handouts

Percent of Increase

Stores charge more for merchandise than they pay for it. This is how a store makes a profit. The difference between the selling price of an item and what the store paid for the item is called the markup on that item. In this activity, you will see how to calculate the percent of markup.

1. At the top of the Gizmo[tm], under Markup, model an item that cost the store $25 and that the store is selling for $40. To do this, drag the rightmost handle on the markup ruler to $40 and the leftmost handle to $25.
    1. What is the amount of the markup on this item?

    2. Make an equation that relates the selling price, the original cost, and the markup. Write the equation in general, using words. Theu substitute the values from this problem into your equation.

    3. You should have found that the markup on this item is $15. Now rewrite your equation using a markup of $20 instead of $15. What is the new selling price of the item?

    4. Change your model in the Gizmo to reflect that item now has a markup of $20. Which of the three colored bars in the Gizmo chauge when you do this? Which bar stays the same? Explain why.

2. Suppose that a store is selling a sweatshirt for $24 that cost them $16. Model this in the Gizmo under Markup.
    1. What is the amount of the markup on the sweatshirt? What is the percent of the markup? To find the percent of markup, use this proportion:

$$\% \text{ of change} = \frac{\text{new} - \text{original}}{\text{original}} * 100$$

Substitute the numbers you know in the correct locations and put a variable in place of the unknown number. Then find the cross prodncts and solve for the variable.

2. In the Gizmo, the percent of markup is written below the markup ruler. Does your answer agree with this answer? Is the percent of markup a percent of the original cost or of the selling price?

3. Under Markup, look at the percents below the colored bars. Which value in the problem lines up with 100%: the original cost, the markup, or the selling price?

4. You should have found that the original cost lines up with 100%, and the percent of markup is 50%. What percent does the rightmost handle on the graph point to? How does this relate to 100% and 50%?

3. Suppose the store has another shirt that also sells for $24, but the original cost for this shirt is only $8.
    1. Use proportion above to find the percent of markup for this shirt. What does it mean when the percent of markup is greater than 100%?

    2. Under Markup, with the rightmost handle set to $24, slowly drag the leftmost handle from $16 to $8. How do the percents shown below the colored bars change as you drag the leftmost handle? Where does the 100% go? What happens to percents greater than 100% as you drag?

Percent of Decrease

Stores often have sales in which they reduce their prices. The difference between the original price and the sale price is called the discount. In this activity, you will explore the percent of discount.

1. Under Discount, model an item that was originally priced at $28 and is now on sale for a sale price of $21. To do this, drag the rightmost handle on the discount ruler to $28 and the leftmost handle to $21.
    1. What is the amount of the discount on this item?

    2. Make an equation that relates the sale price, the original price, and the discount. Write the equation in general, using words. Then substitute the values from this problem into your equation.

    3. You should have found that the discount is $7. If the store increases the discount from $7 to $11, what is the new selling price of the item?

    4. Change your model in the Gizmo to reflect that item now has a discount of $11. Which of the three colored bars in the Gizmo change when you do this? Which bar stays the same? Explain why.

2. Suppose that a store sells a shirt with an original price of $50. The shirt now goes on sale for a sale price of $40. Model this in the Gizmo.
    1. What is the amount of the discount on the shirt? What is the percent of the discount? To find the percent of discount, use this proportion:

$$\%\text{ of change} = \frac{\text{new} - \text{original}}{\text{original}} * 100$$

Substitute the numbers into the proportion and put a variable in place of the unknown number. Then find the cross products and solve for the variable.

2. Under Discount, look at the percents below the colored bars. Notice that there is no percent greater than 100% on the discount ruler. Why is it impossible for the percent of discount to be greater than 100%?

3. Find the amount of the discount and the percent of the discount for each item below. Do the work on your own. Then use the Gizmo to check your answer.
    1. Original price = $30, sale price = $27
    2. Original price = $30, sale price = $20
    3. Original price = $48, sale price = $44
    4. Original price = $5, sale price = $1

Partner work

1.A music store buys compact discs for $12 each and sells them for $15 each. What is the percent of markup on these compact discs?

A. 3%
B. 20%
C. 25%
D. 80%

2.If a furniture store buys a coffee table from a manufacturer for $120 and sells it at a 100% markup, what is the selling price of the coffee table?

A. $60
B. $120
C. $240
D. $360

3.If a pair of shoes has an original price of $80 and they are on sale for $48, what is the percent of discount?

A. 32%
B. 40%
C. 60%
D. 66.7%

4.Suppose that a car normally sells for $16,500 and is now on sale for $14,000. What is the percent of discount? If necessary, round your answer to the nearest tenth.

A. 15.2%
B. 17.9%
C. 25%
D. 2500%

Exploring Large & Small %'s Handout

Using Grid Models

By drawing grid models, you can use the shaded regions to compare numbers. A greater shaded region means a greater number. This Gizmo[tm] allows you to model and compare two numbers with values between 0 and 2.

1. Use the left drop-down menu above the left grid to choose percent. Then use the other drop-down menu above the left grid to choose 100 squares = 1 unit. This setting divides each large square into 100 smaller squares. (Note that each large square, outlined in black, is one unit or one whole.) Use the left drop-down menu above the right grid to choose percent. Then use the other drop-down menu above the right grid to choose 100 squares = 1 unit. Model 14% in the left grid by typing 14 in the box below the grid and pressing ENTER. Model 140% in the right grid.
    1. Which of these numbers has the largest shaded region? Which number has the smaller shaded region?

    2. Look at the model for 14%. How many squares are shaded? Is 14% more or less than 1 whole?

    3. Look at the model for 140%. How many total squares are shaded? Is 140% more or less than 1 whole?

    4. What percent is equal to 1 whole?

2. Predict what the following % will look like and verify using the gizmo.
    1. 150 %

    2. 135 %

    3. 180 %

3. Model the following percents on grid paper.
    1. ½ %

    2. 1/3 %

    3. ¼ %

4. Is 150% greater or less than 100%?

5. How many wholes would you need to show 250%?

6. Is ½% greater or less than 1%?

7. Compare ½% and 50%?

Simple Interest Handout

Simple Interest

Using Excel

Follow the steps listed below the answer the following question.

A) You put $750 in a savings account 5 years ago. With no other activity on this acct, how much interest will you have earned in that time?

1. Open the file titled SimpleInterest.xls by double clicking on it.
2. Notice the labels at the top: Principal, Time, Rate, Interest and Balance.
3. In cell A2, type 750 because this is the principal or the amount you started with.
4. In cell B2, type 5.69% as a decimal, because this is the rate.
5. In cell C2, type 5, because this is the number of years the money was left in the account.
6. In cell E2, type = A2 * B2 * C2. This represents the formula for interest which is I (interest) = p (principal) * r (rate) * t (time)
7. Now to get the new balance, in cell F2, type = A2 + E2. For this we are adding the starting amount to the amount of interest that was earned.

Try this problem on your own:

B) $125 deposited in a certificate of deposit (CD) for 18 months at 5.18% interest annually. What is the new acconnt balance?

Partner work:
Find the simple interest to the nearest cent.

1. $300 at 7.5% for 5 years.

2. $668 at 9.25% for 15 months.

3. $360 at 18.5% for 2 years.

Find the total amount in each account to the nearest cent.

4. $800 at 7.5% for 8 months.

5. $235 at 8.5% for 3 years.

6. $385 at 12.6% for 9 months.

7. Suppose $1250 is placed in a savings account for 2 years. Find the simple interest if the interest rate is 4.5%.

8. Estrella's bank statement listed a balance of $328.80. She originally opened the account with a $200 deposit and a simple interest rate of 4.6%. If there were no deposits or withdrawals, how long ago was the account opened?

Appendix D

Tickets to Leave

Ticket #1

1. I learned better… In the classroom In the computer lab

2. I was more on task… In the classroom In the computer lab

3. Overall, I prefer to be taught… In the classroom In the computer lab

4. Explain #3.

Ticket #2

1. A math class had 25 students. If 2 more students enrolled in the class, what is the percent of change?

2. A savings account starts with $980. If the simple interest rate is 5.5%, find the total amount in the account after 4 years.

3. I learned better… In the classroom In the computer lab

4. I was more on task… In the classroom In the computer lab

5. Overall, I prefer to be taught… In the classroom In the computer lab

6. Explain #5.

Appendix E:

Quiz Questions

% Quiz

1. Express 0.08% as a decimal.

   a) 0.8 b) 0.008 c) 0.08 d) 0.0008

   1. _____

2. Find the percent of change in taxes if the old taxes were $38.00 and the new taxes are $41.61.

   a) 10.5% b) 9.5% c) 11% d) 12%

   2. _____

3. Find the amount of discount and the sale price of a $6.99 cassette that is on sale for 20% off. Round to the nearest cent.

   a) $1.40; $5.59 b) $1.39; $5.49
   c) $1.38; $5.61 d) $1.45; $5.44

   3. _____

4. Paula deposited $300 into a savings account which earns 4.5% interest annually. She does not withdraw or deposit any money for 5 years.

   a) How much interest will she earn?

   b) What will be the new balance on her account?

5. The table below shows the number of students who attended Walters Middle School each year during a 5-year period.

Year	Number of Students
2000	511
2001	548
2002	587
2003	664
2004	705

What is the approximate percent increase in the number of students from 2000 to 2004?

A) 50%
B) 40%
C) 30%
D) 20%

6. Ben wants to buy a guitar. The regular price of the guitar is $329.99. The sale price of the guitar is 25% off of the regular price.

A) What is the sale price of the guitar? Show all work.

Answer: $_____

Erin, Very nice work! Grade on paper and in class is A