ANALYZING THE IMPACT OF WEB-BASED GEOMETRY APPLETS

ON FIRST GRADE STUDENTS

by

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This study investigated the impact of web-based geometry applets on first grade students' academic achievement as well as on student attitudes, behaviors, and interactions. The applets were created or reviewed as part of the MarcoPolo Education Foundation.

Thirty-one students were randomly assigned. Both groups studied identical objectives, but the treatment group used applets for practice unless a corresponding applet was not available. A pretest and posttest at both the first and second grade levels was conducted, as well as four mini-tests to investigate the impact of individual applets.

The pretests showed that the treatment group began lower than the control group, and at a significantly lower level ($p < 0.05$) on the first grade test. Posttest results showed that the treatment group outscored the control group on both grade level tests, though not at a significant level ($p > 0.05$). The treatment group had significant improvements ($p < 0.05$) on both grade level tests, while the control group only had significant improvements ($p < 0.05$) on the second grade level test.

The treatment group teacher recorded her daily thoughts regarding the applets and observations regarding student attitudes, behaviors, and interactions. She reported

increased instructional time, repetition of practice activities, time-on-task, and feedback. She noted that students showed increased motivation and challenged themselves to higher levels.

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CHAPTER I

INTRODUCTION

Context of Study

Teachers are using computer and Internet resources, such as on-line practice activities and model lesson plans, more frequently with their students. In the year 2000, 76 percent of teachers reported using computers daily for planning and/or teaching, and 63 percent reported using the Internet for instruction (CEOForum, 2001). The integration of computers into the daily instruction of students has become more than acceptable practice, it has come to be expected (Miller & McInerney, 1994-95).

This expectation is partially a result of the large financial and time investments made on computer systems and Internet accessibility. One estimate suggests that over $6 billion was spent in 1999-2000, and technology expenditures have tripled in K-12 schools during the last decade (Sivin-Kachala & Bialo, 2000). In 2000, the average public school contained 110 computers. Instructional rooms with Internet access increased from 3 percent in 1994 to 77 percent in 2000. Nearly 98 percent of schools had Internet access in 2000, an increase from 35 percent in 1994 (CEOForum, 2001; Snyder, 2002). The increase in computer and Internet access has made web-based instruction and classroom activities a viable option for educators, and illustrates the tremendous faith that is placed on the capability of computers and Internet to improve instruction (D'Amico, 1990).

Background of Problem

Mere faith in technology and the Internet doesn't justify the adoption of and expenditures for computer and web-based resources. A call for accountability in all areas of education has been a dominant theme in recent years. This is no more evident than in President Bush's No Child Left Behind Act of 2001. This law calls for the use of instructional methods and materials that have met the standard of being positively evaluated using "scientifically based research," a phrase that appears 111 times in this new law. The law defines "scientifically based research" in the following manner:

> (A) means research that involves the application of rigorous, systematic, and objective procedures to obtain reliable and valid knowledge relevant to education activities and programs; and
>
> (B) includes research that –
>
> (i) employs systematic, empirical methods that draw on observation or experiment;
>
> (ii) involves rigorous data analyses that are adequate to test the stated hypotheses and justify the general conclusions drawn;
>
> (iii) relies on measurements or observational methods that provide reliable and valid data across evaluators and observers, across multiple measurements and observations, and across studies by the same or different investigators;
>
> (iv) is evaluated using experimental or quasi-experimental designs in which individuals, entities, programs, or activities are assigned to different conditions and with appropriate controls to evaluate the effects of the condition of interest, with a preference for random-assignment experiments, or other designs to the extent that those designs contain within-condition or across-condition controls;

(v) ensures that experimental studies are presented in sufficient detail and clarity to allow for replication or, at a minimum, offer the opportunity to build systematically on their findings; and
has been accepted by a peer-reviewed journal or approved by panel of independent experts through a comparably rigorous, objective, and scientific review.

Many opinions exist regarding the effectiveness and appropriateness of technology use with young children and these are forcefully shared in a variety of venues. These opinions range from a call for a moratorium on computers in elementary classrooms (Fool's gold: A critical look at computers in childhood, 2000) to the response to that article by people like Thornburg (2001), who promote the use of technology as an effective learning tool with students of all ages. While opinions and anecdotes may be interesting and informative, they do not satisfy the requirements of the No Child Left Behind Act of 2001.

Background on MarcoPolo

This research project focused on web-based geometry applets created and reviewed as part of the MarcoPolo Education Foundation. MarcoPolo is a partnership between nine renowned educational organizations. These partnerships were created to produce seven discipline-specific educational web sites: EconEdLink, Xpeditions, EDSITEment, Illuminations, Science NetLinks, ARTSEDGE, and ReadWriteThink. The web sites are geared primarily toward K-12 teachers, although some of the sites' resources are also appropriate for college-level work and for family activities (MarcoPolo, 2002).

MarcoPolo provides “Internet Content for the Classroom,” or web-based lesson plans, resources, and student activities that can supplement and/or replace traditional textbooks. This content is provided totally free-of-charge, and is based on national standards, many of which have been created by the nine partner organizations.

One of the partners, The National Council of Teachers of Mathematics (NCTM), is the creator of the website “Illuminations.” This site exemplifies the NCTM Principles and Standards for School Mathematics (NCTM, 2000) and has the goal of improving the teaching and learning of mathematics for all students. The site consists of five main sections: iMath investigations, reflections on teaching, selected web resources, Internet-based lesson plans, and Math-lets. The iMath investigations and Math-lets are online, interactive, multimedia math lessons and activities, which were the focus of this research project. They are built around interactive math applets, some of which can be downloaded and then run directly from a computer’s hard drive or burned to a CD-ROM. In the selected web resources section, the NCTM Editorial Board reviews other mathematics education websites that share NCTM’s goals and provides links to these sites. Some of the applets used in this study were taken from the selected web resources.

The researcher was a national cadre trainer for MarcoPolo at the time of the study.

Statement of Problem

This study examined if the MarcoPolo partner created and partner reviewed web-based geometry lessons and student activities were effective practice activities when used with first grade students. These activities were compared to the typical geometry practice activities as recommended in the midwestern school district's adopted math text, which was authored by a nationally known text publisher. The NCTM's standards were also listed as the foundation of the math text.

Research Questions

1. What differences exist among the academic achievement of first grade students who use the web-based geometry practice activities and those students who use traditional text-based practice activities?
2. Do particular web-based geometry practice activities have a greater impact on academic achievement than others?
3. What are the treatment teacher's impressions and observations on student attitudes, behaviors, and interactions when using web-based activities?

Limitations of Study

1. The population of all first-grade students receiving geometry instruction was limited to a sample consisting of first-grade students enrolled at the elementary school. This sampling procedure limited the generalizability of the results.
2. The sample size was n = 31, which limited the statistical power of the experiment. If there was a real effect size associated with the treatment that was too small, it was possible that it would remain undetected, producing a Type II error.
3. Two different teachers taught the treatment and control groups. Although the instruction was planned to be identical for each day, it was impossible to control for differences between teachers.

CHAPTER II

LITERATURE REVIEW

Introduction

This literature review explores the three dominant themes of the research questions: symbolic representation of concepts, impact on academic achievement, and student attitudes, behaviors, and interactions. While geometry is the academic subject area of this particular research project, the scope of this literature review is expanded to include research that examines the dominant themes of the research questions, regardless of the specific academic subject area.

In 1996, the National Association for the Education of Young Children adopted its current position statement on the use of technology with children aged three to eight, based to a degree on several of the studies covered in this literature review (NAEYC, 1996). Some of the research studies in this review also refer to this current NAEYC position statement and previous position statements of the NAEYC and address their guidelines and concerns. This demonstrates a commitment by both the research community and early childhood leaders to work together towards finding appropriate and effective ways to integrate technology, and not just allow opinions to guide their work with children.

Symbolic Representation of Concepts

One argument critics often raise against young children using computers is that computer environments are not concrete, asserting the Piagetian belief that children construct knowledge through interaction with materials and people, and that children cannot handle the symbolic representations present in a computer environment (Barnes & Hill, 1983; Wood, Willoughby, & Specht, 1998). However, what is “concrete” to a child may have more to do with what is meaningful and manipulable than with physical characteristics.

The well-known Logo programming language is a prime example of an effective method for working with symbolic concepts by utilizing an interactive computer environment. The programming involved in Logo promotes abstract thinking and returns a concrete visual picture (Allocco et al., 1992). Comparisons between Logo and non-Logo students have shown that Logo students are more effective in solving problems involving concepts and applications. They also score higher on figure classification, quantitative reasoning, and have shown a significant improvement in the achievement of geometry skills (Robinson, Feldman, & Ulhig, 1987). Computers not only enhance children’s learning experiences by allowing them to visualize connections among various topics (Enderson, 1997), but can indeed facilitate their cognitive development, leading to students investigating ideas beyond grade-level expectations (Duarte, Young, & DeFranco, 2000).

In a study comparing the symbolic computer environment to the “concrete” environment, a researcher (Ainsa, 1999) used M&M’s as math manipulatives to measure children’s ability to accomplish a mathematical task and the use of a computer to do a similar task. The study found that 101 subjects, aged four to six, showed no significant differences in their abilities to match colors and numbers, identify shapes, count items, or perform addition and subtraction. The researcher indicated that a combination of approaches yielded in enthusiastic learning, although the students tended to request M&M's anytime a math concept was discussed. A similar study showed that third grade children who used both manipulatives and computers demonstrated sophistication in classification and logical thinking and showed more foresight and deliberation in classification than did children who used only manipulatives (Clements, Nastasi, & Swaminathan, 1993).

Shade and Watson (1990) conducted a study in which young children learned to classify a unique array of objects, such as tables, cars, lamps, etc., based on the simple concept of inside or outside. Children aged 18 to 42 months spent one hour manipulating computer graphic objects in and around the background scene of a house and yard. These students were then asked to classify the matching "real" objects. The study found that around the age of 36 months, the computer manipulation of the objects enabled the children to be able to correctly classify the series of actual objects.

Another study (Clements et al., 1993) involved asking young children to create "bean stick pictures" in either a felt board or computer environment. Students could freely select and arrange beans, sticks, and number symbols on a computer, just like the real bean stick environment. The results of the study showed that the computer environment actually offered equal, and sometimes greater, control and flexibility to young children.

These studies indicate that children are able to transfer symbolic learning from the computer environment to the actual environment. This suggests that teachers could use computer software and web resources with their students and have the confidence that they are providing appropriate materials and experiences that are conducive to student learning.

Impact on Student Achievement

Not all technology is created equal, and research by Haugland (1992) suggests that the types of computer activities and software young children are exposed to makes a difference in their cognitive development and academic achievement. Haugland identified nine software programs as “developmental,” meaning they incorporated characteristics such as age appropriate, child control, expanding complexity, independence, process oriented, real-world modeling, trial and error, and transformations. Nine other programs were identified as “non-developmental.”

Haugland studied four preschool classes that were exposed to four different treatments during one school year. These treatments were: developmental software plus corresponding off-computer activities; developmental software only; non-developmental software only; and no exposure to computer software. The two groups that included developmental software in the treatment demonstrated significant gains in intelligence, non-verbal skills, structural knowledge, long-term memory, and complex manual dexterity. The group that included corresponding off-computer activities showed significant improvement in verbal skills, problem solving, abstraction, and conceptual skills. The group with access to non-developmental software demonstrated significant gains in concentration and short-term memory but significant losses in creativity.

The use of word processing software is an area where a teacher’s instructional decisions will impact if the technology is used appropriately. When compared to the characteristics listed above, word processing software fits well as it provides tools such as easy text entry, spell checking, and editing that allow students to experiment and creatively communicate with language. Students using a computer to write can cooperatively plan, write, and revise within the frameworks of the six-trait writing model that is used in Nebraska schools. However, if a teacher makes the specific features of word processing software the focus of instruction instead of the writing process, they would not likely see any improvement in the quality of student writing.

Clements et al. (1993) found that when children write on computers, their stories are more fluid, they write more, their stories are more complex, they make fewer mechanical errors, they worry less about making mistakes, and they are more willing to make revisions. These findings are similar to Russell and Haney (1997) who conducted a study with middle school students accustomed to writing on computers. When comparing computer and paper-and-pencil essays, students writing their essays on the computer performed "substantially better" than those who wrote using paper-and pencil. Thirty percent of paper-and-pencil essays were rated as satisfactory, compared to 67 percent of the computer essays. Students who performed the assessment on the computer tended to write almost twice as much and were more apt to organize their responses into more paragraphs. The researchers observed that computers allowed students to write and revise much more easily and quickly than with a pencil. Crippen (2000) notes that nearly all standardized writing tests are paper-and-pencil, and states, “There is an emerging gap between how students are taught and how they are assessed.” This is evidenced in Nebraska by the fact that the state writing assessment is paper-and-pencil based.

Related closely to word processing is the topic of keyboarding with young children. Several teachers utilize keyboarding as a way to support and reinforce the language arts. The National Business Education Association (1992) supports the introduction of keyboarding instruction at grade three because students at that grade are generally more anatomically ready to learn keyboarding. Students younger than grade three may not have the dexterity or hand size to master the reaches. They also recommend that keyboarding instruction be introduced one year prior to word processing and emphasize that it if students are not going to use their keyboarding skills by using a word processor, then it is a waste of instructional time.

McClendon (1991) conducted a study with a first grade class to see if keyboarding instruction could improve spelling. The first half of the year was taught using the direct instruction method and the second half of the year with a combination of direct instruction and keyboarding practice. The first graders were randomly assigned to the class and the group consisted of two high achievers, eight average achievers, and eight low achievers. Results indicated that students' attitudes toward spelling class improved with the keyboarding included, and achievement test spelling scores at the end of the year showed a significant difference when compared to gains made during the first half of the year. Students' keyboarding rates were equal to or faster than their handwriting rates. Recommendations included introducing the keyboarding instruction at the beginning of the year, and completing the keyboarding lessons before integrating them with the spelling lessons. This study is important more for the fact that student attitudes improved than for the spelling achievement. The increased positive student attitudes regarding spelling, and the demonstration of first graders acquiring keyboarding skills equal to or better than their handwriting speeds seem to be two compelling reasons for integrating keyboarding into language arts classes.

Cowles (1983) studied 24 students from a summer-enrichment keyboarding program ranging in ages from five to eight. Results of the study indicated that even young children can learn to type correctly and they can do so without frustration. Some factors that may have influenced the success of this study were the small class sizes of six students per age group, and that this was an enrichment program which was not a random, typical sample of students in that age population. The most relevant finding in this study was that being able to read was important to acquiring keyboarding skills.

Connected to the ability to read, researchers (Foster, Erickson, Foster, Brinkman, & Torgesen, 1994) conducted two experiments on the instructional effectiveness of a computer program, DaisyQuest, designed to increase phonological awareness in young children. In experiment one, twelve kindergarten-aged children worked on the program for 20 sessions of about 20-25 minutes each. Children in this group showed significantly ($p < 0.02$) greater gains in phonological awareness, as measured by two different tests, than the control group of 15 children who did not receive training. In experiment two, 34 kindergarten-aged students completed an average of 4.9 hours of training with DaisyQuest and they significantly ($p < 0.01$) outperformed a control group of 35 children on three different phonological tests. The DaisyQuest training produced an average effect size of 1.05 standard deviations. The researchers cited studies of similar experiments concerning teacher-led phonological training. While the teacher-led sessions produced an average effect size of 1.23 standard deviations, slightly higher than DaisyQuest, those sessions involved double the training time with students. This would suggest that DaisyQuest may have advantages in terms of accelerating the acquisition of reading, and the researchers stated they also intended to examine the effectiveness of the program in a future study on children who are at risk for serious difficulties in learning to read.

Clariana (1994) investigated the effects of a computer Integrated Learning System (ILS) on the mathematics and reading standardized exam scores of four separate third grade classes. According to the Office of Technology Assessment (1988), ILS generally refers to a system that includes extensive courseware plus management software running on a networked system. The four classes in the study were taught by the same teacher over a period of four years, and had a total of 85 students. The first and second groups received traditional classroom instruction while the third and fourth groups received traditional classroom instruction plus ILS instruction. The ILS groups showed a larger gain for mathematics with an effect size of 0.49 than for the reading groups that had an effect size of 0.06.

Two years later, Clariana (1996) reported on the effects of an ILS on the standardized test scores of elementary students. He selected three consecutive fifth grade cohorts from five elementary schools, for a total of 873 students. The first and second cohorts received traditional classroom instruction while the third received traditional classroom instruction plus ILS mathematics instruction. The median effect size gains for the ILS group compared to the non-ILS groups were 0.13 for computation, 0.63 for concepts, and 0.33 for applications. Clariana points out that while most computer math software tends to focus on computation skills, the greatest effect size in this study was in the area of mathematical concepts.

In another ILS study (Underwood, Cavendish, Dowling, Fogelman, & Lawson, 1996), researchers followed a six month ILS trial in nine schools. The student population ranged from 8 to 13 years of age. The researchers compared the academic performance of treatment and control groups and also monitored student behavior. An effect size of 0.4 was reported in the ILS math groups. General observations on behavior were that students in the ILS groups had a higher time on task than students in the control groups. There were no differences in recorded attendance rates between the groups.

Computer assisted instruction (CAI) was compared to traditional instruction in a sample of 48 hearing impaired children (Braden, Shaw, & Grecko, 1991). The treatment and control groups were compared on measures of written language, in-class quizzes, and standardized achievement scores. The CAI math group had significantly higher scores ($p < 0.01$) on in-class math quizzes than the control group. No other statistically significant differences were found on the other measures of achievement. The researchers reported informally that the CAI students enjoyed using the computer, stayed on-task when using the computer, and that parents, teachers, and administrators all rated CAI favorably.

In a meta-analysis (Christmann, Badgett, & Lucking, 1997) comparing the academic achievement of students in eight curricular areas who received either traditional instruction or traditional instruction supplemented with computer assisted instruction, researchers reported an overall mean effect size of 0.209 for students who received CAI. The specific subject areas had the following effect sizes: science, 0.639; reading, 0.262; music, 0.230; special education, 0.214; social studies, 0.205; math, 0.179; vocational education, -0.80; and English, -0.420.

Kulik's (1994) meta-analysis on computer-based instruction found that on average, computer-using students at the elementary level scored at the 64th percentile on achievement tests compared to students without computers who scored at the 50th percentile. Kulik also noted that students learn more in less time when they receive computer-based instruction and that students like their classes more and develop more positive attitudes.

A report on Missouri's eMINTS program showed that students who participated in eMINTS classrooms scored consistently higher on the Missouri Assessment Program (MAP) tests than non-participants (MOREnet, 2002). The eMINTS program combined multimedia and computer technology, inquiry-based teaching, and professional development. Researchers analyzed test scores from 85 eMINTS classrooms and 203 non-eMINTS classrooms. Results of the MAP tests show that a higher percentage of eMINTS students scored in the top two achievement levels. The eMINTS students in special programs, such as special education, Title 1, and free and reduced lunch programs, also showed substantial increases in their MAP scores.

A large scale, longitudinal study of West Virginia's Basic Skills/Computer Education (BS/CE) program analyzed 950 fifth-grade students from 18 elementary schools (Mann, Shakeshaft, Becker, & Kottkamp, 1999). The study began with a cohort of kindergarten students in the 1990-91 school year. Each year the state of West Virginia provided participating schools with enough technology equipment to serve the cohort and technology training, software, and support for the teachers. The analysis of the cohort showed that when the cohort reached grade three, the statewide test scores went up five points in one year, compared to a total six point rise in the previous four years. As fourth graders, the cohort had the second highest reading scores among southern states. In fifth grade, the cohort showed gains in the Stanford-9 achievement test, with higher gains than non-cohort students. Girls and boys in the cohort did not differ in achievement, access, or use of computers in the study.

Student Attitudes, Behaviors, and Interactions

Some critics maintain that the use of computers with young children may detract from the social environment present in early learning settings, yet many researchers have found that computers can be effectively used at this age with positive influences on student attitudes, behaviors, and interactions (Rockman, 1993; Wood et al., 1998)

Goldmacher and Lawrence (1992) studied two groups of preschool children enrolled in a Head Start program. One group followed the standard Head Start program while the other group participated in computer enrichment activities in addition to their standard Head Start activities. The computer activities were theme-based and built around a variety of software. Students in the computer group exhibited significantly more behaviors indicative of positive self-concept than did students in the non-computer group.

In a full-inclusion kindergarten, researchers (Symington & Stanger, 2000) used inclusionary math software to investigate how classroom dynamics would change and how the software would help children with disabilities. The researchers reported that the accessible math software allowed students with various disabilities to become active participants in their classrooms. This led to the improvement of the children's self-perception, and a stronger connection with classmates. One teacher involved in the study stated, “It helped him develop his self-confidence because of the degree of feedback the software provided to him.”

A similar study (Stanger & Khalsa, 1998) reported that accessible math software forced some students with disabilities to work harder than they had before. One boy with cerebral palsy had poor handwriting and often used that as an excuse to not complete his math work. The software took away that obstacle and allowed the boy to focus on the math problems instead of the handwriting difficulty. His teachers reported that this helped him become a more integral part of the class, more independent in other areas, and they noticed a change in perception by classmates.

Haugland (1996) conducted a study where the self-esteem of four-year-old children in classrooms with computers was compared to the self-esteem of children in a classroom without computers. At the end of the nine-month study, the children in the classroom with computers had significantly higher increases in measures of self-esteem than the children in the classroom without computers. The researcher hypothesized that this occurred because children view computers as “adult machines” and when given the opportunity to explore and manipulate the computers, they feel important, capable, and competent.

In a comprehensive three-year study (Hutinger & Johanson, 2000), a portion focused on young children’s behaviors during various classroom activities. Eleven common activities, including free play, books, computer, art, and snack time were observed, described, and coded. Results showed that of the eleven observed activities, computer use was most often followed by desirable behavior and least likely to be followed by aggression. While at the computer, communication and turn taking accounted for 63% of the observed text units (35% communication and 28% turn taking). These results are comparable with the level of communication during free play (43% communication) and superior to the level of turn taking during free play (4% turn taking). Children in this study with behavior problems exhibited fewer disruptive behaviors during computer time, interacted socially more often, and communicated more. Observations revealed that some students displayed unsuspected skills and abilities and became the “computer expert” of the class.

Wood et al., (1998) echo these findings as they report that children aged four and five engaged in more social interactions with their peers when using a computer than when solving jigsaw puzzles. They were more cooperative and engaged in more helping and sharing behaviors after a computer was introduced into their classroom than prior to its introduction.

As part of a review of 219 published and unpublished research projects, Sivin-Kachala & Bialo (1997) reported that students felt more successful in school, were more motivated to learn, and had increased self-confidence and self-esteem when using computer-based instruction. Evidence for these positive effects was the strongest in the areas of language arts, mathematics, and science.

CHAPTER III

METHODS

Introduction

Two sections of first grade students were studied. One section of students received geometry instruction as outlined in Chapter 8 of *Math Central*. All of the student practice activities were recommended in the math text. The other group of students used the same text for their primary source of instruction, but their practice activities were replaced by *MarcoPolo* created and reviewed web-based geometry activities. If a corresponding web-based activity was not available, the students completed the text-based practice. Each student had a Macintosh® iBook® laptop computer that was connected to the Internet via a wireless network. When available, the web-based activities were pre-loaded on their local hard-drives to prevent loss of practice time due to any unforeseen Internet connectivity problems. This study was conducted from May 6, 2002 through May 17, 2002. This corresponded to the instructional timing and sequence planned by the classroom teachers for the geometry chapter.

Data collection was conducted by utilizing the *Math Central* assessment activities and tests. A pretest was given prior to any geometry instruction to establish baseline data. Individual practice assignments were used to assess the effects of specific online activities. The chapter assessment was utilized at the end of the geometry chapter to test for overall effects. To accommodate possible ceiling effects of the pretests and posttests, both first grade and second grade versions of the tests were used.

The treatment group classroom teacher wrote a daily journal to record her impressions regarding student time-on-task, work behaviors, effectiveness of the activities, and overall thoughts on the process.

Population and Sample

The population for this study was first graders who receive geometry instruction. The sample of this population was the 31 first grade students enrolled during the 2001-02 school year at an urban, midwestern elementary school. The classroom teachers involved in the study had comparable academic backgrounds. The control group teacher held a Bachelor's degree in Elementary Education plus 18 hours of graduate credit. She had taught for nine years. Her mathematics teaching preparation included a university elementary math methods course as well as district staff development courses. The treatment group teacher held a Bachelor's degree in Elementary Education with an endorsement in special education plus 24 hours of graduate credit. She had taught for seven years. Her mathematics teaching preparation included a university elementary math methods course as well as district staff development courses. For reporting purposes, the pseudonym of the treatment group teacher was Karla.

Variables and Measures

Prior knowledge of geometry concepts such as patterns, shape identification, and symmetry was measured for each child using the Grade One Form A and Grade Two Form A assessment tests from *Math Central*. These assessments were delivered as a pretest during the first class period of the geometry chapter. A corresponding Grade One Form B and Grade Two Form B assessment test was delivered as a posttest on the final day of the geometry chapter, following all of the instruction and practice activities.

The classroom teacher of the treatment section recorded and emailed her daily thoughts to the researcher regarding the teacher's observations and impressions regarding student attitudes, behaviors, and interactions, effectiveness of the activities, use of technology, and overall thoughts on the process.

Procedural Steps

This study was conducted using the following procedures:

1. The classroom teachers and school principal were asked to participate in the study.
2. Approval was obtained from the school district. (Appendix A)
3. Approval was obtained from UNL IRB. (Appendix B)
4. A letter from the principal and classroom teachers was sent to potential participants encouraging their participation in the study. (Appendix C)
5. Parent consent and child assent forms were collected from the participants. Informed consent forms were collected from teachers. (Appendix D)
6. A coin toss determined which teacher was assigned to the control or treatment group.
7. Students were randomly assigned to the treatment or control groups.
8. Prior to the two weeks of geometry instruction and practice activities, the students took Grade One Form A and Grade Two Form A of the assessment test.
9. A brief survey regarding home computer and Internet access and use was distributed to parents and guardians. (Appendix E)
10. The teacher of the text-based activity classroom conducted geometry instruction and student practice activities according to the chapter plan recommended in the

Math Central textbook. The teacher of the web-based activity classroom conducted the same instruction, but the student practice activities utilized the web-based geometry activities. If a corresponding web-based activity was not available, the students used the same practice activities as the control group. (Appendix F)

11. Following the completion of an objective or a set of related objectives, a short assessment was given to both sections to collect data on the students' performance related to use of the applets.
12. Following the two weeks of geometry instruction and practice activities, the students took Grade One Form B and Grade Two Form B of the assessment test.

Treatment

The objectives covered in the two week geometry chapter were that students would be able to: identify spheres, cylinders, rectangular prisms, cones, and pyramids; copy a plane shape and be able to transform a shape into a larger/smaller shape; draw a plane shape with a given number of sides; draw a shape with a given number of corners; identify and draw plane shapes that are the same size and shape; state a rule for a given pattern; use problem solving strategies to continue a pattern; draw lines of symmetry; identify and show equal parts in a plane shape.

Students in the control group used their student textbooks and corresponding worksheets for practice. The treatment group used the same books for instructional purposes, but used the applets described below for practice. Sun Microsystems (Applets, 2002) defines an applet as, "a program written in the Java™ programming language that can be included in an HTML page, much in the same way an image is included. When you use a Java technology-enabled browser to view a page that contains an applet, the applet's code is transferred to your system and executed by the browser's Java Virtual Machine (JVM).” If a corresponding applet was not available for an objective, the students completed the same practice activity as the control group.

Shape Spinner

The Platonic solids applet or shape spinner (Cannon, Dorward, Heal, & Edwards, 2001) allowed students to rotate three-dimensional shapes (Figure 3.1). This tool also permitted students to color-code the faces of the shapes, highlight edges and corners, and increase or reduce the size of the shape. With the accompanying online worksheet (NCTM, 2002) the students could record their observations as they noted properties of shapes such as number of edges, corners, and faces, and could practice shape identification. This applet was used for Objective 8.4.

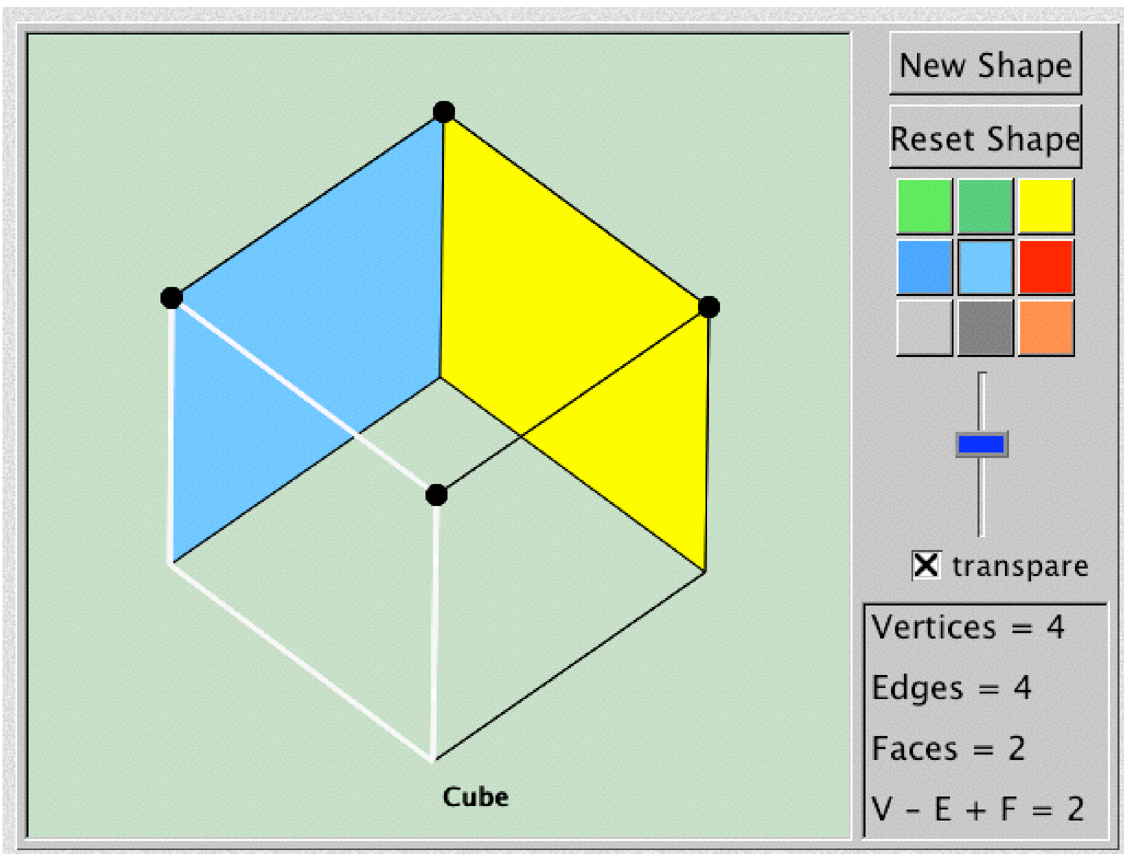


Figure 3.1: Shape Spinner

Geoboard

The geoboard applet (NCTM, 2002) allowed students to identify simple geometric shapes, describe their properties, and develop spatial sense (Figure 3.2). The geoboard was also used to identify lines of symmetry, and to transform shapes into larger or smaller shapes. This applet was used for Objectives 8.2, 8.3, and 8.9.

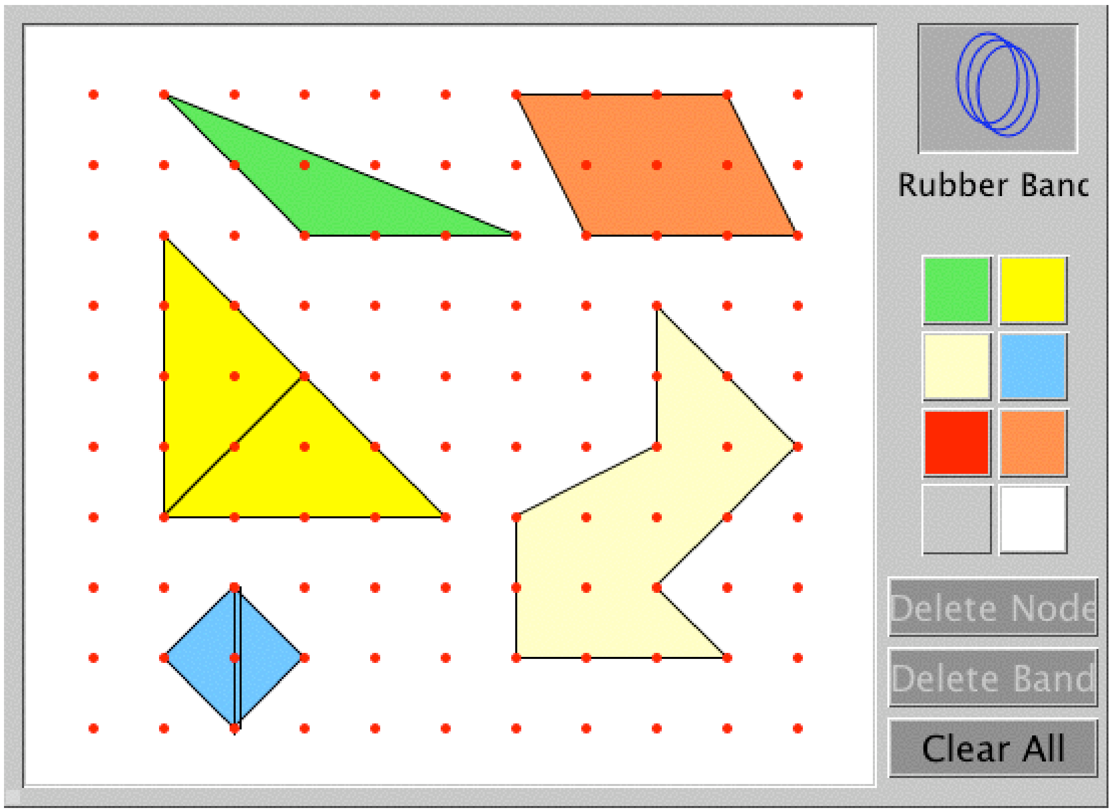


Figure 3.2: Geoboard

Pattern Maker

The pattern generator applet (NCTM, 2002) allowed students to create, compare, and view multiple repetitions of pattern units (Figure 3.3). Students created pattern units of squares, then predicted how patterns with different numbers of squares would appear when repeated in a grid and checked their predictions. This applet was used for Objective 8.7.

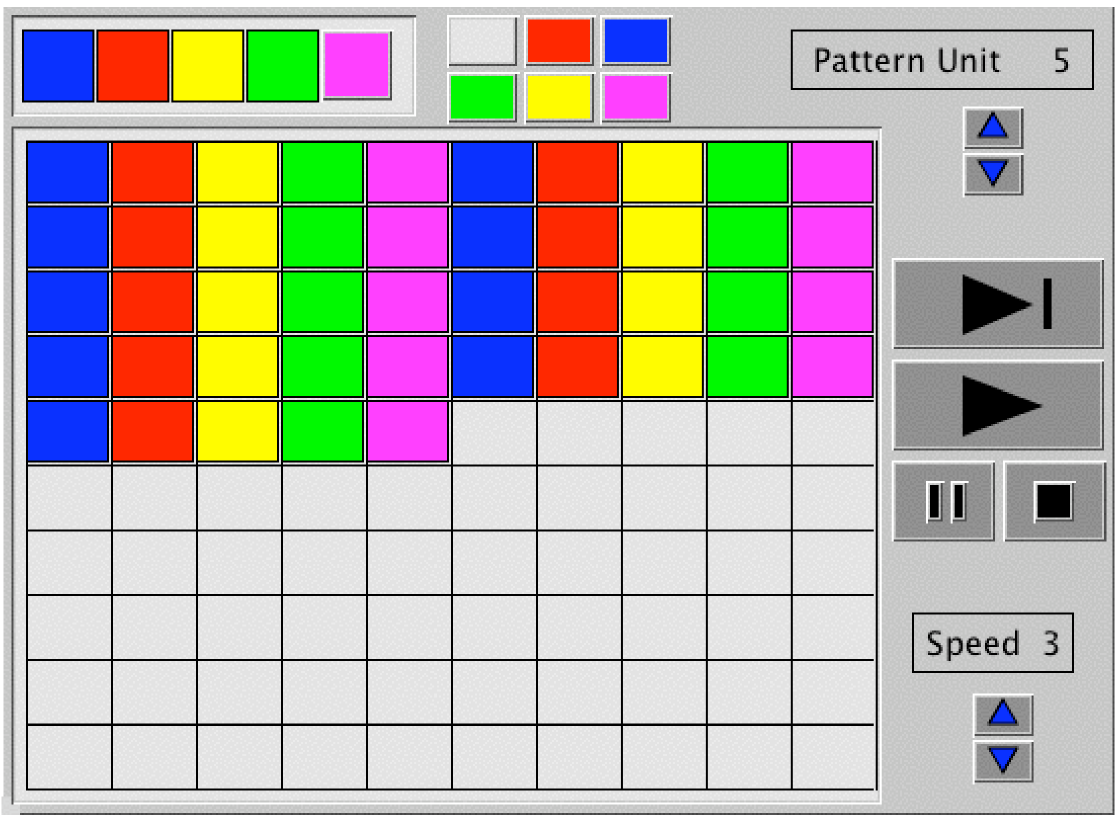


Figure 3.3: Pattern Maker

Pattern Blocks

The pattern blocks applet (Bulaevsky, 1998) allowed students to manipulate different shapes in several ways (Figure 3.4). Students could move, rotate, and repeat shapes to create patterns. This applet was used for Objectives 8.5 and 8.7.

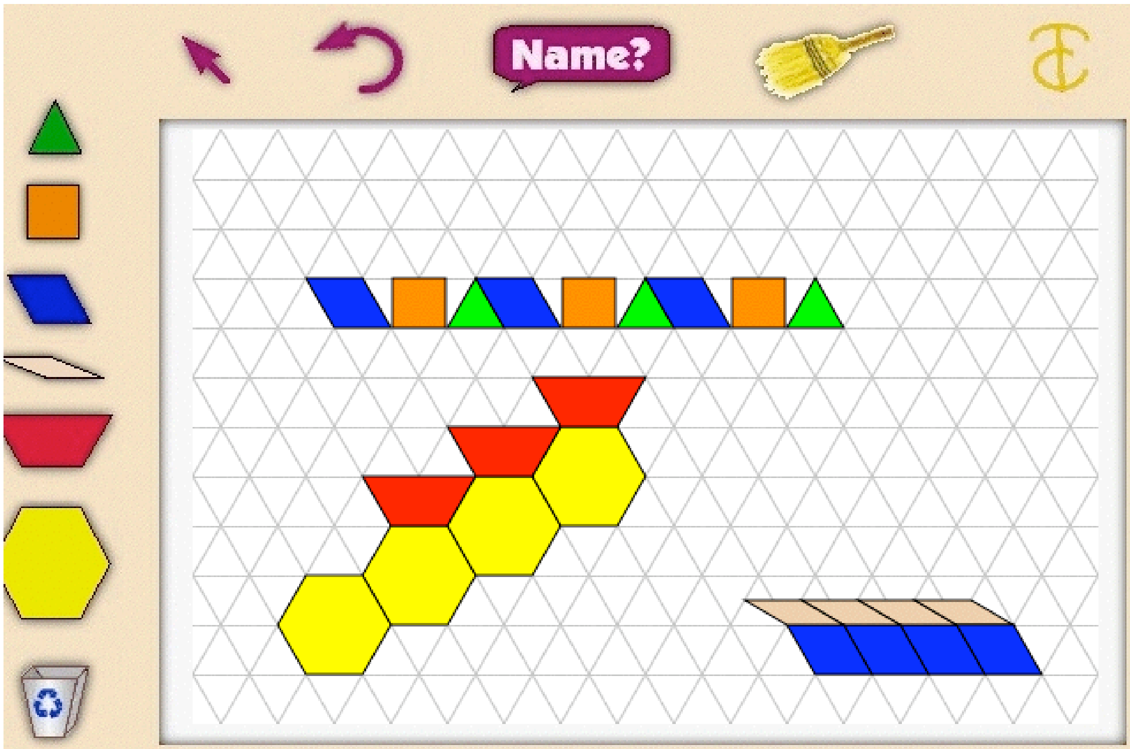


Figure 3.4: Pattern Blocks

Color Patterns

The color patterns applet (Cannon et al., 2001) allowed students to analyze how both repeating and growing patterns are generated (Figure 3.5). Students used the applet to recognize, describe, and extend patterns of color. The applet checked for accuracy and allowed students to correct mistakes in the predicted pattern. This applet was used for Objective 8.8.

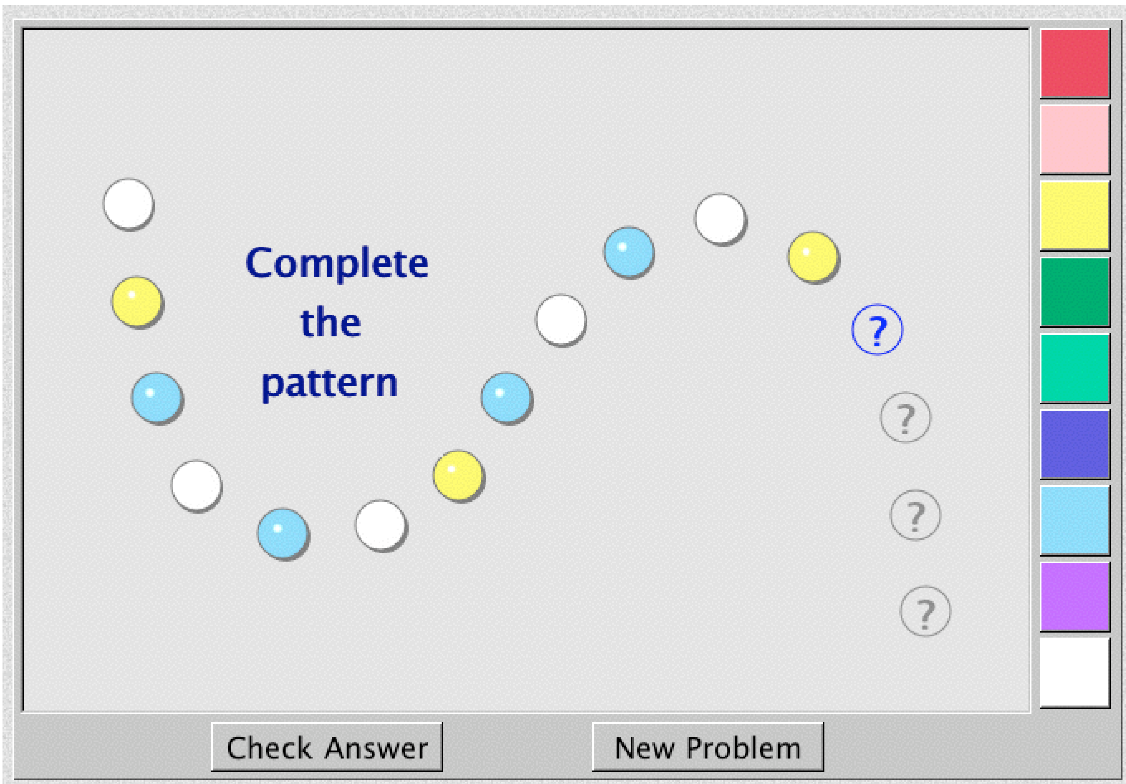


Figure 3.5: Color Patterns

Tangrams

The tangrams applet (NCTM, 2002) allowed students to describe figures and visualize what they look like when they were transformed through rotations or flips or were put together or taken apart (Figure 3.6). Students could choose a picture and use all seven pieces to fill in the outline, or students could use tangram pieces to form given polygons. This applet was used for the World Games activity.

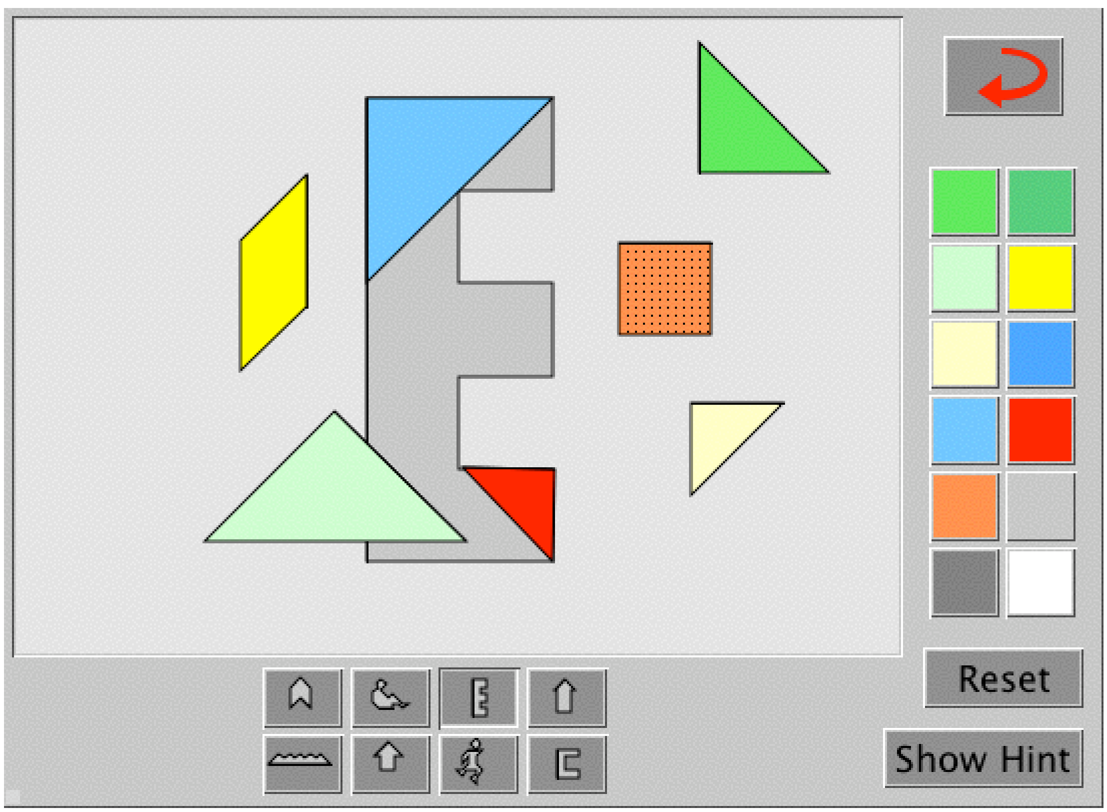


Figure 3.6: Tangrams

Polygon Playground

The polygon playground applet (Petti, 2000) allowed children to explore and create designs using multicolored triangles, squares, pentagons, hexagons, and octagons (Figure 3.7). Students could create patterns or pictures using the geometric shapes. This applet could also be used to practice recognizing and naming shapes, and to create pictures that illustrate symmetry. This applet was used for Objectives 8.5 and 8.9.

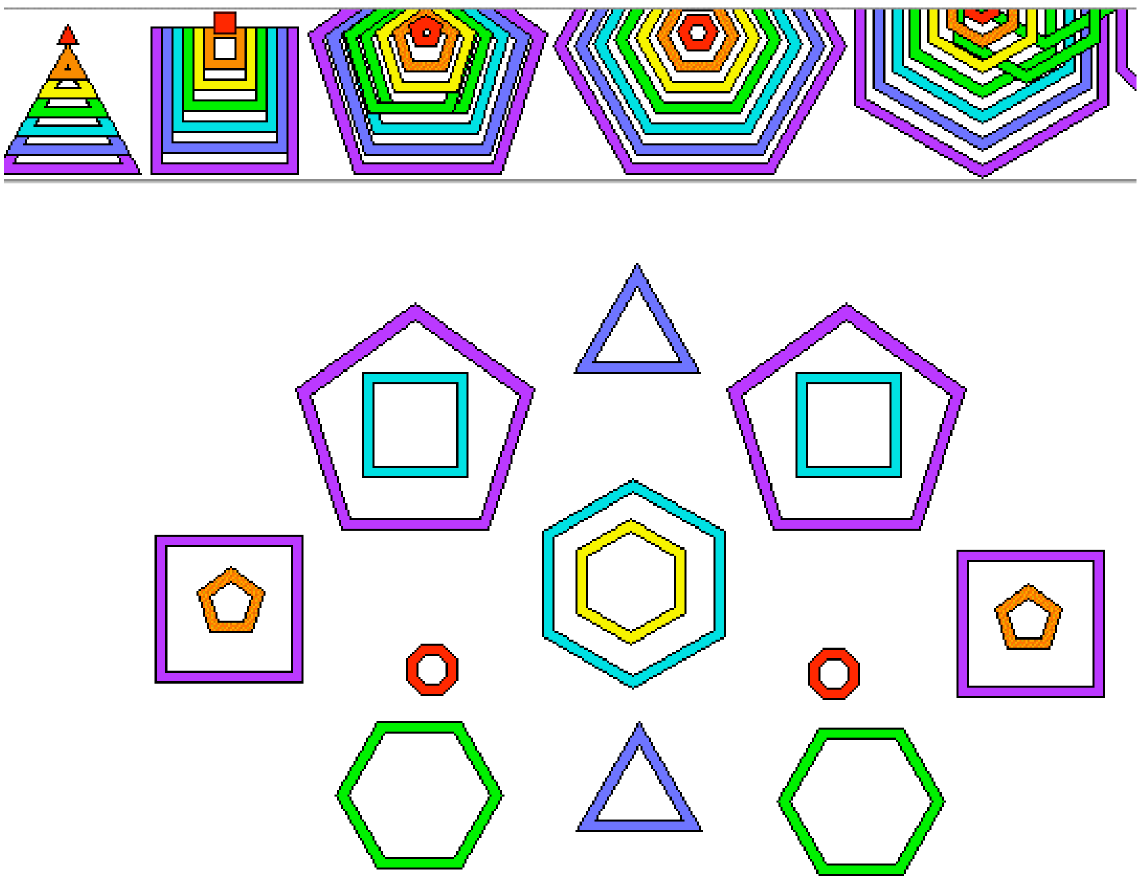


Figure 3.7: Polygon Playground

Statistical Analysis Plan

Group descriptive statistics, such as mean and standard deviation, were calculated to classify and summarize data. For the comparisons between individual practice activities, t-tests with □ = 0.05 were conducted. A corrected, more conservative value of □ = 0.05/number of tests conducted was used when appropriate. A 2x2 (pretest-posttest by control-treatment) mixed model ANOVA with □ = 0.05 was conducted to examine changes from pretest to posttest.

CHAPTER IV

RESULTS

Grade One Test Results

The first graders took two different sets of pretests and posttests, one at the first grade level and one at the second grade level. As displayed on Figure 4.1, on the first grade level pretest the treatment group had a mean of 22.2 out of 31 items (a mean of 71.6%), with a standard deviation of 4.8. The control group had a mean of 27.7 (89.5%) with a standard deviation of 1.8. On the posttest, the treatment group had a mean of 30.0 (96.8%) with a standard deviation of 1.0. The control group had a mean of 29.9 (96.3%) with a standard deviation of 1.2. Levene's Test of Equality of Error Variance showed that on the pretest, the error variance was not equal across groups. This violated the assumption of homogeneity of variances. However, according to Green, Salkind, & Akey (2000):

> If the group sizes are equal or approximately equal (largest/smallest < 1.5) then the F statistic is robust for unequal variances. That is, the actual □ stays close to the nominal □ (level set by researcher). The only time one need worry is when the group sizes are sharply unequal (largest/smallest > 1.5) *and* a statistical test shows that the population variances are unequal.

The ratio of treatment group size to control group size in this study was 16/15 = 1.07 (less than 1.5). This indicated that the F statistic was robust.

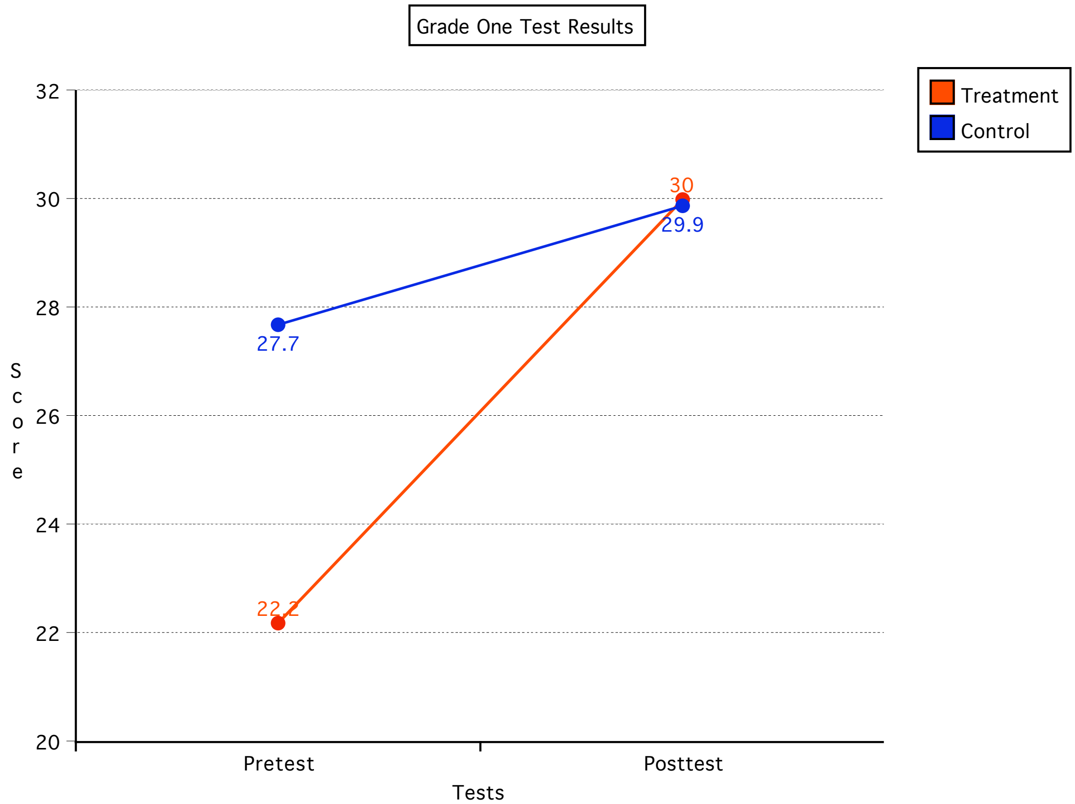


Figure 4.1: Grade one test results

A 2x2 (pretest-posttest by control-treatment) mixed model ANOVA was conducted. The results for the ANOVA indicated a significant main effect for the within factor, F (1, 29) = 54.16, p = 0.000, partial η^2 = 0.7, a significant main effect for the between factor, F (1, 29) = 14.68, p = 0.001, partial η^2 = 0.3, and a significant interaction between pretest to posttest and group membership, F (1, 29) = 17.654, p = 0.000, partial η^2 = 0.4, a large effect size (Green et al., 2000).

Because the interaction between pretest to posttest and group membership was significant, the main effects were ignored. Follow-up tests were conducted on the simple main effects to explain the interaction, with the alpha value corrected to 0.025.

There was a significant difference (p = 0.000) between the groups at the time of pretest. There was no significant difference (p = 0.747) between the groups at the time of posttest. There was a significant difference (p = 0.000) from pretest to posttest for the treatment group. There was no significant difference (p = 0.036) from pretest to posttest for the control group. The 95% confidence intervals displayed on Figure 4.2 also reflect the follow-ups.

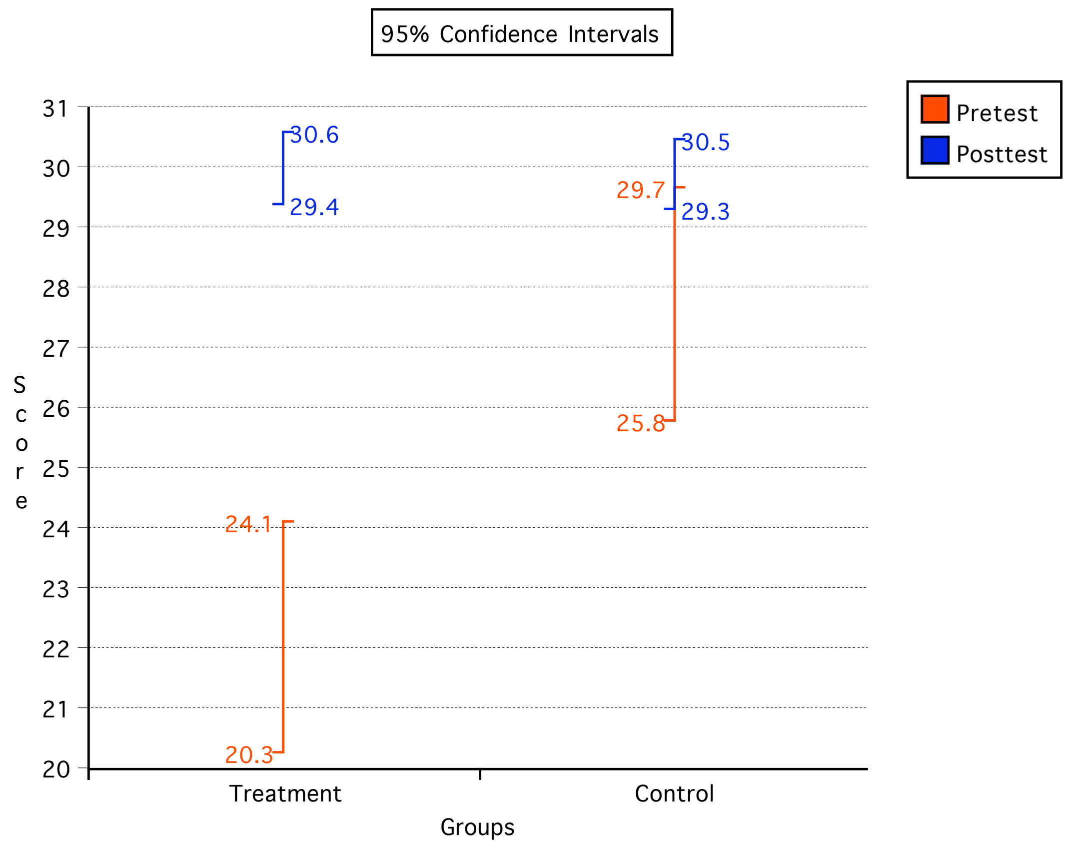


Figure 4.2: 95% Confidence intervals for grade one

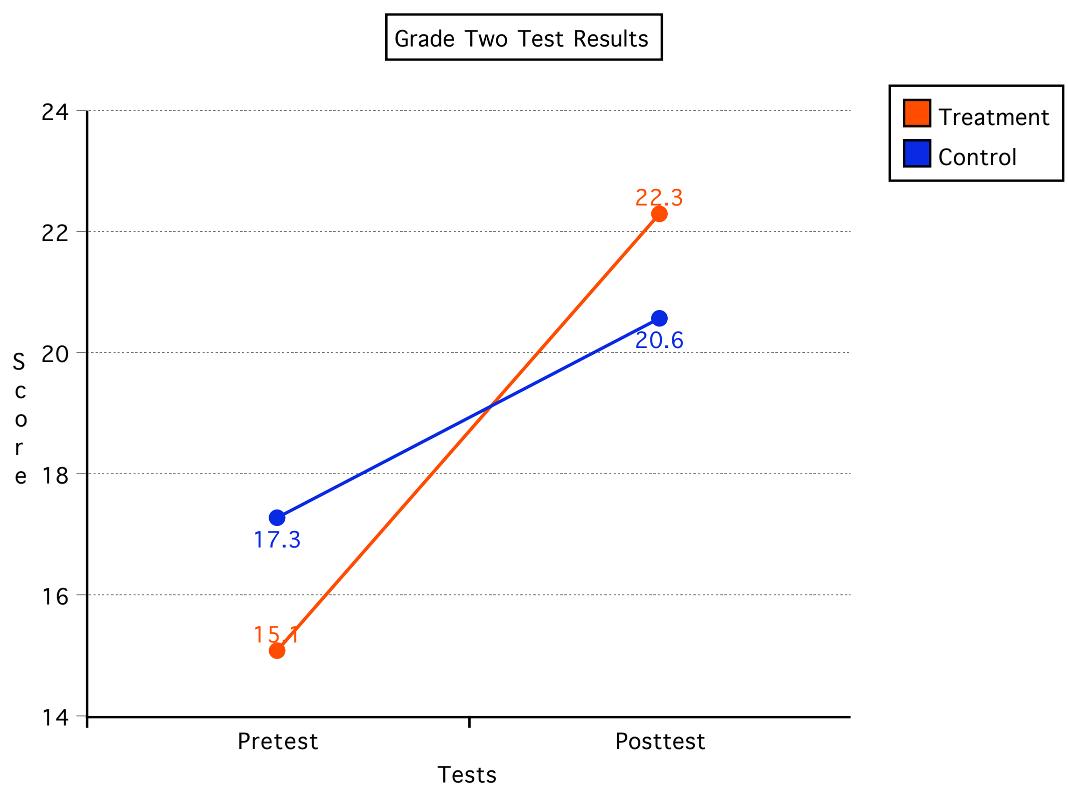
A t-test was conducted to analyze the overall change for each group from pretest to posttest. The treatment group had a mean change of 7.81 with a standard deviation of 4.87. The control group had a mean change of 2.13 with a standard deviation of 2.00.

The t-test showed a significant difference between groups, with a p value of 0.000. The effect size was 1.47, a large effect size (Cohen, 1988).

<u>Grade Two Test Results</u>

As displayed on Figure 4.3, at the second grade level the treatment group had a pretest mean of 15.1 out of 24 items (a mean of 62.8%), with a standard deviation of 5.1. The control group had a mean of 17.3 (72.0%) with a standard deviation of 2.7. On the posttest, the treatment group had a mean of 22.3 (93.0%) with a standard deviation of 1.5. The control group had a mean of 20.6 (86.0%) with a standard deviation of 2.7.

Levene's Test of Equality of Error Variance showed that on the pretest, the error variance was not equal across groups. This violated the assumption of homogeneity of variances. Since the ratio of treatment group size to control group size in this study was 16/15 = 1.07 (less than 1.5), the F statistic was robust (Green et al., 2000).



<u>Figure 4.3:</u> Grade two test results

A 2x2 (pretest-posttest by control-treatment) mixed model ANOVA was conducted. The results for the ANOVA indicated a significant main effect for the within factor, $F(1, 29) = 52.35$, $p = 0.000$, partial $\eta^2 = 0.6$, a nonsignificant main effect for the between factor, $F(1, 29) = 0.071$, $p = 0.792$, partial $\eta^2 = 0.002$, and a significant interaction between pretest to posttest and group membership, $F(1, 29) = 7.17$, $p = 0.012$, partial $\eta^2 = 0.2$, a large effect size (Green et al., 2000).

Because the interaction between pretest to posttest and group membership was significant, the main effects were ignored. Follow-up tests were conducted on the simple main effects to explain the interaction, with the alpha value corrected to 0.025. There was no significant difference ($p = 0.145$) between the groups at the time of pretest. There was no significant difference ($p = 0.037$) between the groups at the time of posttest. There was a significant difference ($p = 0.000$) from pretest to posttest for the treatment group. There was a significant difference ($p = 0.004$) from pretest to posttest for the control group. The 95% confidence intervals displayed on Figure 4.4 also reflect the follow-ups.

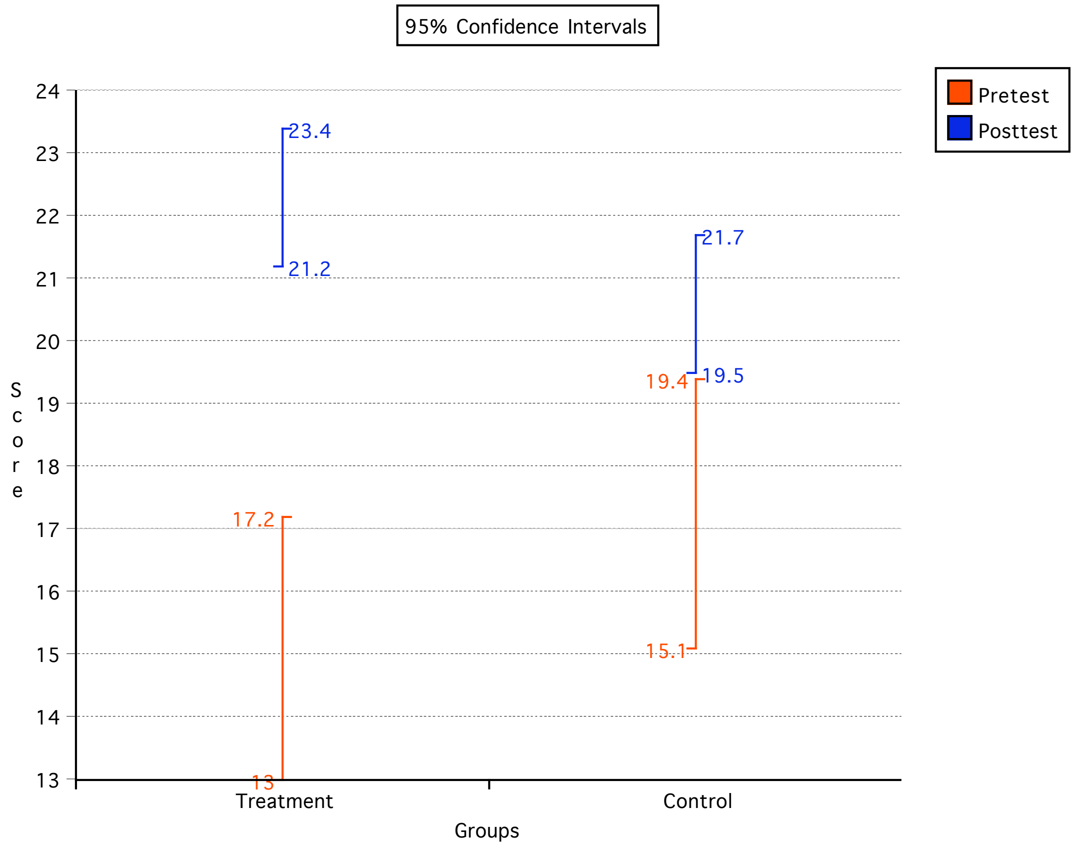


Figure 4.4: 95% Confidence intervals for grade two

A t-test was conducted to analyze the overall change for each group from pretest to posttest. The treatment group had a mean change of 7.25 with a standard deviation of 4.74. The control group had a mean change of 3.33 with a standard deviation of 3.20. The t-test showed a significant difference between groups, with a p value of 0.012. The effect size was 0.94, a large effect size (Cohen, 1988).

Observation (Mini-test) Results

Following the completion of the instruction and practice on an objective or set of closely related objectives, an observation, or mini-test was given to the students to determine the effectiveness of particular applets. According to Levene's Test for Equality of Variances, the assumption of homogeneity of variances was not met for Observations two, three, and four, so the Welch t-test, which does not assume equal variances, was used for all four observations.

Observation One covered Objectives 8.1 through 8.4 and included the geoboard and shape spinner applets. As shown on Figure 4.5, the treatment group had a mean of 15.5 out of 18 with a standard deviation of 1.5 and the control group had a mean of 13.8 with a standard deviation of 2.5. The t-test showed a significant difference between the groups, with a p value of 0.031. The effect size was 0.81, which according to Cohen (1988) is a large effect size.

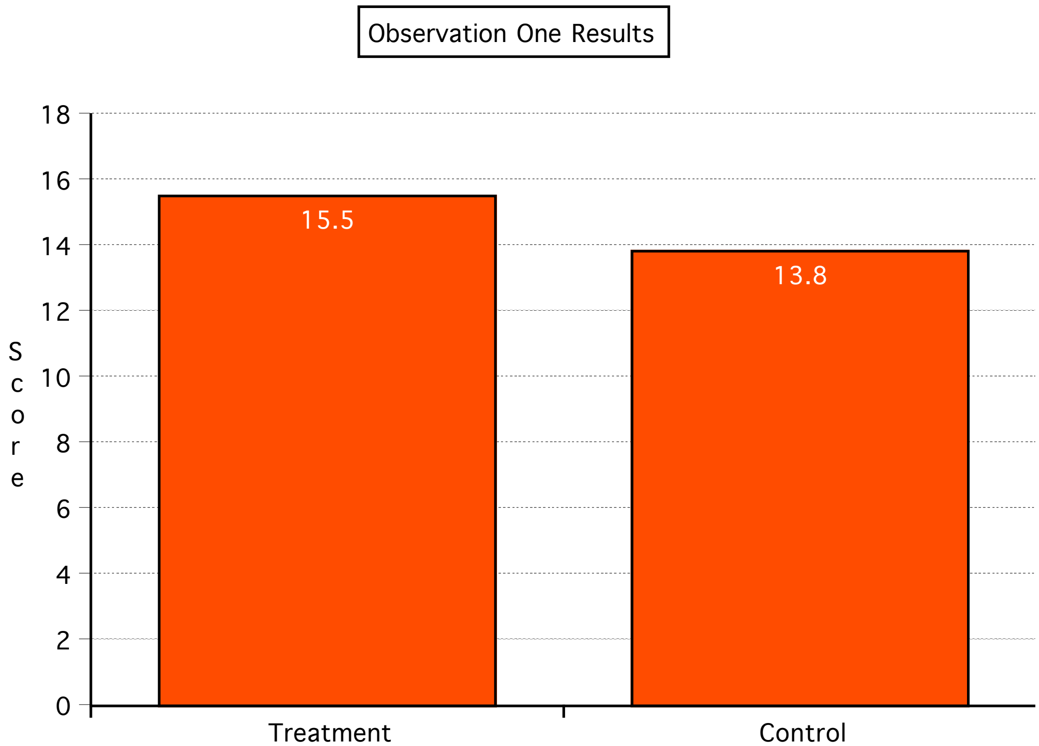


Figure 4.5: Observation One results

Observation Two covered Objective 8.5 and included the pattern blocks and polygon playground applets. As shown on Figure 4.6, the treatment group had a mean of 14.6 out of 15 with a standard deviation of 1.0 and the control group had a mean of 13.5 with a standard deviation of 1.4. The t-test showed a significant difference between the groups, with a p value of .026. The effect size was 0.84, a large effect size (Cohen, 1988).

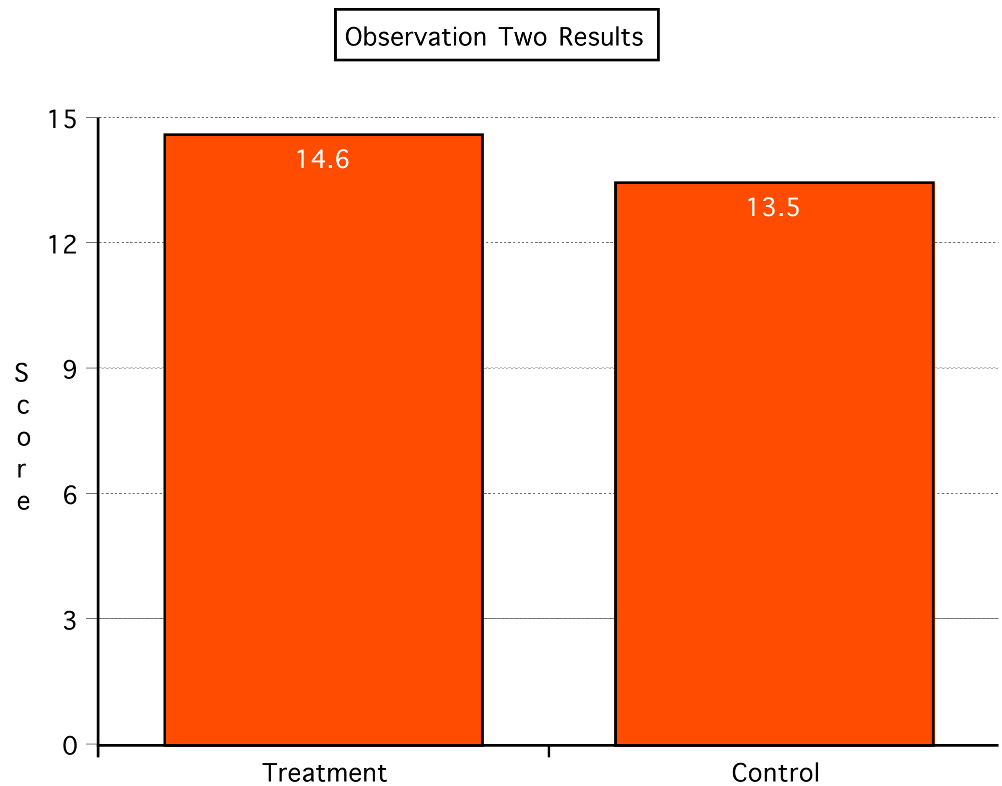
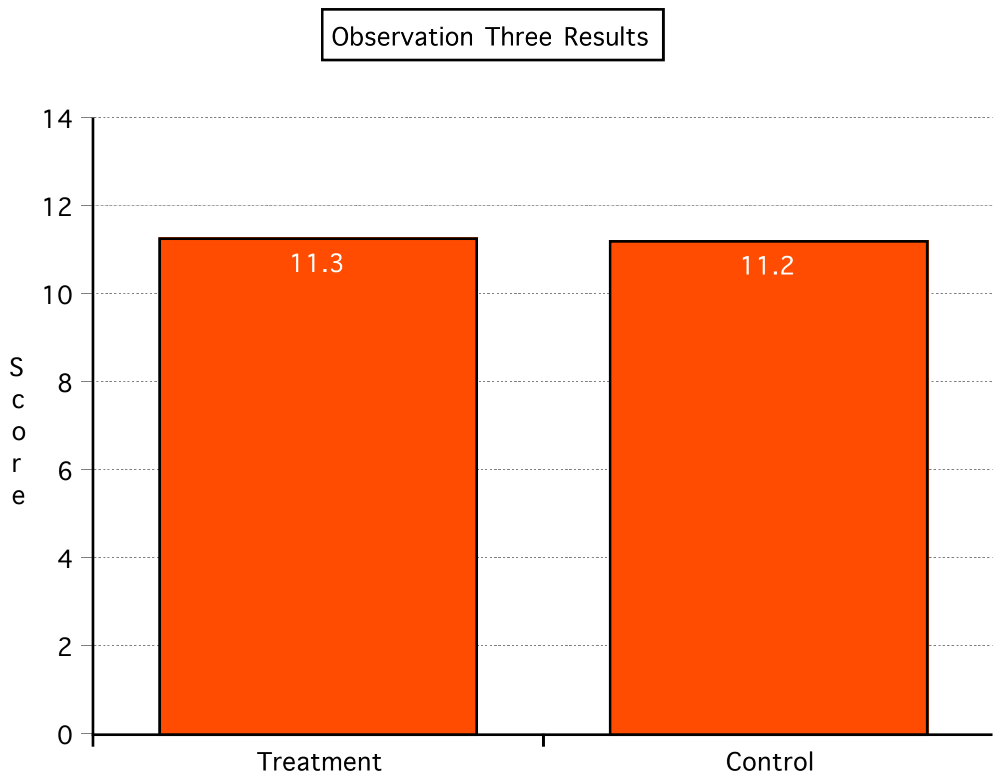


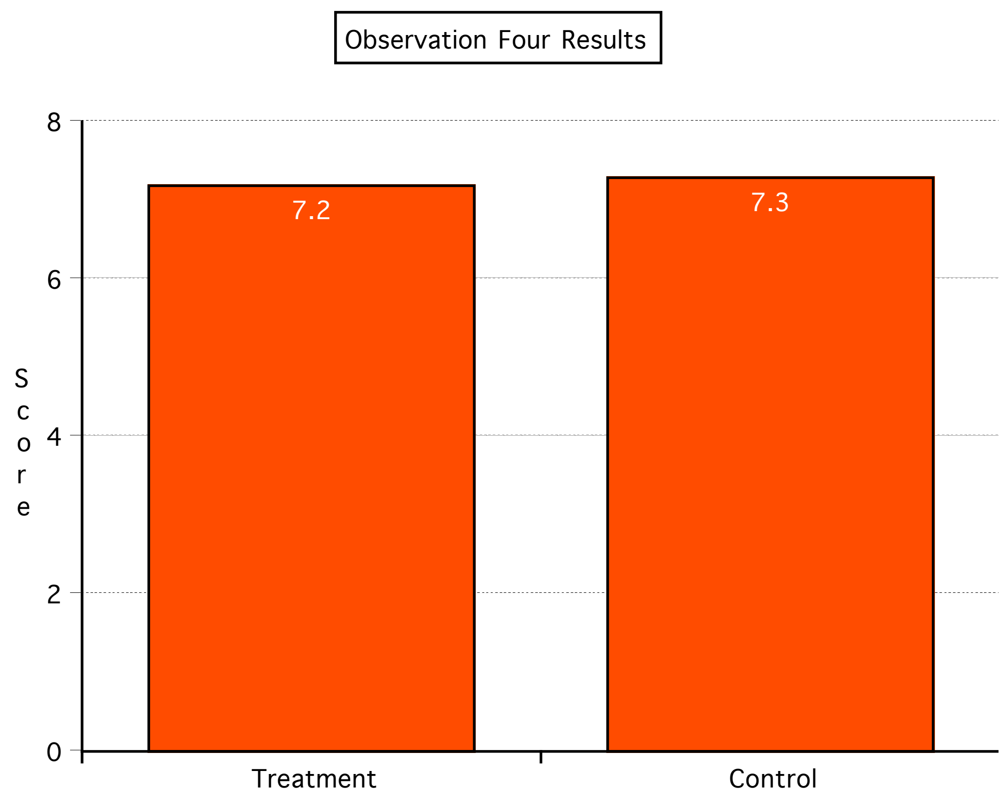
Figure 4.6: Observation Two results

Observation Three covered Objectives 8.7 and 8.8 and included the pattern blocks, pattern maker, and color patterns applets. As shown on Figure 4.7, the treatment group had a mean of 11.3 out of 14 with a standard deviation of 2.8 and the control group had a mean of 11.2 with a standard deviation of 2.5. The t-test showed no significant difference between the groups, with a p value of .959. The effect size was 0.02, a small effect size (Cohen, 1988).



<u>Figure 4.7:</u> Observation Three results

Observation Four covered Objective 8.9 and included the polygon playground and geoboard applets. As shown on Figure 4.8, the treatment group had a mean of 7.2 out of 8 with a standard deviation of 1.0 and the control group had a mean of 7.3 with a standard deviation of 1.0. The t-test showed no significant difference between the groups, with a p value of 0.822. The effect size was 0.08.



<u>Figure 4.8:</u> Observation Four results

Home Computer and Internet Access Survey

According to the United States Department of Commerce (2000), as of August, 2000, 51.0% of households in the nation had home computers, and 41.5% of households in the nation had Internet access. In Nebraska, 48.5% of households had computers, and 37.0% had Internet access. According to the parent/guardian survey, with all households responding, 77.4% of the participants' households had home computers and 64.5% had Internet access (Figure 4.9). The school had 43.4% of its population participating in the free and reduced lunch program compared to the state average of 31.0% (NDE, 2001). According to the United States Department of Commerce (2000), access to home computers and Internet increased with income. Home computer access ranged from 30.1% for households with an income from $25,000-$34,999 to 86.3% for households with an income over $75,000. Internet access ranged from 21.3% for households with an income from $25,000-$34,999 to 77.7% for households with an income over $75,000 (USDC, 2000)

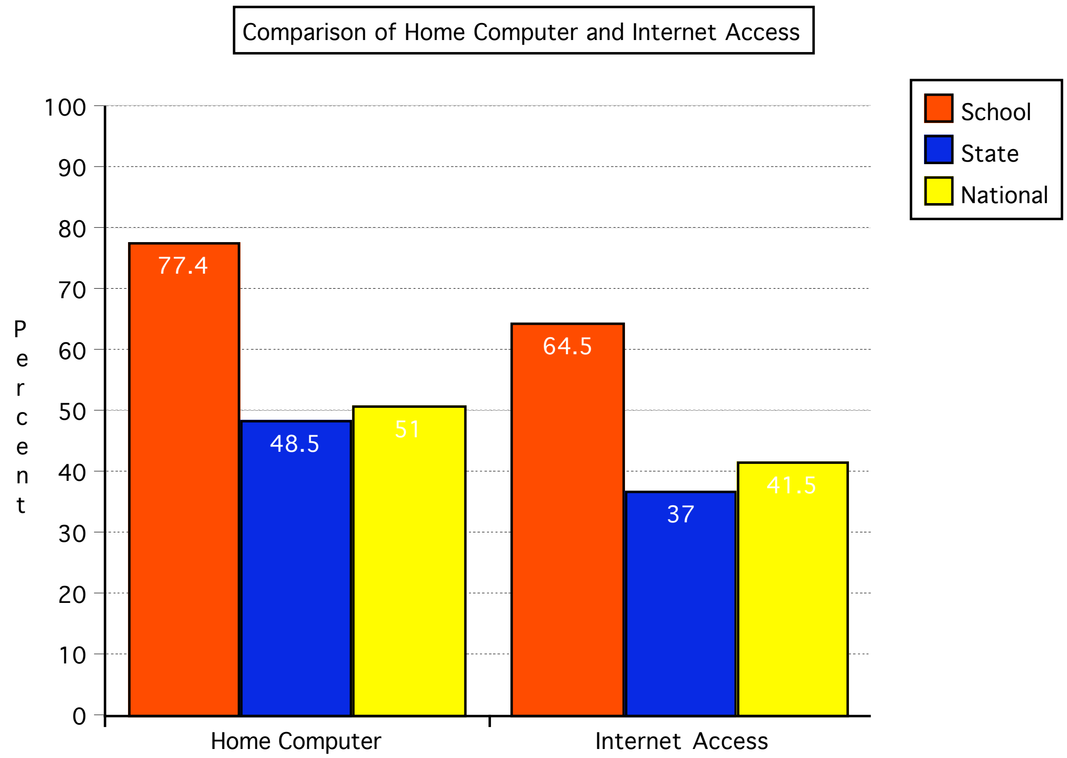


Figure 4.9: Comparison of home computer and Internet access

As shown in Figure 4.10, 75% of the treatment group had home computers and 68.8% had Internet access. In the control group, 80% had home computers and 60% had Internet access.

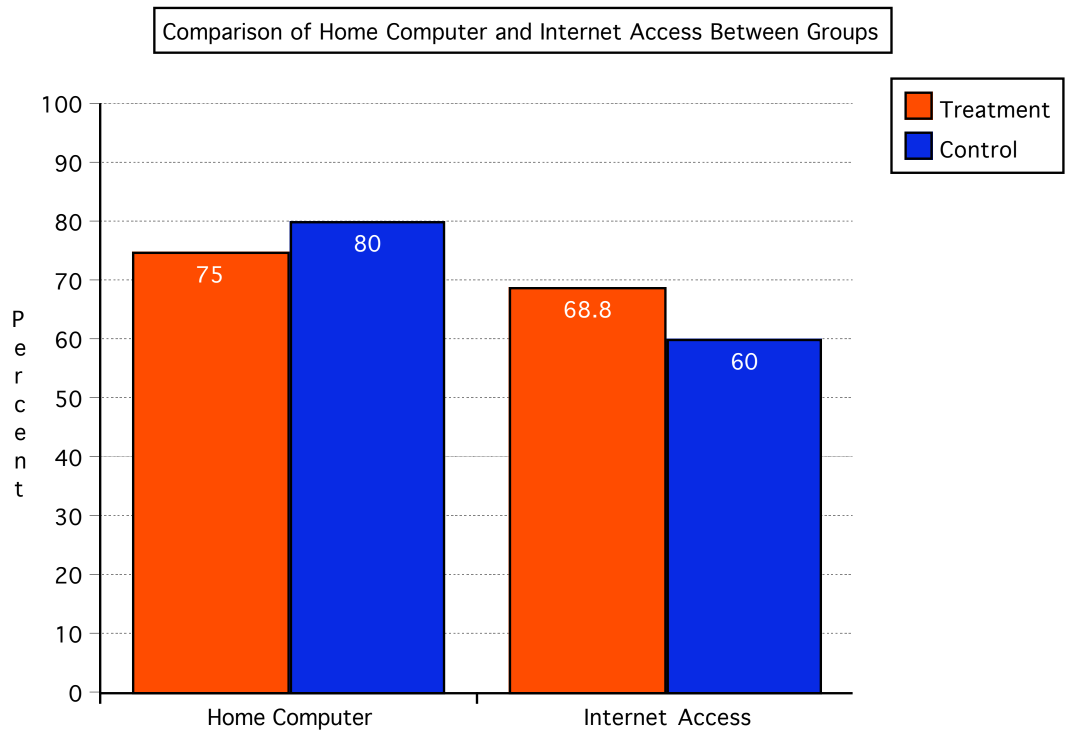


Figure 4.10: Comparison of home computer and Internet access between groups

As shown in Figure 4.11, in the treatment group, for students who had home computers, their parents reported that the student used the computer an average of 2.9 hours per week. In the treatment group, for students who had Internet access, their parents reported that the student accessed the Internet an average of 0.5 hours per week. In the control group, for students who had home computers, their parents reported that the student used the computer an average of 3.0 hours per week. In the control group, for students who had Internet access, their parents reported that the student accessed the Internet an average of 0.8 hours per week.

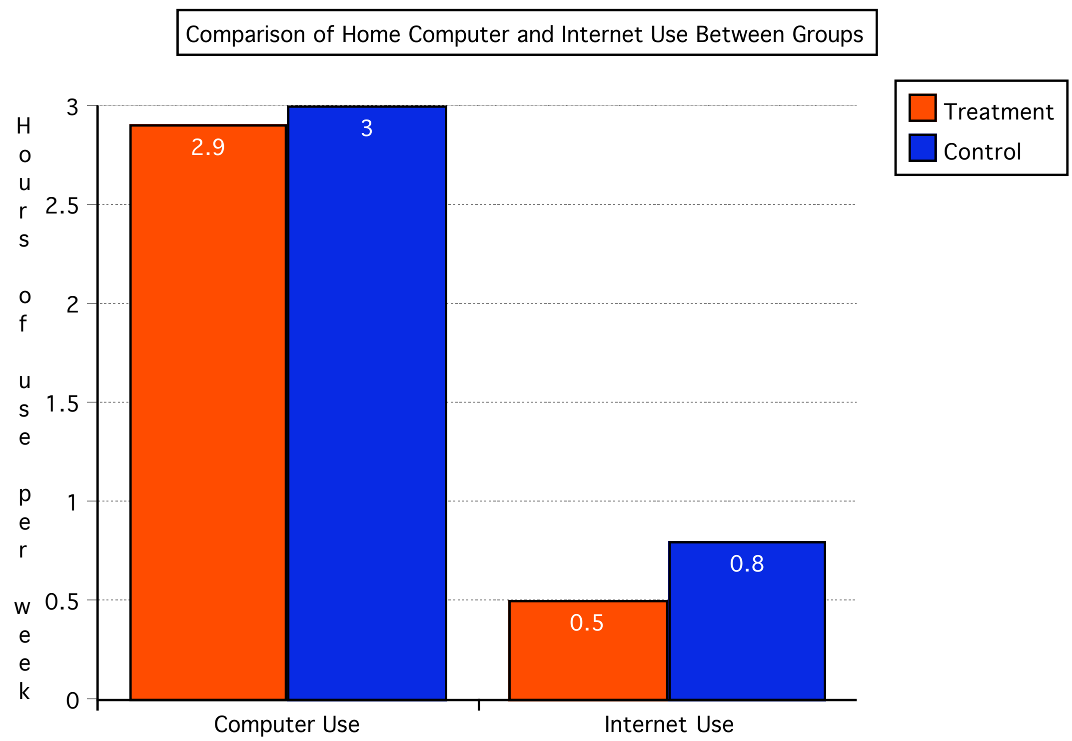


Figure 4.11: Comparison of home computer and Internet use between groups

CHAPTER V

DISCUSSION

Introduction

This chapter will address the first two research questions. They are re-listed below for convenience. Following the discussion of the first two research questions, the total cost of the study is presented. The third research question will be addressed in Chapter VI.

1. What differences exist among the academic achievement of first grade students who use the web-based geometry practice activities and those students who use traditional text-based practice activities?
2. Do particular web-based geometry practice activities have a greater impact on academic achievement than others?

Research Question One

On the first grade level pretest, the treatment group scored significantly lower than the control group (22.2 for treatment and 27.7 for control). At posttest, following the completion of the geometry unit, the treatment group closed the gap and actually slightly outscored the control group, though not at a significant level (30 for treatment and 29.9 for control). The post hoc analysis demonstrated a significant change within the treatment group from pretest to posttest, but no significant change within the control group. The change data also showed that the treatment group had a significantly greater overall improvement during the two weeks of the geometry chapter.

On the second grade level pretest, the treatment group scored slightly lower than the control group (15.1 for treatment and 17.3 for control). At posttest, following the completion of the geometry unit, the treatment group again surpassed the control group, but the difference was not statistically significant (22.3 for treatment and 20.6 for control). The post hoc analysis demonstrated a significant change within both the treatment and control groups from pretest to posttest. The change data also showed that the treatment group had a significantly greater overall improvement during the two weeks of the geometry chapter.

At both grade levels of posttesting, both groups actually ended up with excellent group mean scores, the lowest being the control group at the second grade test level with a group mean of 86.0%. Based on the data, the case could be made that this whole group of students would be ready for third grade level geometry instruction as second graders in their next academic year. The treatment group did overcome large gaps from pretest to posttest at both grade levels and had significant improvements from pretest to posttest at both grade levels. The control group only showed a significant improvement at the second grade test level. The results indicate that the use of the applets as an instructional tool was extremely effective for the treatment group, and perhaps more effective than the use of the traditional text activities. This echoes an observation by Bennett (1992) in a review of computers in math education:

> The computer appears to be a successful teaching tool when it is used by good teachers using appropriate teaching methods. It will make a good teacher better; it will not make a poor teacher an excellent teacher.

At the very least, the results demonstrate that the web-based applets were as effective as the traditional text activities and that the students at this age level were able to transfer what they learned in the symbolic environment of the computer to the paper and pencil environment of their tests. It needs to be reemphasized that the treatment group never touched actual physical geometry manipulatives during this study. What may ultimately be more important is the impact on students' attitudes, behaviors, and interactions as presented in Chapter VI.

Research Question Two

Based on the quantitative data collected from the observations (mini-tests), it is not possible to determine if one type of applet had a greater impact than any other. This may speak to the overall high quality of all the applets as created and reviewed by the MarcoPolo project. For example, a significant difference ($p = 0.031$ with an effect size of 0.81) was found on Observation One, which was conducted after the students had used the geoboard and shape spinner applets. However, on Observation Four, no significant difference was found (with the control group actually outscoring the treatment group 7.3 to 7.2 out of 8 items). Observation Four was conducted after the students had used the geoboard and the polygon playground applets. So what was the difference? Perhaps it was the use of the polygon playground. However, the polygon playground (along with the pattern blocks applet) was part of Observation Two. Observation Two found a significant difference ($p = 0.026$ with an effect size of 0.84). So was it the pattern blocks applet that was so effective as to make-up for the polygon playground? Observation Three, which covered the use of the pattern blocks applet as well as pattern maker and color pattern applets, also showed no significant difference.

Overall, the results demonstrated that all of the applets were effective. Based solely on the quantitative data collected, it is not possible to determine which particular types of applets were most effective.

In Chapter VI, Karla provides more detailed qualitative insights regarding which aspects of each applet were most beneficial. The amount and quality of feedback (both direct and indirect), was one element that Karla discussed. Instant feedback is regarded as an effective and motivational feature of computers and video games (Chaffin, Maxwell, & Thompson, 1982). Video games, which are so appealing to kids, are a model of how instant feedback can motivate children. As soon as a child makes a decision in a video game, they know within a matter of seconds the results of that decision, and will often return to try a different decision path. In terms of student interaction and motivation, Jenkins (2002) writes:

> Games create opportunities for leadership, competition, teamwork and collaboration — for nerdy kids, not just for high-school football players. Games matter because they form the digital equivalent of the Head Start program, getting kids excited about what computers can do.

The type and amount of feedback that is present in video games is recommended for educational software (November, 2002). In the case of the color pattern applet, students did not have to wait for to Karla check their work. With the click of a button, the applet directly and immediately indicated if they were correct. The tangram applet allowed students to ask for a hint if needed, without having to wait for Karla to offer advice. Features such as use of colors on the geoboard and the ability to mark sides and corners on the shape spinner provided indirect feedback for the students. While such features didn't provide direct feedback on the students' accuracy, they definitely made it easier for the students to self-regulate and make adjustments individually and privately. Karla also noted that these same indirect features made it easier for her to check their work by quickly glancing at the computer screens as she moved around the classroom. Karla's observations mirror what Shute and Miksad (1997) discussed in their study of the use of computers with preschoolers:

> Under real-life classroom conditions, the computer may indeed be beneficial by providing feedback more readily than a busy teacher.

Another benefit that Karla reported was the instructional time saved. Students did not have to clean-up rubber bands, they did not have to put away pattern blocks, they did not have pass out manipulatives, and re-doing an activity was not an ordeal. The advantage of this time saved was the increased amount of time-on-task and increased number of repetitions of a practice activity. Several times Karla noted that her students were able to do more practice with the applets than her previous classes had done when using actual manipulatives.

Karla also discussed the benefit of the flexibility of the applets. Several of the applets were used for more than one objective. As the students became more comfortable with using the applets and the computers, they were able to spend less time learning simply how to use the applet, and could focus more on the objectives for the lesson. One example of this flexibility of use is how the geoboard applet was utilized for three objectives on three different days.

Flexibility of an applet does not just refer to how many objectives it can cover. It also refers to how the applets can do some things that actual manipulatives cannot do as effectively or efficiently. Karla noted that the shape spinner applet's ability to rotate a three-dimensional shape enhanced the students understanding of sides and corners. Students were able to see how a three-dimensional shape was comprised of several individual faces, comprised of the sides and corners they were identifying. Karla reported that this allowed students to go more in-depth than previous classes had done without the applets. She also observed that the applets allowed students to adapt the activity to meet an appropriate level of challenge. While using the pattern blocks applet, students could make more complex patterns or more simple patterns. Either way, it was the students' individual choice and private. More often than not, Karla noted that students challenged themselves to higher levels, utilizing the features of the applets. The overall flexibility of the applets is one main reason why it was difficult to quantify which applets had the greatest impact. Perhaps one measure of an applet's quality and potential impact is simply how flexible the applet is.

Another benefit of the applets was that it allowed for every child to have equal access to the same high quality lessons and activities. Students did not have to wait to take turns to share manipulatives, which again increased time-on-task and number of repetitions. In terms of educational equity, if these applets were used in an entire school district, it would mean that all children would have equal access to high quality and effective materials.

A final benefit was that two of Karla's students who have difficulty with the motor skill of writing were able to easily use the applets. This allowed them to focus on the math objective instead of on the difficulty of using a pencil or stretching a rubber band across an actual geoboard. Karla reported that these two students typically struggled in math. Using the applets, these students excelled in math.

Total cost of study

To obtain all the necessary technology for this study, four computers were borrowed from a local university, eleven computers were borrowed from Apple Computer, Inc., one computer was borrowed from the state Department of Education, and one computer was borrowed from the school. The wireless base station was borrowed from the Department of Education, and the projector was borrowed from the school district. It is unfortunate that the school was only able to provide one computer and did not simply have all of the necessary technology available on-site. The two computers that would have been available in the teachers' classrooms at the school were all at least seven years old and incapable of running the applets. Also, no projection device was available. The school had a computer lab with a projector and modern computers, but the lab was not available for the times of this study. The lab is typically not available to classroom teachers as it is used to teach "specials" and to cover teachers' preparation periods. This is yet another barrier to effective technology integration at this school and many other schools. All of the "good stuff" is in a lab, and all the "old stuff" is in the classroom, typically with no projection device. Some solutions that schools are implementing to overcome this barrier include the use of mobile wireless labs, laptops for every student, or a combination of computer labs and laptops or modern computers in classrooms.

Of course, it is not inexpensive to incorporate technology into classrooms; however, it is also not inexpensive to purchase textbooks and "real" manipulatives. A cost comparison of the technology used by the treatment group and the textbooks/manipulatives used by the control group is shown below. Prices for the computer equipment were obtained from the online Apple Education Store (Apple, 2002).

Treatment Group	
Projector:	$3000 (LPS, 2002)
One teacher iBook®:	$1699
Sixteen student iBooks® at $1099 per computer:	$17,584
Seventeen Airport® cards at $91 per card:	$1547
One Airport® base station:	$269
	Total = $24,099

Control Group	
Math texts: Fifteen student texts and one teacher text:	$390
Activity workbooks, review books, skill pad, etc.:	$1865 (approx.)
Geometry manipulatives:	$310 (approx.)
	Total = $2565

The treatment group also utilized the math text (but never touched any "real" geometry manipulatives) at times when no corresponding web-based activity was available, so that would actually increase the overall cost. While the cost of the technology was higher than the math texts, this technology could easily be shared among many classrooms in a school and the technology could be used in all subject areas. The first grade math materials are of little use in any other grade level. An additional cost consideration for the control group is that their texts and practice books are consumable items; they are annually recurring costs. Also, the total cost for the control group is only for the subject of math. The approximate total cost of the control group would actually be multiplied by all the subjects that require texts. Schools could potentially eliminate texts and workbooks for some subject areas or at least reduce the number ordered and allocate that money for additional technology resources and training.

The "computers replacing textbooks" debate (or at least reducing the use of textbooks) is outside the scope and purpose of this study. Again, in this study, the treatment group utilized textbooks for some objectives. Also, the objectives and sequence of instruction were taken from the text. However, the reduction of textbook purchases is an issue that schools may wish to consider when making purchasing decisions. Concepts such as total cost of ownership of technology and useful life cycle of a text obviously need to be included in any such discussion. Future technologies may truly blur the line between what a laptop computer is and what a textbook is to the point where no debate will be warranted.

CHAPTER VI

TEACHER THOUGHTS

Introduction

To investigate the third research question, “What are the treatment teacher’s impressions and observations on student attitudes, behaviors, and interactions when using web-based activities?” the treatment group teacher, Karla, kept a daily journal of her thoughts and observations regarding each lesson. She focused on the benefits or drawbacks of each applet and the use of technology. She included comments on student behaviors, attitudes, and interactions. This chapter will present Karla’s observations as well as include discussion regarding the third research question.

The researcher was present at the school each day of the lessons to provide technical support if required. The researcher stayed out of the classrooms and let the teacher and students work through any computer glitches as much as possible. There were only a few instances where the researcher assisted with troubleshooting. Near the end of the study the researcher did not enter the room at all as both Karla and her students had become more comfortable with using the computers, and they learned how to restart an application or reboot the computer if needed.

May 7, 2002

This was the first day for the students to use the computers and the geometry applets. The computers and applets had been demonstrated and explained to the students during the prior week. This was the first opportunity for the students to use the applets themselves. Karla noted that the students were extremely excited about using the computers. Objective 8.2 was covered (which reviewed the plane shapes: square, triangle, rectangle, and circle). The treatment group students used the geoboard applet to practice forming the plane shapes; the control group practiced on a regular geoboard with rubber bands. Students worked with partners. One student made a shape, and then their partner made the same shape, but larger or smaller.

Karla found this activity to be effective for several reasons and observed that a majority of the students were very excited and eager to take part in the activity. Even students typically less interested in learning were motivated and on-task, as Karla noted:

> I found that many students who I have often observed being fairly passive in their learning, were quite active. We were able to accomplish more because students were focused on the objectives of the activity.

The computer applets also provided some features that are not available when using a regular geoboard with rubber bands. One very practical benefit Karla mentioned was that the students did not have to deal with the distractions of flying and breaking rubber bands or arguing over who got which geoboard. Also, to increase time-on-task, when students were ready to start a new formation, they could do this by simply pressing a button to clear their board. Another way that time-on-task was increased was that clean-up time was dramatically reduced. Students simply had to close their computer, as compared to plucking off the many rubber bands, putting them back into their bags, and stacking the geoboards. As a result of these timesaving elements, the students could do more repetitions of the practice activities. Karla wrote:

> I felt we were able to add more to our study of the objective as a result of using the computers. The applet allowed students to color in the shapes they made. This is not possible with regular geoboards. I was able to ask students to make their shapes certain colors. For example, I had one student make two triangles and two squares. Then, their partner was to color the triangles blue and the squares red. This definitely would not have been possible without the applet.

The use of color-coding provided Karla with a way to quickly and easily check student work for accuracy and helped students monitor their own work and their partner's work.

In terms of student behaviors and attitudes, Karla noted:

> One interesting thing I observed today was that two students who tend to struggle a bit with math, excelled in the activity today. Interestingly, these are students who dislike writing and have difficulty with the motor skill of letter/number formation. They felt really good about themselves and had a lot of confidence. I am anxious to see how they do throughout this unit.

May 8, 2002

Objectives 8.3 and 8.4 were covered (sides and corners). Students were to learn that the number of sides and corners is always the same in a given shape and that shapes that have the same number of sides and corners do not have to look exactly the same. The first practice activity utilized the geoboard applet. Since this was the second day using the geoboard applet, the students were able to quickly get to work and focus on the objective for the day, with only minimal review of how to use the applet. Karla noted:

> If I had the opportunity to use these programs in future years, I learned that I would want to use them as early as possible in the year for many different objectives. I think the more comfortable students get with using the programs, the more productive their practice time will become.

For the practice activity, students worked with partners to create a shape with a certain number of sides or corners. Then, their partner was asked to create a shape on the geoboard with the same number of sides and corners, but which looked different. Karla found that the applets made this task easier for her students and wrote:

> I was impressed to see many students challenging themselves to make shapes with a large number of sides/corners. They seemed much more willing to try this than in previous years when I have done this activity with regular geoboards. When

> forming shapes with a designated number of sides/corners on geoboards, it is often a process of trial and error for students. I found students more willing to keep trying until they got it right than I have seen when working with regular geoboards. I feel this could be because they enjoy using the computer program more, and it is much less cumbersome and taxing to form the shapes on the computer than when working with the actual boards and rubber bands. It doesn't seem so overwhelming to them to have to start over and try again.

The feature of the geoboard applet that clears all the bands with the click of a button again allowed for more repetitions of the practice activity and increased time-on-task. A student who made an error did not need to remove several rubber bands; a correction could be made much more efficiently.

The second practice activity of the day was the shape spinner applet, which consisted of three-dimensional shapes that students were able to rotate, mark sides and corners, and zoom in or out. Students could also color-code the faces of the shapes. This applet was probably the most difficult for the students to learn how to use. As Karla noticed:

> The part of the program that we struggled a bit with was that students had to hold the shift key while clicking on the parts of the shape in

> order for them to be marked. However, once students got used to it, it was not an issue. It just took a little time.

Despite the initial struggle with using the applet, Karla felt that this applet enriched the lesson. She wrote:

> I felt this program was beneficial because students were able to see that three-dimensional shapes have many sides and corners. This is more in-depth than I have gone in the past when teaching this lesson without the computer program. We have typically just focused on flat shapes. Also, by outlining the sides and corners, they were able to easily see the shapes of the individual faces.

As part of the lesson, students also practiced counting the total number of sides and corners on the faces and the shapes. The marking component of the applet helped the students accomplish this task. Karla commented:

> When I have students count the sides and corners of a shape on paper, I encourage them to mark the sides and corners as they count them. I liked this program because it allowed students to do this without having to write anything, which can be difficult for some students. Also, students sometimes mark the same side or corner

> twice on their paper and lose track of how many there are altogether. This program prevents that.

<u>May 9, 2002</u>

Objective 8.5 was covered (congruent shapes). The first practice activity used the pattern blocks applet, which allowed students to make designs with the traditional pattern block shapes by clicking and dragging them on a grid. Karla began by using the projector to show a design. Then, students created a design that was congruent. Later, with partners, student created a shape on their computer, and their partner created a shape that was congruent. Using the projector, Karla also asked students to create a congruent shape that was rotated. Karla appreciated the rotate feature of the applet and wrote:

> One of the things that I like about this program is that it allows students to rotate the individual pattern block shapes easily. This reinforces the knowledge that shapes that are rotated in different directions can still be congruent.

The applet also made it easier for the student to create their shapes, as Karla noted:

> Another advantage of this program is that students have an unlimited supply of pattern blocks with which to work. They don't have as many when they have to share the actual

> manipulatives. Also, when working with actual pattern blocks, the shapes students make tend to get shaken or moved. It is difficult to keep their shapes intact long enough for a partner to form the congruent shape. This is not the case with the computer program. One of the only disadvantages of the computer program that I observed was that sometimes it was difficult for students to get the shapes exactly where they wanted them. The grid they were placing them on inhibited them at times.

The second practice activity of the day used the polygon playground applet. This applet allowed students to drag shapes of different sizes and colors to make designs. Karla used this program by creating a design on the projector and having students create a congruent design on their computers. They did the same activity with their partners. Karla felt that this applet was a good complement to the pattern block applet and wrote:

> I liked using this program in conjunction with the pattern block program because it demonstrated to students that many different types of shapes can be congruent, not just shapes made from the pattern blocks. I think this helped them generalize the skill.

Karla also found that even though applets were selected for their ability to meet certain objectives, they were also useful for reviewing and reinforcing other objectives. Karla wrote:

> The program was also useful for reinforcing the skill of identifying and counting sides and corners. Students were able to count the sides and corners of the various polygons to make sure they were making congruent designs.

One drawback of the polygon playground was that, unlike all the other applets, this one lacked a reset or clear-the-screen feature. The only way to accomplish this was to refresh and reload the applet, which tended to be time consuming. Students tried to work around this by just moving their individual shapes back to the "shape area" one at a time.

Today was also the first observation or assessment day. Part of the assessment required students to create a shape on their geoboard with a designated number of sides or corners, and then draw the figure they had formed on dot paper. Karla wrote:

> I noticed several students struggling a bit to transfer what they had made on their geoboards to the paper. One thing that makes this more difficult is that the geoboard on the computer has more dots than are on the actual geoboards and on the dot paper. I am learning that it is important to have a balance of computer and paper/pencil practice activities. This is

> especially important if students are assessed with paper activities. However, I feel computer assessments are also extremely valuable.

<u>May 10, 2002</u>

Today students worked with the tangram applet for the World Games activity. This applet allowed students to click and drag shapes to make tangram designs and add color to their designs. Once again, while the primary purpose of the applet was to practice making tangram designs, the applet was also utilized to review and reinforce prior learning. Karla noted:

> This program helped reinforce the concepts of sides and corners because students were able to count them in the tangram shapes. It also reinforced the concept of congruence. The shapes could be rotated, so students could see that a shape can be congruent even if it is in a different position.

As Karla and the students became more accustomed to using the computers and web-based activities, other unforeseen benefits began surfacing. The first benefit was that some of the applets allowed the students to select an appropriate difficulty level, without having other students know if they needed extra help or not. Karla wrote:

> Students, who want to challenge themselves, can make their own designs with the blocks. They can also pick a pattern to fill in. Additionally, they have the opportunity to ask the computer to

> give them hints. I found this to be helpful with students who were struggling. This range of levels of difficulty is not as easy to provide without the computer program. Also, because students have their own computers, the level they choose to work on is more private. Therefore, students felt more comfortable picking an activity with which they could be successful.

A second benefit was that the students were getting quite proficient with the set-up and operation of the computers. This allowed students to get more done, as Karla noted:

> Students were extremely focused today and actively involved during the entire practice time. I find that we are getting more done as the students and I become more comfortable with using the computers. They are also being more helpful in the set-up of the computers. For example, they are now able to plug in their own computer mouse.

A third benefit of using the computers was the realization by the students of just how portable the computers were. Karla wrote:

> Often today, I found that a student would want to share what he/she had created with me. If I

> were working with another student, I would just ask them to bring it to me. They were a bit surprised and impressed with the mobility of the computers. I don't think they were very aware of this before.

Finally, Karla noticed today that the students were beginning to take interest in using the trackpads instead of the mouse. She noted:

> I feel this would be useful if I wanted the students to move around more with their computers or sit on the rug for a group activity. It would be much easier if students do not have to move the mouse with them. I found that this was a new skill for most students. They were intrigued by it, but seemed to feel more comfortable with the mouse. However, I'm sure that with more practice, they would become skillful with the track pad.

May 13, 2002

Objective 8.7 was covered (recognize, identify, make, and extend patterns). The first practice activity used the pattern blocks applet. This applet had been used for a previous objective, demonstrating the flexibility of the use of the applets to meet multiple objectives. Karla began by having students look at a pattern she made on the projector. She then asked them to identify the pattern and determine what would come next. Karla found that the applet allowed her to work with patterns not easily created with traditional pattern blocks and wrote:

> I demonstrated how one could make a pattern out of designs they make with pattern blocks, instead of just having a simple pattern of individual blocks. This is something I have not done previously without the computers.

Karla then had students design certain kinds of patterns, such as an AABAAB pattern, using any particular pattern block they wanted. As a final activity with the applet, students worked with partners. Partners made a pattern on their computer, and then their partner tried to determine what the pattern was and what would come next. Karla noted increased complexity of patterns, more practice time, and better behavior. She wrote:

> The students did a great job with this activity. Several made patterns out of designs they had made with their blocks. There were some fairly complicated patterns! They got in many more practice repetitions than they normally would have using manipulatives or paper/ pencil activities. There was also less fighting over blocks because students had their own, unlimited supply of them on the computer.

The second applet used was the pattern maker applet, which allowed students to create and run patterns up to five units at a time. The pattern was repeated on a grid, and students could control the speed of the repetitions. Karla had the students complete several exercises with this applet. She asked students to look at a pattern she had made and predict what color the first box on the next line of the grid would be. Students were asked to make a pattern that resulted in the vertical lines of the grid matching and then not matching. Karla reported that a few ambitious students even made patterns where the diagonal lines on their grid matched. Karla appreciated the flexibility of the applet for use with different levels of challenge and wrote:

> One of the things I like best about this program is the higher-level problem solving skills that can be worked on. This particular program made practicing skills like prediction and determining pattern rules relatively simple.

With the study nearing completion, Karla began to reflect on the usefulness of having a projector for instruction. A barrier for effective technology integration at this school is the lack of modern computers in the classroom, coupled with no available presentation system for the teachers. Karla commented on using the projector:

> One of the tools that I am finding to be extremely beneficial is the projector. It is very helpful to be able to demonstrate how the programs work for students on the screen. It is also valuable for showing examples and giving students activities to practice. When we were working on congruent shapes, I made a shape with the pattern block program. Then, students could

> look on the screen and make a congruent shape on their own computers. I think that a projector is a necessary piece of equipment to ensure the success of activities like these.

<u>May 14, 2002</u>

Objective 8.8 was covered (identifying, recognizing and making patterns). Students used a color pattern computer program as a practice activity. This applet displayed a pattern of colored dots with four clear dots containing questions marks at the end of the pattern. Students worked to figure out the pattern and fill in the open dots to complete the pattern correctly. A check button allowed students to check their answers, and another allowed students to start a new problem.

This applet contained the most direct feedback of all the applets. Karla felt that the self-check feature was one of the biggest benefits of the applet. She found that the feedback helped guide students' practice, promoted positive attitudes, increased motivation, and increased time-on-task. She described its usefulness:

> When students complete the problem correctly and they press the check button, the computer screen reads, "Good job." When they are incorrect, they are asked to try again. Students can keep trying until they get the correct answer. Also, if they get extremely frustrated, they can press the new problem button and move on to the next pattern. Therefore, it is appropriate for students of many different ability levels. Answers are

private, so students are not embarrassed if they get a problem wrong. Therefore, I feel they are more apt to keep trying to get it right. Students enjoyed the feedback from the computer and were motivated by it. It kept them focused on on-task. I find that often first graders want the teacher to see and check everything they do to make sure it is right. When using this program, they didn’t need as much feedback from me. They were able to get more practice in rather than waiting for me to get to them. I was pleased with the engagement of students while working on this program. Students were working on the program the entire time with very few distractions. The variety of patterns that showed on the computer was motivating and interesting to students. They were excited by “hard” patterns. They were also thrilled when they were shown an “easy” pattern such as dots that were all the same color. They were motivated to keep moving to see what pattern would come up next. I was extremely pleased with the amount of practice each student got with this program. They completed a great deal more

> patterns than they would have with activities not involving the computer.

<u>May 16, 2002</u>

Objective 8.9 was covered (symmetry). Students worked on recognizing and creating symmetrical pictures and designs. The first applet used was the polygon playground. Students were able to drag down shapes of different sizes and colors to create symmetrical designs. Although the applet didn't have a clear button, as discussed previously, it still was effective for the symmetry practice. Karla wrote:

> One of the things I like about this program is that if a student has created a design that is not symmetrical, it can be easily corrected. If they were drawing or painting on actual paper this would not be the case. I think it would also be nice for students to print out one of their designs.

The second practice activity utilized the geoboard applet. Students made symmetrical pictures and designs on their computer geoboards. They used bands to make lines of symmetry on their designs, finding horizontal, vertical, and diagonal lines of symmetry. This was the third time the students used this applet, and the students had become quite proficient at it. Karla recognized the benefit of this proficiency and noted:

> It reinforces the idea for me that it is important to use these programs with students often and early in the year. They got so much

> done today because they knew exactly how the program worked.

An advantage of the geoboard applet over a traditional geoboard is that students can add color to their designs, by using different colored bands or by filling in shapes with different colors. Karla felt that the coloring helped students see the symmetry even more clearly.

Overall Thoughts

At the completion of this research project, Karla wrote a reflection article discussing the impact of the applets on the students and her own teaching. She reinforced that the applets kept students focused, increased the quality and quantity of practice, adapted to appropriate difficulty levels, and had other features not available when using traditional paper and pencil or manipulative activities. She discussed the need for teachers to be proficient with the use of the applets, have time to find appropriate computer activities, have access to presentation systems, and to have computer troubleshooting skills. Her overall thoughts are below:

> I have had a lot of fun working with this project. My students have enjoyed it as well. It was enlightening for me to see how computer programs could be used to help meet our objectives. I found them to be extremely effective in doing this for several reasons.
>
> First of all, students were more focused while using the computer programs. They were on task a vast majority of the time during practice

activities. They found the programs interesting and were excited about using them. I was pleased with their active involvement in their learning.

Another benefit was that both the quality and quantity of practice was improved. The computer allowed students to compete activities quickly and fairly independently. Thus, they got in more practice repetitions. For example, on the color patterns program, students could complete the pattern by clicking colors, self-check, and move on at a very efficient pace. They didn't have to spend time coloring in objects on paper or getting out and sorting manipulatives. Also, students were able to practice skills in a more in-depth way. For example, when studying sides and corners, we used the shape spinner program. Students were able to find the number of sides and corners on three-dimensional shapes rather than just plane shapes. Many programs allowed students to use color. This added a different aspect to several activities.

I was encouraged to see how most of the programs could be easily adapted to meet the needs of students of all different ability levels. I had a wide range of ability levels in my group, and they all seemed to feel comfortable using the programs. They also all experienced success. In fact, I found that two students who typically struggle in math excelled in this unit. These two students have difficulty with the motor skills of writing and avoid it whenever possible. I think that computer practice activities are a wonderful tool for teaching all students, especially those who might have motor difficulties.

I learned several things I think teachers need to do in order to make computer program practice activities successful. I found that it was extremely important for me to know the programs very well before presenting them to students. I needed to know how I was using them to meet my objectives. I also needed to know how I wanted to explain them to students. The projector was an invaluable tool for demonstrations and examples. I also learned that set-up is an important aspect. Teachers need to plan for and become proficient in setting up the programs and troubleshooting when problems arise both prior to and during student use. I think students can also learn to do this, but the teacher must be able to show them how. I found that it was most helpful when students had their own computer. They were more actively involved, with much less down time. Partner activities were very valuable, but it was best when they could each work on something and then look at their partners' screens.

I feel that teachers should use the programs as much and as early in the year as possible. The more familiar students are with the programs, the more comfortable they become. Thus, they get more done and experience more success. I feel that it is helpful for students to use different programs for the same objective. This helps them to generalize the skills and not limit themselves.

One of the challenges I see in using computer practice activities in the future is finding the programs to match the specific objectives on which we must focus. I feel this would be quite time consuming. I think it would be helpful for different teachers and computer resource people to work together to do this. Perhaps a school could keep a running list of the programs teachers have used for what objectives.

I have really enjoyed using these computer programs with students over the past two weeks. It has been a beneficial experience for students as well as myself. Students learned a lot about the geometric objectives we worked on and I have learned a lot about using computer programs as practice activities. I would definitely consider using programs like these in the future.

CHAPTER VII

SUMMARY AND RECOMMENDATIONS

Introduction

This chapter provides a summary of this study, which involved the use of geometry applets in a first grade math unit. Following the summary, recommendations for future research and a conclusion are presented.

Summary

This research study was a two-week long investigation of the impact of web-based geometry applets on first grade students. These applets were created or reviewed as part of the MarcoPolo Educational Foundation. The study was designed to answer the following research questions.

1. What differences exist among the academic achievement of first grade students who use the web-based geometry practice activities and those students who use traditional text-based practice activities?
2. Do particular web-based geometry practice activities have a greater impact on academic achievement than others?
3. What are the treatment teacher's impressions and observations on student attitudes, behaviors, and interactions when using web-based activities?

Thirty-one first grade students were randomly assigned to either the treatment or control group. Both groups studied the same geometry objectives, but the treatment group used the applets for practice unless a corresponding applet was not available. A pretest and posttest at both first and second grade levels was conducted, as well as four observations or mini-tests to investigate the impact of individual applets.

The pretest results showed that the treatment group started out at a lower level of understanding of the geometry concepts than the control group, and at a significantly lower level on the first grade test. Posttest results showed that by the end of the study, the treatment group had closed the gap and actually outscored the control group on both grade level tests, though not at a significant level. The treatment group had significant improvements on both grade level tests, while the control group only had significant within group improvements on the second grade level test. Change data was analyzed to compare overall posttest to pretest changes between groups, and the treatment group had significantly higher improvements on both the first and second grade level tests.

The treatment group teacher recorded her daily thoughts regarding the applets, the use of technology, and observations regarding student attitudes, behaviors, and interactions. Karla reported increased instructional time, increased repetition of practice activities, increased time-on-task, and increased feedback. She noted that students showed increased motivation and challenged themselves to higher levels. Most notably, she reported that two students that had difficulty with the motor skill of writing were able to easily use the applets. These two students typically struggled in math, yet excelled when using the applets.

Karla also commented that she had become more comfortable with the use of technology and would definitely use the applets in the future. A continuing barrier for Karla and her future students will be access to modern technology devices. She has limited access to a projector and modern computers. This is truly unfortunate considering the findings of this study and the growth that Karla and her students demonstrated in their technology abilities.

Recommendations for Future Research

It would be beneficial to repeat this study with a larger sample size to increase the statistical power. If a researcher only had access to the same amount of equipment as in this study, they could repeat the study within different buildings in a school district to gather more data. Matching the study to the planned instructional timing of the geometry unit would be critical. The researcher would encourage that the applets be directly loaded on the computers or run off a CD-ROM to avoid any loss of instruction due to unforeseen Internet connectivity problems.

Another suggestion for replication would be actually to include a third group, one that receives no geometry instruction. For ethical reasons, that third group would need to receive appropriate geometry instruction following the study. Finally, to better reduce any potential teacher effect, it is recommended that the same teacher teach all the groups in the study if possible.

A longitudinal study following a cohort of students through several years of geometry instruction would be useful for determining any long-term impacts of the applets and the use of technology. Due to the grade level of the students in this study, no standardized test data was available. A longitudinal study would be able to include more types of data as students move through elementary school.

An expanded study of Research Question Three could be conducted. Case studies of individual students who are using technology could provide more insight into their attitudes and behaviors. In addition, student interactions, time-on-task, and repetitions of practice activities could be recorded as quantitative data. Surveys could be conducted to gauge student opinions on the use of the applets. However, at the first grade level a survey would have several validity and reliability concerns.

Finally, and perhaps most importantly, further research should investigate the amount and types of feedback incorporated into applets. Both qualitative and quantitative information could be gathered regarding what elements of feedback are most beneficial for students and teachers. This information needs to be provided to designers of educational software so even more effective applications can be developed.

Final Thoughts

> “Teachers who are afraid they will be replaced by a computer probably should be.” (Anonymous)

It should not be inferred that the intent of this study was to suggest that textbooks and teachers should or could be replaced by technology. However, technology is a tool that definitely changes the teacher-student relationship (McGrath, 1998). Technology expands learning; it allows for instant access to vast amounts of information, it can create connections to other people and places beyond the walls of a classroom, and online courses allow for anytime/anyplace learning. Technology also brings outstanding resources to the classroom, such as the MarcoPolo applets described in this study.

At the beginning of this research project in May 2002, it would never have been imagined that MarcoPolo would ever be in jeopardy. However, recent events surrounding the WorldCom bankruptcy have placed MarcoPolo in immediate peril (Branigan, 2002; Trotter, 2002). It is the hope of the researcher that the results of this study can be utilized to help secure additional funds for the MarcoPolo Educational Foundation so this incredible resource for teachers and students does not simply fade away.

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