ABSTRACT

CLINKSCALES, MICHAEL JOHN. Computer-Assisted Instruction Versus Traditional Classroom Instruction: Examining Students' Factoring Ability in High School Algebra One. (Under the direction of Karen Flanagan Hollebrands.)

The purpose of this study is to examine the effectiveness of computer-assisted instruction compared to the traditional instruction of a classroom teacher in mathematics. The results of the study are based a series of tests administered to two classes of Algebra I students. The test scores are used to analyze the achievement each class demonstrated through the tests. The study also examines the perceptions of students' experiences using computer-assisted instruction and its ability to meet their educational needs.

The study uses two randomized classes in a high school setting. The two classes are Algebra I classes dealing with factoring polynomial expressions. The control group received traditional classroom instruction on factoring. The experimental group received instruction from an on-line learning system, called NovaNET. Both classes had equal number of students (n = 25) and were given their respective instruction during the same time period. The experimental group participated in a group discussion at the end of the study to relate their experience with computer-assisted instruction.

A two-sample t-test was used to determine that there was no significant difference between the two forms of instruction. The students also did not show any significant difference in retaining the information taught. These analyses were determined from a posttest and retention test administered during the research period. Another analysis was performed on individual concepts learned during factoring. The item analysis of the posttest showed inconclusive data. During the discussion, the students' comments leaned

toward favoring a more traditional classroom environment. Some students did recognize the power of the computer and suggested that both forms of instruction be integrated.

Overall, the results suggest that there is no significant difference between the two methods of teaching. Both methods have positive features that bring the best out of instruction. It is recommended that continued research be done on computer-assisted instruction and comparing its methods with that of traditional instruction.

COMPUTER-ASSISTED INSTRUCTION VERSUS TRADITIONAL CLASSROOM INSTRUCTION: EXAMINING STUDENTS' FACTORING ABILITY IN HIGH SCHOOL ALGEBRA ONE

by

MICHAEL JOHN CLINKSCALES

A thesis submitted to the Graduate Faculty of
North Carolina State University
in partial fulfillment of the
requirements of the Degree of
Master of Science

MATHEMATICS EDUCATION

Raleigh, North Carolina

2002

APPROVED BY:

Dr. Karen F. Hollebrands Chair of Advisory Committee	Dr. John R. Kolb
Dr. Mohan S. Putcha	

DEDICATION

I would like to dedicate this thesis to my family, friends, colleagues, and students. They have supported me in this event everyday and have given me the encouragement and drive to complete this thesis.

BIOGRAPHY

Michael John Clinkscales was born in Watseka, Illinois on June 28, 1976. He is the son of Robert and Kathleen Clinkscales. He attended Perquimans County High School in Hertford, North Carolina where he graduated Valedictorian in June, 1994. He was an undergraduate at North Carolina State University where he was a North Carolina Teaching Fellow, National Beta Club Scholar, and MetLife Pathways Scholar. He received a Bachelor of Science in Mathematics and Mathematics Education in May, 1998. He was recognized with the Outstanding Senior Award in Math Education during the departmental graduation.

Michael began teaching mathematics in August, 1998 at Needham Broughton High School in Raleigh, North Carolina. He has taught Algebra I, Geometry, Advanced Geometry, Advanced Mathematics, and AP Calculus (AB). In 1999, he began coaching the Quiz Bowl team at Broughton High School. He has been a part of the faculty for the International Baccalaureate program, writing the curriculum for the Math Methods component. In 2002, he became a mentor teacher.

In August, 2000, Michael entered the graduate school at North Carolina State University while continuing his teaching position at Broughton High School. He began under the direction of Dr. John Kolb and continued with Dr. Karen Hollebrands. His research focuses on instructional methods in the classroom, especially with the computer.

Michael is still teaching at Broughton High School. His parents still live in Hertford, North Carolina. His brother, Mark, is currently teaching science and coaching football at Leesville Road High School in Raleigh. Michael enjoys playing music for churches and pleasure. He also hosts a television program, “The Math and Science Show,” on a local television station.

ACKNOWLEDGEMENTS

The process of receiving this degree has had the support and encouragement of many people. I would like to acknowledge their contributions.

The biggest support has come from my parents. They have pushed me in positive directions my entire life and have been there for every step of it. Their love and support has made this achievement possible. I cannot begin to thank them for everything they have done for me. They are a large part of my life. Also, thanks goes to my brother Mark for his encouragement through this process with my parents.

My thanks go out to all of my friends. Especially noteworthy are Chris Guard and Adam Snipes. They had to live with me for the years I spent on this process. They have lived through the headaches and frustrations, and still continued to support my work. Thank you my brothers at Bashford. I also thank Dennis and Cherilyn Peay. They have been friends for years and encouraging through all that has happened in this process. They have stood by me and encouraged me to do the best. Their prayers and thoughts have gone the distance. And to my other friends who have been there, I say thank you – it is because of you that this process is possible.

I could not have made it without the support of my students, colleagues, and administration at Broughton High School. Everyday they helped make the process better. Thank you for listening and giving me direction. I especially thank Mrs. Heather Freeman for her help with the study and Mrs. Diane Payne for the administrative support needed. To my colleagues and friends in the Math Department, you are the best. To John, Ellen, and Anna, thanks for helping with the class work and being a sounding board through all of this experience.

Special thanks goes to my advisor in this program, Dr. Karen Hollebrands. She has been dedicated and supportive since we met. She has expected nothing but the best from me. And she has been the backbone of direction in this project. I am truly grateful for all of her help and wisdom. Thanks also to my committee members: Dr. Mohan Putcha and Dr. John Kolb. You have been encouraging and supportive. Thank you for the years you have dedicated to teaching.

Finally, I give all glory, honor, and praise to God Almighty. He blessed me with many wonderful gifts, including the gift to teach and the gift of family and friends. I can truly do anything through Him who gives me strength.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The computer is an entity that is ever present in our current society. We as humans see the computer being used every day to do even the most basic tasks. The use of the computer for difficult and challenging tasks continues as well. As computers evolve to perform better such challenging tasks, they are becoming more apparent in education. In America, 71% of teachers are assigning some amount of work to be completed using the computer. One-third of those teachers do so on a regular basis (Becker, 2000). Some people believe that the computer has capabilities to teach everyone. In the past few years, technology has been an integral part in the reformation of mathematics education (McCoy, 1996). Public schools are providing more access to computers (Wilson, Majesterek, & Simmons, 1996). Studies are being conducted to determine if the use of computers can improve learning for students with learning disabilities (Mastropieri, Scruggs, Shiah, & Muschinski Funk, 1995). It is possible that because today's society may view the computer as being dependable, society believes the computer can be the ultimate and, possibly, the perfect teacher. Many parents believe that if their child has access to a computer, then their child will receive a better education (Armstrong & Casement, 2000).

Mathematics education is not immune to the thought of computers influencing the learning of mathematics. In 2000, the National Council of Teachers of Mathematics (NCTM) challenged teachers of mathematics with the following statements:

> ….Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning….Technology should not be used as a replacement for basic understandings and intuitions; rather, it can and should be used to foster those understandings and intuitions. In mathematics-instruction programs, technology should be used widely and responsibly, with the

> goal of enriching students' learning of mathematics….Technology does not replace the mathematics teacher….The teacher plays several important roles in a technology-rich classroom, making decisions that affect students' learning in important ways….(p. 24 – 26)

This challenge suggests that computers may possess powers to influence student learning in mathematics. Many believe that the computer has the power to demonstrate ideas and provide enrichment that can go beyond what teachers provide. A good example of the computer's computational power is seen in computer algebra systems (CAS). CAS software can manipulates symbolic expressions or equations, find exact values for functions or equations, and graph functions and plot relations. What many students had to do by hand, students today can use CAS software to do the symbolic manipulation so they can spend more time understanding the mathematical concepts that are taught (Heid, 1995). CAS software allows students to view graphs of functions with better detail than by simply drawing them by hand. CAS software can also simplify cumbersome rational expressions or polynomial series in less time than by hand. Heid says such software can allow students to focus more time on asking the "what if" questions. Heid also says technology allows the students more time to generate evidence to support or dismiss mathematical statements.

As technology, such as CAS, advances, classroom learning is modified. Algebra becomes more of a "thinking" subject rather than set of techniques used to complete tasks (Heid, 1995). With this shift towards thinking in Algebra, mathematics teachers must modify their instruction to teach new skills to students. Eventually, there becomes no single solution process to demonstrate problem solving (Heid, 1995).

The growth of technology in the classroom has prompted other ideas towards educating students. If computers can produce diagrams and features that help students learn mathematics, then computers should be able to teach them as well. Software designers and programmers have teamed up to produce different applications that can instruct students on material necessary for success. Programmers take the latest knowledge of how students learn and apply such knowledge to their programs. Designers use the trends in society to create animation and characters suitable for connecting the material with the student at his level. Examples of such programs are NovaNET and Math Blaster.

A fear that arises from the influx of computer use in the classroom is the outcome of student learning. Many people see the computer as a potential substitute for teaching, thus replacing teachers with a machine. In 2000, the *Principles and Standards for School Mathematics* states that technology should not be used as a replacement for learning. "Technology does not replace the mathematics teacher" (NCTM, 2000). Rather, researchers and educators see teachers incorporating technology into everyday instruction. The teacher plays many important roles, one of which is making decisions that affect how students will learn math.

The results of using computers to assist in the instruction of mathematics has been mixed. A study on students using computerized drill and practice showed students, specifically learning-disabled students, were at a disadvantage of learning material by repeated practice in a game format (Christensen & Gerber, 1990). Their conclusion was based on the repetition that students faced. The researchers said the students were at a disadvantage because of the quality of instruction they received. The students were tested using computer software in a game format. A second study used computers to tutor students in three different topics of a College Algebra class (Tilidetzke, 1992). The study showed no significant difference between the group receiving tutoring assistance and students who did not receive assistance. Another study used portable computers to see if attitudes toward studying would improve (Morrison, Gardner, Reilly, & McNally, 1993). The study did show positive impact on student learning especially in areas where students were assigned to a specific content area. Even though the study was conducted in 1973, Erlwanger showed that students can answer computer generated questions correctly, but learn incorrect mathematical procedures and develop misconceptions. The reason is that the methods that are used by the student may work for just one or two specific examples. Yet the method fails for other examples thus not working for any problems. Yet the computer assumes that because students provide correct answers to one or two problems that the student has sufficiently learned the mathematical concept or procedure. The challenge that faces teachers and students even today – can a computer program provide such a set of objectives and methods for teaching and assessing that will lead to students learning correct procedures developing appropriate conceptual understanding?

Statement of the Problem

Mathematics education appears to be receiving enormous attention about the use of computers in the classroom. Just as a parent nurtures its newborn child and observes the child as it grows, math teachers need to do the same with computers and their use in the classroom. The computer's use cannot be over looked.

This study will compare two high school Algebra 1 classes in a large city located in North Carolina. One class will receive traditional mathematics instruction from a second-year teacher. The second class will receive instruction from a computer program called NovaNET, which is already used by many students at this school. This group will receive no other assistance. They will be given a time period comparable to that of a traditional classroom to complete the instruction. Both classes will receive a pretest, posttest, and retention test. Statistical analyses will be performed on the data received from the tests.

Research Questions

This study will address the following research questions:

1. After studying similar units of instruction on factoring polynomials, will students who receive computer-assisted instruction outperform students who receive traditional classroom instruction on a test of basic skills and concepts related to factoring?
2. Will students who receive computer-assisted instruction outperform students who receive traditional instruction on a retention test of basic skills and concepts related to factoring polynomials?
3. Will students who receive computer-assisted instruction outperform students who receive traditional instruction on specific items from a test of basic skills and concepts related to factoring polynomials?
4. Will students who receive computer-assisted instruction recommend similar instruction to future students learning about factoring polynomials?

LITERATURE REVIEW

The following information is a culmination of different findings on computer-assisted learning. Much of the information shows computer-assisted instruction being integrated within daily instruction. Students are using computer-assisted instruction to reinforce skills being taught in the traditional classroom. Computer-assisted instruction is used in this document to refer to instruction that is delivered only by a computer programmed with instructional software. Computer-based instruction refers to the general use of computers to instruct students. There have been some studies that focus on computer-based instruction as well as computer-assisted instruction being used as reinforcement for comprehension. The review in this section also includes discussions about what NovaNET is and why factoring is an important topic for students of Algebra to understand.

Computer-Assisted Instruction

The past few decades have seen an influx in the use of computers. Computers and related technology are seen as the wave of the future. Our society has seen many different technologies develop in its history. These developments have led to many different uses of the computer in the classroom. Such uses include, but are not limited to, drill and practice to develop skills needed in mathematics, computer-assisted tutorials that provide student different methods of answering a problem and provide immediate answers, exploratory software programs to allow students opportunities to engage in mathematical investigations, and programming skills that develop logical reasoning in students. From the uses, software programmers have developed different types of software amendable to various uses. Such programs include Logo, Math Blaster, Geometer's Sketchpad, and on-line learning systems, like NovaNET.

The different opportunities that technology provides for improving classroom instruction have been clearly seen in mathematics education. Educators believe that "technology can help students learn math" (NCTM, 2000). Different forms of technology have evolved year after year. One example is the calculator. I have seen the calculator change from a tool that does basic math to a tool that can graph the most complex functions. The use of the computer is believed to do the same. In fact, computers can be seen as part of the rapid evolution for teaching ideas that has taken place over the past decades (Phillips & Pead, 1994). An example is the creation of a computer program called Logo (Armstrong & Casement, 2000). Created by Seymour Papert and Marvin Minsky, Logo was designed to stimulate the cognitive abilities of the young mind. Students controlled a turtle that would move according to the commands issued by the programmer. The purpose was to make the programmer create visual diagrams according to geometric properties. For example, the programmer would be asked to create a square. To make a square, the programmer must command the turtle to move a certain distance and to turn through an appropriate angle measure. A predicted outcome was the programmer would utilize different properties of the square as discussed in the geometry class. Another outcome was students discovering their own ideas about how geometric figures were constructed. Programming skills have been shown to have a mild effect for teaching cognitive skills (Liao & Bright, 1991).

Today, we see more software that provides tutorial exercises for student learning. Many of the programs are designed to assist the student in understanding material. Of these software programs, the vast majority are drill and practice (McCoy, 1996). Computer-based instruction is seen as new environments in which computers have been completely integrated into activities. These activities affect the computer's environment and the computer affects the environment of the activity (De Corte, Linn, Mandl, & Verschaffel, 1992). The two most common areas computer-based learning is found are drill and practice and programming.

Drill and practice software are generally used to reinforce skills. These skills may need to be reviewed or these skills may need more practice. Most drill and practice software take a game approach to their instruction. Math Blaster is a good example that has been used in schools for years while integrating a game approach. Math Blaster is an arcade-style game that puts the operator in a situation to save a small, green alien who has been kidnapped by a trash alien. By using hand-eye coordination, the operator maneuvers through the trash to destroy it before it destroys the alien, who is being controlled by the game player. The trash is destroyed by answer questions dealing with math. The questions generally relate to building number sense. The operator develops skills in the four basic operations, fractions and decimals, estimation, number patterns, and some problem solving (http://www.terc.edu/mathequity/gw/html/MathBlaster.html). It has been my experience that students who have better developed skills in these areas of mathematics, along with an idea of number sense, gain a better understanding of future topics in mathematics. The students are able to proceed through new material with better understanding than those whose skills are not as developed. Having such skills mastered also allows the student to spend more time learning and understanding new concepts rather than having to continue mastering basic skills at the same time.

Programming languages have also provided learning opportunities for students. As stated previously, programming is shown to improve cognitive learning. Programming requires students to know all there is to know about particular areas. Programming has the potential to provide students with opportunities to improve logical deductive skills as well (Liao & Bright, 1991). It can also be used to assist students in building organizational skills. I recall the use of BASIC during my elementary school experiences. BASIC provided a simple understanding of programming that included organization of steps. In college, I attended a computer programming class that used C++. Its language is a little more advanced than BASIC. The programmer has to understand how mathematics works to write lines of code. One example is understanding how the order of operations for simplifying expressions. The programmer must be aware of how grouping symbols work and also how fractions are treated in programming languages. These are just two examples of programming languages that exist. Each one has its own language, but they require a certain understanding of mathematics in order to write. By encouraging students to program, teachers can gain a better sense of whether students understand the mathematics they are taught.

Some researchers compare the programming of tutorial software to that of a tutor. Tutors monitor how the student determines the solution to a problem. The monitoring includes process and understanding of the topic. What the tutor does next is prescribe a remedy to improve the students understanding of the topic. These researchers call this process task sequencing because it is "the ability to generate an intelligent sequence of tasks for the student" (McArthur et. al, 1988). Software programmers create their packages based on this idea of task sequencing. These programs assume many inferences in their programs. The inferences made lead to prescriptions for student progress. But these prescriptions are generally based on skills. A tutor, being human, can instantly see many characteristics as to why a student does not understand the material. A computer program can only base its prescription on the data it collects and the inferences it makes. The programming can also be difficult due to the number of questions that must be satisfied to determine the prescription. The questions used are based on skills that the student must master before proceeding through a lesson. The task is made more difficult when the program may need a combination of questions to be answered. When we think the computer is doing a good job of instruction, we might want to think twice about that question. We may want to consider the programmer who created the software. It is they who generated the prescription.

As an educator I have seen the computer used as an aid to instruction. One example is the Geometer's Sketchpad. The Sketchpad allows students the opportunities to construct geometric figures as if they are using the compass and straightedge by hand. Once the figure is constructed, it maintains all of the properties that are implied by the construction. That is, if two lines are constructed so that they are perpendicular then no matter how the lines are dragged the lines will remain perpendicular. Such a feature is quite powerful for students to visualize. If students see what it means to be perpendicular, it becomes more meaningful in their future use of perpendicular lines. The dragging feature can demonstrate transformations of figures. Such a feature shows students that no matter how you change the shape constructed by dragging, the lines remain perpendicular because they were constructed in that manner. The use of Sketchpad can be seen in many classrooms. But often students are not taught by

Sketchpad alone. The use of Sketchpad is just one example of how instruction aids students in their learning of mathematics.

So where is computer-based instruction being used? Special education has been an arena where computers are used to help students learn subjects. Dr. Rich Wilson and his partners (Wilson, Majsterek, & Simmons, 1996) say a lot of the software being used is limited to drill and practice so as to reinforce specific skills. Wilson, an associate professor and chair of the Department of Special Education at Bowling Green State University, is committed to investigating and disseminating empirically validated instructional methods and behavior management techniques for students with learning disabilities and behavior disorders. They have found that students need to have understanding of foundational skills before problem-solving skills can be mastered. Researchers have discovered that for software to be effective, the programs must include sufficient opportunities to respond, provide contingent and frequent feedback, and be linked to teacher-directed instruction. The reason Wilson and other researchers suggest special educators are using computer-based instruction is that it allows students to move at their own pace. The student can continuously repeat a lesson until he understands it. Or he can skip a lesson if he feels he understands it. It is as if the student is receiving the individualized attention he needs for success. Although the results have not been significant in special education, the idea might be used for regular academic classrooms.

Computers and their programs have been used in different ways to instruct students. The programs and software used in past instruction have experienced changes. It is my thought that these changes have led to improvements in classroom instruction.

One type of learning system that is being used currently in schools, and still going through changes, is NovaNET.

What is NovaNET?

Computer software is continually undergoing change to fit the needs of education. People see computer-based instruction as providing a sound environment for education to occur. A system that has been used for many years to instruct students is NovaNET. "The NovaNET system is a computer-based, online learning system linking educators with progressive technology and proven teaching methods" (*NovaNET NOW*, v). It began as a collection of educational methods and technological development 30 years ago at the University of Illinois. NovaNET provides individualized instruction with the use of the largest library of online instructional materials (*NovaNET NOW*, v). The manual and other promotional materials state that the methods used are proven to prepare students for the challenges of tomorrow. NovaNET has an on-line help program that is available to answer questions immediately. Its communication is up-to-date with the latest innovations communicating electronically.

NovaNET is self-paced and delivers hours of instruction to users. The system manages its own record-keeping program to monitor and evaluate user progress. NovaNET provides users with many subject options, including Math, English, Social Studies, and SAT Preparation.

For a student to begin using NovaNET, a teacher, or other operator, must enter the user into the system. Once entered, the operator assigns the user certain subjects on which he will work. Users generally begin with a placement test before beginning the computer-based instruction. The placement test provides NovaNET with the information necessary in creating a prescription of computer based lessons (also referred to as tutorials). From there, the user goes at his pace and completes the tutorials and is evaluated by various assessments along the way. Users also have the option of beginning at a specific topic that needs improvement. For example, a student in Algebra may need assistance in solving one-variable equations. The student may select the unit on Solving Equations and begin there instead of having to start at the initial unit, which may be refining basic operational skills. Teachers and other educators with access to NovaNET can monitor student progress.

NovaNET uses different operating scenarios. The program begins with menus that list different user options. These options can be initiated by using the keyboard or the mouse. During the tutorial, the user (also referred to as a student) uses a combination of keystrokes and the mouse to proceed through the tutorial. Students use the mouse to click correct answers or move objects according to the directions of NovaNET. The student uses the keyboard to enter responses to open-ended questions. The system recognizes the use of variables as well as superscripts and subscripts. The student must use a combination of key-strokes to enter a character in a superscript or subscript form. Such use of key-strokes can cause confusion and frustration for the student and use extra time. For example, to enter x^2, students must type x first. To have a number raised as a superscript, the student must press SHIFT and one of the function keys. Then the student can type 2 and it will appear as x^2. Because the system is networked, the programs may run at a slow pace, and even lock-up at times. Thus the student will have to use more time towards getting the program running again.

Students are assessed by the use of different methods. In the mathematics curriculum, students can be assessed by a multiple-choice test at the end of each tutorial. NovaNET also assesses student progress with open-ended responses. NovaNET can assess the student's ability to solve a problem. It will ask the student to complete a problem step-by-step according to the instructed methods. Students need to be assessed using different methods. NCTM suggests that student assessment move from mastering concepts and skills. The assessment needs to communicate a clearer picture of a student's understanding by using multiple methods of assessment.

NovaNET can be used in the learning of many different subjects generally offered in grades 9 – 12 and standardized tests. The subjects are based on NovaNET's library of instructional material. The library includes SAT curriculum, subject curricula, and state curricula. Its creators developed these curricula for NovaNET. Each curriculum is aligned with respect to the area of study based on objectives from textbooks or standard course of studies. Thus the user focuses on a more specific area. So a user may need help with geometric concepts based on a state's guidelines. Instead of using the math instruction for the SAT, the operator can place the state's curriculum for the user's use.

Wake County Public School System currently has a license agreement with NCS Learn, the company that developed NovaNET. The agreement allows students access to the NovaNET system via the World Wide Web. Because NovaNET is available 24-hours a day, students are able to use the system at their convenience. Many Wake County Schools use NovaNET as an after school tutorial. Some teachers use the program concurrently with classroom instruction. Wake County Schools received a Safe Schools Grant that funded a study involving at-risk students and the use of NovaNET. The study found during 2000-2001 the number of failing grades decreased significantly for participants. However, students using NovaNET were more likely to drop out than in comparison to other students in the district.

NovaNET has been shown to be successful in accelerating basic skills, reducing dropout rates, preparing for standardized tests, and providing local course credit. The system has received numerous awards including the 2001 eSchool News Readers' Choice Award: Best Curriculum Software Choice, Comprehensive Courseware Category and 1999 Media & Methods Magazine Awards Portfolio Winner.

The applications contained within NovaNET provide a great opportunity for students to obtain a better understanding of instructed material. The fact that NovaNET has received recognition for its efforts and that it includes national curriculum shows the direction computer applications are taking. The instructional package in NovaNET provides an excellent opportunity for students to gain a better understanding in mathematics, especially in Algebra. Factoring is one area that receives a good deal of attention in NovaNET.

As a teacher of mathematics, I have seen NovaNET assist students towards a better understanding of mathematics. It provides students with an alternative source for instruction. Currently, in Wake County, NovaNET has mathematical topics that include Algebra, Geometry, and Trigonometry. In North Carolina, students must pass Algebra I to receive a high school diploma. NovaNET contains a thorough set of tutorials that help students understand Algebra I. These tutorials included lessons on equation solving, graphing linear equations, and factoring polynomials. However, some questions arise about the effectiveness of NovaNET and its instruction on topics from Algebra. One question is will students learn better in a traditional classroom or from NovaNET? Algebra is a class that involves more than learning a set of procedures or skills. It involves a different style of thinking. It involves taking a different approach to solving a problem. To illustrate this idea better, let's look at a topic from Algebra that requires more than just learning skills or a procedure. Factoring in Algebra I is a topic that will provide details to what is being stated.

<u>Factoring in Algebra</u>

Math educators agree that all students should be instructed in the basic thinking and understanding of Algebra. Many of the errors students make are due to differences in how Algebra is viewed (Rauff, 1994). The process that students produce is logically undesirable from a nonstandard model. If these errors in logic are not corrected, then the student has a false understanding of material which impacts future understanding of material. Rauff show is in his article examples of the false understandings students have in factoring. One is that factoring means to "UNFOIL." Another is to get each set of numbers to their lowest prime number. Such errors need to be corrected before a student proceeds to a higher level of mathematics. Algebra is the field where such errors can be corrected. Webster's Dictionary defines Algebra as a generalization of arithmetic in which letters representing numbers are combined according to the rules of arithmetic (Webster, 1993). The New World Dictionary of Mathematics describes Algebra as the study of operations and relations through the use of literal symbols (variables), thus giving a more general scope of mathematics (Karush, 1989). Topics that are typically included in the first course of Algebra are equation solving, graphing linear equations, and polynomials. These topics have the potential to open the student's mind towards different styles of thinking and understanding. Algebra is seen as the subject that provides the tools for solving specific problems and for expressing general solutions to such problems (Margolinas, 1991).

A major topic of conversation that receives devoted attention from math teachers is factoring polynomials (Roebuck, 1997). A factor is any symbol (number, variable, etc.) that when multiplied to another symbol yields a product. An example is $3*(x+y)=3x+3y$ where 3 and $(x+y)$ are factors that when multiplied yield the product $3x+3y$. Students typically are presented with multiplying numbers in elementary school. As students progress through school, they begin to include variables and other symbols. In the first year of Algebra, students multiply polynomials – mathematical expressions including one or more terms. After learning to multiply polynomials, students are asked to factor polynomials. When factoring, students are given a polynomial and asked to determine what factors might produce such a product.

From my experience, this topic is so troubling because of the abstract nature used to find the factors of a polynomial. Students are often presented with different techniques and procedures for determining the appropriate factors. Some of those procedures can be applied to particular polynomials. One example is factoring a polynomial of the form A^2-B^2 that is often referred to as the difference of squares. The procedure to factor a difference of squares requires taking the square root of each term. Then combine each of the terms two different ways – one with subtraction and one with addition. So $9a^2-16x^2$ is a difference of squares and factors to $(3a-4x)(3a+4x)$. This example is just one procedure that works for one type of problem. What do students do when the problem is not a difference of squares?

Factoring offers mathematicians an avenue to approach solving a higher-order polynomial for its zeros. The zeros of a polynomial are the real numbers that make the polynomial equal zero (Sullivan & Sullivan, 1998). By factoring a polynomial, one rewrites the polynomial in a different form. This form, generally written as factors, can be set equal to zero and solved to find when the zeros occur. We know this to be true by the Principle of Zero Products (Smith, et. al, 1994). The principle states that for any rational numbers, if their product is zero, then any of the factors for that product can be zero. For example, if $ab = 0$, then $a = 0$ or $b = 0$.

Factoring in Algebra requires more than just a set of procedures or skills to master. Students must look to new methods and experiences to learn this topic. Learning systems, like NovaNET, are programmed to provide such methods for students to experience. But do programs, like NovaNET, do an effective job of teaching mathematics?

<u>Computer-Assisted Instruction and Learning Mathematics</u>

There are mixed results among educators as to the effectiveness of computer-based instruction. A study by Cardelle-Elawar and Wetzel (cited byMcCoy, 1996) showed where students received instruction on problem solving and regularly used computer problem-solving software. The results, based on journals and classroom data, were positive for improving their problem-solving skills. Another study conducted by Funkhouser and Dennis (cited by McCoy, 1996) studied two groups of high school students – one receiving traditional instruction and the other receiving supplementary instruction through problem-solving software. Their results show significantly higher performance for the group receiving the supplementary software.

A separate study shows a different result. Wilson, Majsterek, and Simmons (1996) were studying the acquisition of multiplication facts by four elementary students. The students were labeled learning disabled. The study used a combination of teacher-directed instruction and computer-assisted instruction. Both types of instruction did produce improvement in the students' mastery of facts. However, the researchers found students to have achieved better progress with their multiplication facts through the teacher-directed instruction than through the computer-assisted instruction (Wilson et. al, 1996). The study suggests that the computer-assisted instruction did not provide quality instruction for the students to comprehend. It goes further to state that teacher-directed procedures are more efficient and effective for achieving basic-fact automaticity. The computer and its programs lack something that educators provide to students.

Salomon makes a valid argument about computers and instruction (De Corte et. al, 1992). His argument is that computer-based learning affects the skills acquired by students in problem solving. Computer-based learning environments do affect activities around problem-solving and cognitive reasoning. But he says we cannot attribute such results to one single source – the computer. For learning to take place, students must experience a variety of styles. Computer-based learning provides the opportunities for students to grasp material. It provides features that in many circumstances could not be achieved in traditional environments. But as Salomon is trying to explain, leaving the education of our students to just one single entity, the computer, is not acceptable. The computer-based learning software tends to educate with one method and one approach to viewing a problem. Students may need another medium to experience what must be learned.

Armstrong presents another concern about the "success" of computers in learning (Armstrong & Casement, 2000). Since the introduction of computer to education, society has flocked around them as the savior of learning. Parents are one group that feels computer instruction will enhance their children's knowledge and give them the edge in life they deserve. However, Armstrong suggests that society's feelings for computers has been influenced by data suggesting the success. This data is generally based on standardized tests. Many of these standardized tests, like the SAT or End-of-Course examinations in North Carolina, don't provide adequate information as to what a student has accomplished. How can we trust a computer to say whether or not a student as made significant academic achievement?

Armstrong (2000) also states that the computer does provide benefits that a teacher may not be able to provide. But we must remember that it is the quality of education, not quantity, which the students must receive. Computers are neutral in their effect on student learning. One can say the computer produces its own conditions for exploitation. They present the only method that they are programmed to present. Their responses to the students' answers are not specific to them. Computers can influence speed and control. We can see this idea through the use of computers in drill and practice techniques. But the computer fails to produce sensory experiences and emotional bonds that make the student grow socially. Teachers have a style of interacting with the students they teach. Students receive vocal tones as well as sensory conditioning that build social skills. These tones and other senses are analyzed and tend to provide students with better understandings of what is being communicated. Such conditioning tends to improve student learning. Armstrong quotes an article for *Education Leadership* that notes “when we are able to add emotional input into learning experiences to make them more meaningful and exciting, the brain deems the information more important and retention is increased” (p. 47). The computer just produces an image on the screen or a small sound to communicate success. Armstrong argues that it is through such human interaction that a student remembers what was taught. It builds communication skills as well. Besides, how does a computer teach a student what hot and cold are, happiness and sadness, or love?

Conclusion

To put our fate of teaching mathematics in the hands of computers is a concern. Algebra is a major cornerstone in developing a student’s thinking in mathematics. Computers have been programmed to help students obtain the skills and understanding to be successful mathematicians. But there are many characteristics a computer lacks that a teacher uses. The teacher, whether human or computer, must be able to sense how students are learning and react by making adjustments to the material that is taught. The NCTM Standards promotes a merging of these two instructional forces (NCTM, 1989). To teach with just one method does not provide a student with a well-rounded education (Armstrong & Casement, 2000). But when the two forces are combined, the student can obtain a better understanding of mathematics. In this study, we will look at the benefits of traditional instruction and computer-assisted learning. We will see if students out perform one another using one method or the other. We will look at comments that students made regarding their experiences with computers and instruction. And we’ll see in the end if computer-assisted learning does provide better results.

METHODS

The study involves high school mathematics instruction in two Algebra I classes in a high school located near a large city in North Carolina. The purpose of this study is to examine the effectiveness of computer-based instruction versus traditional classroom instruction. The following chapter contains a description of the students and teachers participating in the study, the materials used for the study, the design of the study, and the procedures used for the statistical analysis of the data.

<u>Subjects</u>

The subjects who participated in the study are high school freshmen that attend the above- mentioned high school. Some of these freshman are taking Algebra I for the first time while the others are repeating the course. The reasons for the students repeating the course vary. Some are repeating due to failure of the course in the 8th grade. Others are repeating at the request of their 8th grade math teacher. The reasons for this retention include teacher, or parent, recommendation due to poor understanding of the material based on assessments and not achieving a letter grade of C or better. The freshmen were enrolled in two different classes that were taught by different instructors. Both classes took place between 8:00 AM and 9:25 AM. The school is on a modified-block schedule meaning that classes meet every other day. The student enrollment in the classes varies in regards to academic classifications. Around five percent of the students are classified academically gifted while around ten percent receive special education services. The instructor of one of the classes was in his fourth year of teaching while the instructor of the other was in her second year of teaching. Both had previous experience in teaching

Algebra I. The textbook used throughout the course is *Algebra I* published by Glencoe. The text has been in use at the school since 1999.

Algebra I is a course taught primarily during the freshman year of high school. The curriculum includes simplifying polynomial expressions, solving one-variable equations, graphing linear equations, factoring polynomials, and analysis of functions. In North Carolina, Algebra I is a requirement for graduation with a high school diploma. The students must also have completed three credits in mathematics for graduation as of 2002. The Algebra I course is also tested at the end of each year in North Carolina. The state legislature mandates each student taking Algebra I must participate in the End-of-Course Test (EOC) for that subject. This legislation includes students receiving special educational services. The EOC Test counts 25% of the final grade for the students in Algebra I.

Instrumentation

The study used three different instruments to assess student knowledge. The three tests are unique to this study only. The testing instruments were given before the study, at the end of the study, and four weeks after the end of the study.

Pre-Test (Appendix A): The researcher (also the author of the text) designed the pretest around four areas that were to be evaluated. The first area was to assess the students' knowledge of polynomials. Both classes had just received instruction on addition, subtraction, and multiplication of polynomials. The test was designed to evaluate students' knowledge of simplifying polynomials, especially multiplying, because factoring is related to multiplication. Questions 5 and 6 dealt with this information. The second area was solving equations with one variable. Students learn to solve quadratic equations by factoring. Question 13 dealt with this information. The third area was their understanding of what factors are. These students should have been exposed to the word factor as well as to the basic idea of what a factor is. Students have seen factoring a composite number into two separate factors. They have also seen prime factorization (or factor trees as the students call them). Students also tend to confuse multiple with factor. The test was designed to determine how students interpreted multiple and factor. Questions 1 through 4 deal with this information. The fourth area was the actual factorization of polynomials. The questions were worded so students would have a sense of what to do. These questions were worded to included multiplication of polynomials to determine what understanding students would have with multiplying polynomials and connecting it with factoring polynomials. Questions 7 through 12 and Question 14 deal with this area. The pretest was administered during class immediately after students in both classes finished the unit on multiplying polynomials. Some of the wording used on the pretest was designed to avoid misinterpretations of factor and multiple. As previously stated, factor and multiple tend to be confused. Other questions were focused on the student's ability to factor.

Posttest (Appendix B): The posttest was designed to evaluate students' knowledge and understanding of factoring polynomials. Both classes participated in the posttest. Some of the questions were designed to correspond to questions on the pretest. Questions 1 through 3 were similar to Questions 1 through 3 administered on the pretest. These questions involve students' knowledge and understanding of factors. Questions 4 through 6 were similar to Questions 7 through 12 on the pretest. These questions test the students' knowledge of factoring polynomials using different approaches. Question 7 involved applying factoring polynomials to solving quadratic equations, which is part of the curriculum. And Question 8 was a real-world application involving polynomials and demonstrating how factoring can be applied.

Retention Test (Appendix C): A retention test was designed test to evaluate the effectiveness of the instruction received in both classes. The retention test was administered one month after the unit on factoring polynomials was completed. Questions 1 through 3 related to Questions 1, 2, and 4 on the posttest. These questions involve students' understanding of factors. Question 4 related to Questions 4 through 6 on the posttest that addressed factoring polynomials. Questions 5 related to Questions 7, which is a quadratic equation that is solved by factoring. Question 6 was another application questions related to factoring polynomials.

Purpose of Study

The purpose of this study is to examine the effectiveness of computer-assisted instruction compared to the traditional methods of a classroom teacher in mathematics. The study also examines the perceptions of students' experiences using computer-assisted instruction and its ability to meet their educational needs.

Research Questions

The study addressed the following research questions:

Question #1: After studying similar units of instruction on factoring polynomials, will students who receive computer-assisted instruction outperform students who receive traditional classroom instruction on a test of basic skills and concepts related to factoring?

Question #2: Will students who receive computer-assisted instruction outperform students who receive traditional instruction on a retention test of basic skills and concepts related to factoring polynomials?

Question #3: Will students who receive computer-assisted instruction outperform students who receive traditional instruction on specific items from a test of basic skills and concepts related to factoring polynomials?

Question #4: Will students who receive computer-assisted instruction recommend similar instruction to future students learning about factoring polynomials?

Treatments

During the research, one control group and one experimental group were used. The independent variable in the study was the treatment – use of NovaNET to complete a unit on Factoring in Algebra I.

The control group (C) received traditional instruction on Factoring in Algebra I. The instruction included lessons on factors, greatest common factors, and factoring trinomials. The students completed a series of homework assignments and quizzes from their instructor during instruction. Students did not use any computer-assisted instructional programs or software. Students did have access to the teacher after normal instructional time.

The experimental group (E) received instruction using a computer-based, online learning system called NovaNET. The students used normal instructional time to complete tutorials on Factoring in Algebra I. Students in Group E were given an introduction to the NovaNET system for approximately 30 minutes. Students in Group E were given a packet of 6 worksheets dealing with Factoring in Algebra I (see Appendix E). These worksheets were completed outside of instructional time. No instruction, or assistance, was given to the students from the instructor of that class. Some students may have had access to a private tutor outside of the class. After completing the posttest, students had the opportunity to receive instruction from their instructor.

The content covered in both classes was generally the same. Both classes followed the objectives established by the North Carolina Curriculum. The only differences were the order that the material was presented and the assigning of homework outside of class.

Response Variable

Both the control group and experimental groups were administered a posttest and retention test. The scores on these tests will be compared as to which group outperformed the other group on those tests. The pretest scores will show the two groups are similar and can be statistically compared.

General Research Hypothesis

The null hypothesis will be the achievement of Algebra I students who receive traditional instruction will be equal to the achievement of Algebra I students who receive computer-assisted instruction. A two-sample t-test will determine the validity of this statement. The significance level (α) will be 0.05.

Design of the Study

The study used one class of Algebra I students as the experimental group and one class of Algebra I students as the control group. The experimental group received only computer-based instruction using a computer-assisted, online learning system called NovaNET. The control group received traditional instruction during the study. The selection of which group was to be control and which was to be experimental was done randomly. Both classes received the same content of instruction during the same interval of time. The same pretest, posttest, and retention test were administered to both classes.

Instruments

The instruments that were used to gather the data in this study include:

1. Pretest
2. Posttest
3. Retention Test
4. Class Discussion Questions

The instruments are discussed in more detail in the instrumentation section previously mentioned.

Procedures

The researcher began the study by obtaining permission prior to the beginning of the study from the school district administration (including the principal of the school) to conduct the research. The researcher then obtained permission from the Research on Human Subjects Committee prior to the beginning of the study. Permission was also obtained from the students' parents/guardians to conduct the research on their children. The students in the study were minors.

Both the control group and experimental group were given a pretest to have a basis upon which to compare achievement during the study. The pretest was administered after both classes completed a unit on polynomials. Upon completion of the pretest, the classes were conducted in different methods.

The control group began with discussion on what factors are. The class proceeded to discuss greatest common factors (GCF) and factoring using the GCF. Students were presented with factoring a trinomial with leading coefficient of one as a product of two binomials. Then student factored trinomials with leading coefficients other than one. Students explored special types of factoring including difference of squares and perfect trinomial squares. Students saw factoring by grouping as a final method to factor polynomials with four or more terms. As an application, the students were introduced to quadratic equations and how to solve them using factoring by the Principle of Zero Products. The unit took two weeks to complete meeting every other day for 90 minutes each class period. The students were periodically assessed with quizzes and finally with a unit test. Students were assigned homework at the end of each class. The posttest was administered immediately after the instructor tested the students. One month after the posttest, the students were administered the retention test, which occurred immediately before final examinations.

The experimental group was introduced to NovaNET during their first session. Afterwards, they were instructed to begin using NovaNET at the beginning of the Factoring unit. NovaNET began with instruction on factoring and what a factor is. Students were presented next with the GCF, followed by instruction on how to factoring using the GCF and factoring by grouping. Students were then introduced to special methods of factoring. These methods include difference of squares and perfect trinomial squares. Students were then shown how to factor trinomials with a leading coefficient of one as a product of two binomials. Then they were shown how to factor trinomials with leading coefficients other than one. Finally they were shown a small number of applications dealing with uses of factoring polynomials. To move from tutorial to tutorial, students had to demonstrate an understanding of factoring at each level. Students were not permitted to move forward unless they demonstrated such understanding. Thus some students completed the computer-assisted instruction quicker than others. The students were given a series of examples to try in each tutorial section. At the end of the unit, students had the opportunity to take the unit assessment designed by NovaNET. The students were given two weeks to complete the unit. At the end of the unit, students were administered the posttest. One month after the posttest, the students were given the retention test, which is prior to their final examination in the course.

Four days after the posttest, students in the experimental group were interviewed during class as a whole. Students had the chance to respond to questions about computer-based learning. The questions included prior experience using computers and tutorial packages, their attitudes during the instruction, and their attitudes after the instruction. An impartial teacher assisted in the interview by writing the responses of the students.

Scoring of the Instruments

The pretest. In scoring the pretest, the researcher looked for correct answers and for some level of understanding. Question 1A, worth one point, looked for a definition of factor. Students relating factor to multiplication or even division were given the point.

Question 1B was worth two points – two points for all of the correct factors and one point for at least three factors correct. Questions 2 and 3 were worth one point each. Question 4A, worth one point, looked for a definition of multiple. From my past experience, students have a tough time distinguishing between a factor and a multiple. Question 4B was worth two points – two points for the correct list of multiples and one point for a partial list. Question 5 was worth two points each. Students received full credit for the correct answer and one point for some correct piece of multiplying polynomials. Question 6 was worth three points. One point was given for the perimeter and two points for the area. Question 7 and 8 were worth two points each. Students received one point for the correct coefficients in the binomial and two points for the correct binomial. Question 9 was worth two points, giving one point for the correct coefficients and two for the correct answer. Questions 10, 11, and 12 are worth two points each for a correct answer. A student earned one point for each correct factor. Question 13 was worth one point each for correct answers. And Question 14 was worth one point each for correct answers.

The posttest. As in the pretest, the posttest was graded for correct responses and for some level of understanding of factoring. Question 1 was worth three points and graded similarly to Question 1 in the pretest. Question 2 was worth two points (one point for each correct answer) and Question 3 was worth one point. Question 4 was worth two points – one point for each correct factor. Question 5 was worth one point for a correct response. Question 6 was worth two points for a correct answer – one point for the correct coefficients in each factor and one point for the correct signs in each factor. Question 7 was worth three points each for a correct answer. Students received one point for a correct factorization and one point for each correct solution. Question 8 was worth one point for each correct answer.

The retention test. The retention test was graded in a similar manner to the pretest and posttest. Questions 1 and 2 were worth one point each for a correct answer. Question 3 was worth two points – one point for each correct factor. Question 4 was worth two points each, giving one point for the correct coefficients in each factor and one point for the correct signs in each factor. Question 5 was worth three points, giving one point for the correct factorization and one point for each correct solution. Question 6 was worth two points, giving one point for the length and one point for the width.

Data Analysis

The only data obtained for the study was from students who had been given permission from their parent/guardian to participate. The data comes from the three tests administered throughout the study. Quantitative analysis was used to assess each test and used to compare the achievement in each class. The tests will be compared using a two-sample t-test comparing the means of the two sets of data. The sets of data will be shown comparable by observing the data collected from the pretest. The item analysis between the two classes will be compared using the means in each item. Descriptive analysis was used with the information from the class discussion session.

RESULTS

This chapter contains an analysis of the quantitative and qualitative data collected for this study. The information is presented in five sections. Section one presents information about the subjects tested in the study. This section will also show both classes were similar in ability. The second section will examine the results of the posttest from both classes involved in the study. Section three will examine the results of the retention test from both classes. The fourth section will present a comparison of the two classes mean scores on individual questions related to factoring. The fifth section will focus on the student interviews.

Initial Evaluation of the Classes

The two classes involved in the study were administered a pretest to assess how similar in ability the students in each of the classes were. The pretest was administered after the classes completed a unit in Algebra I dealing with polynomials. The pretest focused on material regarding the multiplication of polynomials and material regarding previous instruction on factoring. The pretest also included questions that directed students to factor polynomials. Though the students had no prior instruction of factoring polynomials, the questions were worded as to accommodate for this lack of experience. For example, Question 7 says, “Find the binomial that multiplied to $4x-3$ produces $16x^2-9$.” A teacher might typically phrase the question to factor $16x^2-9$. But many of the students have not factored polynomials before this study. I wanted the question phrased in a way that students would understand better what was being asked. Another example is Question 10, which says, “x^2+6x+8 is a product of two binomials multiplied together. What two binomials make this possible?" Again, a typical question would be to ask the student to simply factor the polynomial.

Tables 4.1 and 4.2 show the results from the pretest. The scores are a percentage of points earned out of total points possible.

Table 4.1. Pretest Scores of Experimental Group

STUDENT	PERCENT
1	26.19048
2	47.61905
3	45.2381
4	50
5	40.47619
6	54.7619
7	26.19048
8	71.42857
9	42.85714
10	57.14286
11	38.09524
12	38.09524
13	23.80952
14	26.19048
15	50
16	19.04762
17	61.90476
18	73.80952
19	42.85714
20	76.19048
21	47.61905
22	57.14286
23	26.19048
24	61.90476
25	57.14286

Table 4.2. Pretest Scores of Control Group

STUDENT	PERCENT
1	42.85714
2	57.14286
3	54.7619
4	42.85714
5	42.85714
6	69.04762
7	23.80952
8	52.38095
9	35.71429
10	21.42857
11	28.57143
12	50
13	38.09524
14	59.52381
15	42.85714
16	50
17	38.09524
18	38.09524
19	30.95238
20	35.71429
21	45.2381
22	47.61905
23	38.09524
24	28.57143

The two samples, in this case the two classes' pretest scores, are considered independent. They were not selected in anyway to influence each other. There was no prior knowledge between the two classes of what would happen during the study. We can also state that the data is normal by looking at the following normal probability plots (Figures 4.1 and 4.3) and box plots (Figures 4.2 and 4.4). Because the data in the normal probability plot appears straight in both normal probability plots and there are no outliers in both box plots, we can make this assumption that the data is normal. For the normal probability plot, the x-axis represents the actual data and the y-axis represents the z-values. For the box-and-whiskers plot, the x-axis is the actual values of the data and the y-axis is undefined. The data can now be tested using a 2-sample T-Test.

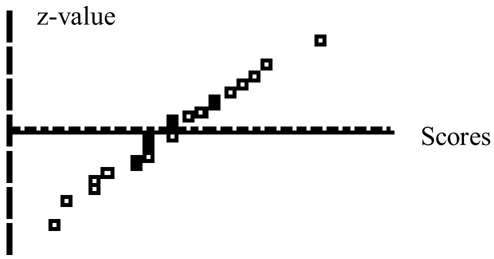

Figure 4.1 – Normal Probability Plot for Control Group

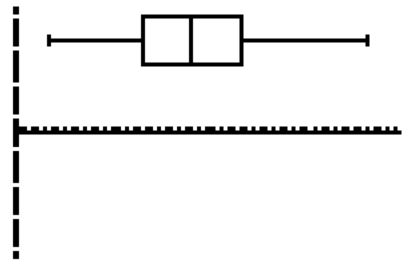

Figure 4.2 – Box Plot for Control Group

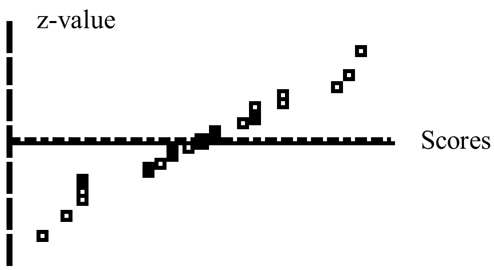

Figure 4.3 – Normal probability plot for Experimental Group

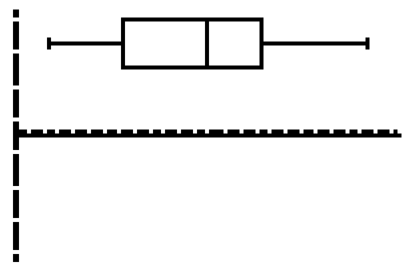

Figure 4.4 – Box plot for Experimental Group

The comparison of scores shows no significant difference between the two classes based on the pretest. A 2-sample t-test was performed on the data. The data produced a t-statistic of –1.048 and p-value of 0.300. The mean of the control group (μ_1) was 42.262 and the mean of the experimental group (μ_2) was 46.476. The null hypothesis (H_0) would be that the two sets of data would be equivalent and is tested against the alternative hypothesis (H_a), which states the two sets of data are not equivalent. Or to state symbolically, H_0: $\mu_1 = \mu_2$ and H_a: $\mu_1 \neq \mu_2$. At a significance level of $\alpha = 0.05$, the t-test shows a failure to reject the null hypothesis. Thus the means on the pretest for the two classes were not different at the beginning of the study.

Posttest Evaluation

After both classes received two weeks of instruction of factoring in Algebra, the classes were administered a posttest. The posttest was designed to evaluate the progress made from the pretest to the posttest and to compare the instruction received by both classes. The posttest covered finding the GCF, factoring polynomials by GCF and grouping, factoring by difference of squares, factoring perfect trinomial squares, factoring trinomials, and solving quadratic equations by factoring. One question was included that discussed an application to factoring.

The following results were recorded from the posttest. The scores are a percentage of points earned out of total points possible.

Table 4.3. Posttest Scores of Experimental Group

STUDENT	PERCENT
1	18.60465
2	16.27907
3	37.2093
4	60.46512
5	48.83721
6	51.16279
7	27.90698
8	51.16279
9	11.62791
10	53.48837
11	4.651163
12	4.651163
13	34.88372
14	11.62791
15	13.95349
16	6.976744
17	16.27907
18	67.44186
19	30.23256
20	72.09302
21	32.55814
22	39.53488
23	27.90698
24	44.18605
25	51.16279

Table 4.4. Posttest Scores of Control Group

STUDENT	PERCENT
1	27.90698
2	62.7907
3	55.81395
4	34.88372
5	25.5814
6	48.83721
7	25.5814
8	48.83721
9	39.53488
10	44.18605
11	53.48837
12	16.27907
13	39.53488
14	30.23256
15	51.16279
16	81.39535
17	27.90698
18	62.7907
19	34.88372
20	39.53488
21	51.16279
22	37.2093
23	20.93023
24	37.2093
25	62.7907

The two samples, in this case the two classes' posttest scores, are considered independent. They were not selected in anyway to influence each other. There was no prior knowledge between the two classes of what would happen during the study. We can also state that the data is normal by looking at the following normal probability plots (Figures 4.5 and 4.7) and box plots (Figures 4.6 and 4.8). Because the data in the normal probability plot appears straight in both normal probability plots and there are no outliers in both box plots, we can make this assumption that the data is normal. The data can now be tested using a 2-sample T-Test. For the normal probability plot, the x-axis represents the actual data and the y-axis represents the z-values. For the box-and-whiskers plot, the x-axis is the actual values of the data and the y-axis is undefined.

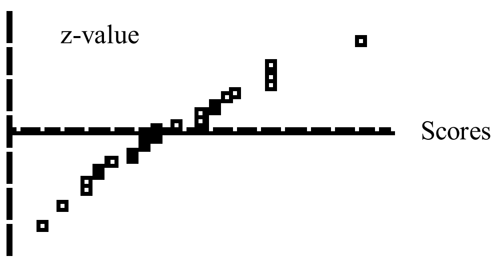

Figure 4.5 – Normal Probability Plot for Control Group

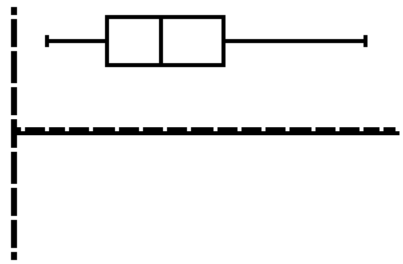

Figure 4.6 – Box Plot for Control Group

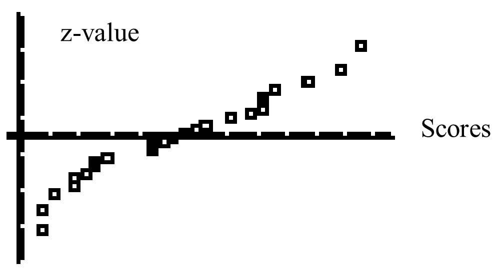

Figure 4.7 – Normal Probability Plot for Experimental Group

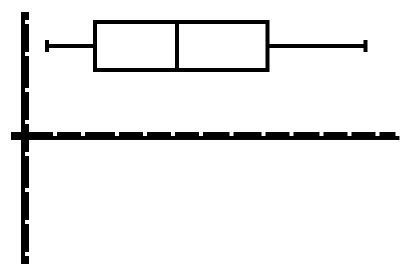

Figure 4.8 – Box Plot for Experimental Group

The comparison of scores shows no significant difference between the two classes based on the posttest. A 2-sample t-test was performed on the data. The data produced a t-statistic of 1.766 and p-value of 0.082. The mean of the control group (μ_1) was 42.419 and the mean of the experimental group (μ_2) was 33.400. The null hypothesis (H_0) would be that the two sets of data would be equivalent and is tested against the alternative hypothesis (H_a), which states the two sets of data are not equivalent. Or to state symbolically, H_0: $\mu_1 = \mu_2$ and H_a: $\mu_1 \neq \mu_2$. At a significance level of $\alpha = 0.05$, the t-test shows a failure to reject the null hypothesis. Thus the data suggests that the data equivalent based on the data received. These results would suggest that there is no difference in computer-based instruction and traditional instruction.

Retention Test Evaluation

The retention test was administered to both groups one month after the administration of the posttest. The retention test contained fewer questions than the posttest. But questions were similar to those that were administered to the students on the pretest and posttest. The retention test also included an application question. The retention test is used to show if there is any significant difference between the two groups with regards to retaining the knowledge they gained during instruction.

The following results were recorded from the posttest. The scores are a percentage of points earned out of total points possible.

Table 4.5. Retention Test Scores of Experimental Group

STUDENT	PERCENT
1	9.52381
2	9.52381
3	52.38095
4	42.85714
5	23.80952
6	38.09524
7	23.80952
8	42.85714
9	38.09524
10	19.04762
11	4.761905
12	42.85714
13	28.57143
14	23.80952
15	14.28571
16	0
17	33.33333
18	42.85714
19	38.09524
20	66.66667
21	52.38095
22	19.04762
23	14.28571
24	38.09524
25	52.38095

Table 4.6. Retention Test Scores of Control Group

STUDENT	PERCENT
1	28.57143
2	38.09524
3	28.57143
4	28.57143
5	14.28571
6	38.09524
7	19.04762
8	23.80952
9	0
10	19.04762
11	0
12	0
13	0
14	33.33333
15	28.57143
16	0
17	23.80952
18	47.61905
19	33.33333
20	38.09524
21	28.57143
22	38.09524
23	47.61905
24	57.14286
25	57.14286

The two samples, in this case the two classes' posttest scores, are considered independent. They were not selected in anyway to influence each other. There was no prior knowledge between the two classes of what would happen during the study. We can also state that the data is normal by looking at the following normal probability plots (Figures 4.9 and 4.11) and box plots (Figures 4.10 and 4.12). Because the data in the normal probability plot appears straight in both normal probability plots and there are no outliers in both box plots (with one exception), we can make this assumption that the data is normal. The data can now be tested using a 2-sample T-Test. For the normal probability plot, the x-axis represents the actual data and the y-axis represents the z-values. For the box-and-whiskers plot, the x-axis is the actual values of the data and the y-axis is undefined.

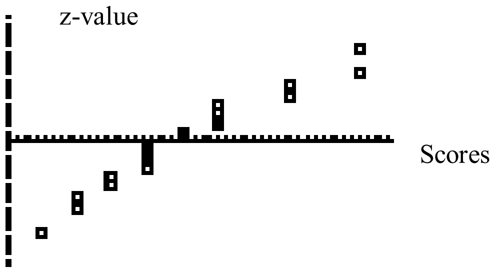

Figure 4.9 – Normal Probability Plot for Control Group

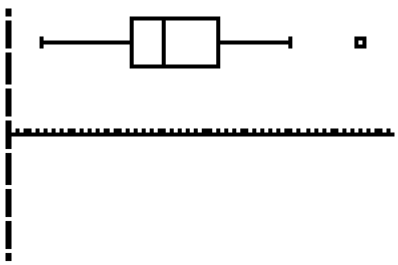

Figure 4.10 – Box Plot for Control Group

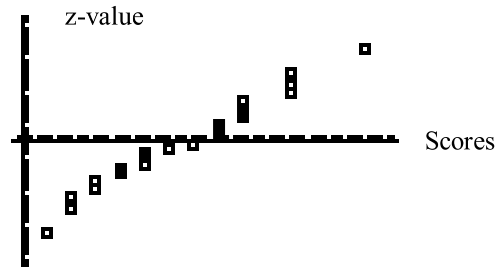

Figure 4.11 – Normal Probability Plot for Experimental Group

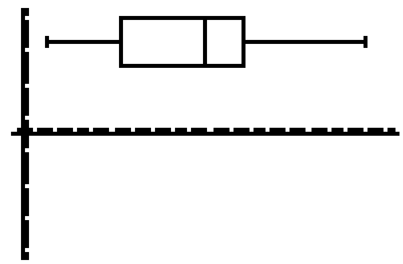

Figure 4.12 – Box Plot for Experimental Group

The comparison of scores shows no significant difference between the two classes based on the retention test. A 2-sample t-test was performed on the data. The data produced a t-statistic of 0.377 and p-value of 0.738. The mean of the control group (μ_1) was 33.571 and the mean of the experimental group (μ_2) was 32.143. The null hypothesis (H_0) would be that the two sets of data would be equivalent and is tested against the alternative hypothesis (H_a), which states the two sets of data are not equivalent. Or to state symbolically, H_0: $\mu_1 = \mu_2$ and H_a: $\mu_1 \neq \mu_2$. At a significance level of $\alpha = 0.05$, the t-test shows a failure to reject the null hypothesis. However, the p-value is too large to say the data is accurate. It could be suggested that the retention test does not provide an accurate representation for the study. The percentages are not as high as the ones for the pretest. Also, the p-value is higher in the retention tests than in the pretests or the posttests.

Individual Item Analysis

Twenty-five students from both classes participated in the posttest. An itemized analysis of questions and student outcomes might show some of the differences between computer-based instruction and traditional instruction. In the itemized analysis, the percentage shown will represent the students who correctly answered the question. The questions were selected because of the important skills they develop within the students.

Question 6. This question assessed the students' abilities to factor a polynomial. The questions included factoring a trinomial with leading coefficient of one, difference of squares, and perfect trinomial squares in terms of the students who correctly answered the questions. We can see that in many cases, the control outperformed the experimental group. Questions 6A, 6B, 6C, and 6F show the control group outperforming the experimental group by 24% or better. The remaining six questions only vary by 10%. The results show that the control group could have developed better skills of factoring than the experimental group.

Table 4.7. Question 6 Percentage Correct

QUESTION	CONTROL	EXPERIEMENTAL
#6A	72%	44%
#6B	56%	32%
#6C	80%	52%
#6D	72%	60%
#6E	16%	20%
#6F	52%	24%
#6G	28%	36%
#6H	16%	20%
#6I	0%	0%
#6J	12%	12%

A t-test will show whether the data is significantly different. We need to look at the percentage of points that the students received in Question 6. The questions in Question 6 totaled 20. The tables show the number of points the students received and the percentage out of 20 possible points.

Table 4.8. Item Analysis Scores of the Control Group – Question 6

STUDENT	SCORE	PERCENTAGE
1	8	40%
2	16	80%
3	11	55%
4	6	30%
5	6	30%
6	14	70%
7	8	40%
8	13	65%
9	11	55%
10	16	80%
11	11	55%
12	1	5%
13	12	60%
14	8	40%
15	10	50%
16	17	85%
17	7	35%
18	13	65%
19	8	40%
20	11	55%
21	12	60%
22	8	40%
23	8	40%
24	13	65%
25	13	65%

Table 4.9. Item Analysis Scores of the Experimental Group – Question 6

STUDENT	SCORE	PERCENTAGE
1	0	0%
2	0	0%
3	12	60%
4	14	70%
5	13	65%
6	13	65%
7	8	40%
8	14	70%
9	3	15%
10	14	70%
11	0	0%
12	0	0%
13	10	50%
14	4	20%
15	0	0%
16	0	0%
17	0	0%
18	19	95%
19	6	30%
20	19	95%
21	5	25%
22	9	45%
23	9	45%
24	11	55%
25	14	70%

We want to test the data for a significant difference between the means of the two results. The mean of the control group (μ_1) was 52.2 and the mean of the experimental group (μ_2) was 39.4. However, as the following figures show, the data in the experimental group does not conform to a normal probability. Therefore, a t-test cannot be performed on the observed results. Thus, it is inconclusive as to whether there is a significant difference between the means of the data. For the normal probability plot, the x-axis represents the actual data and the y-axis represents the z-values. For the box-and-whiskers plot, the x-axis is the actual values of the data and the y-axis is undefined.

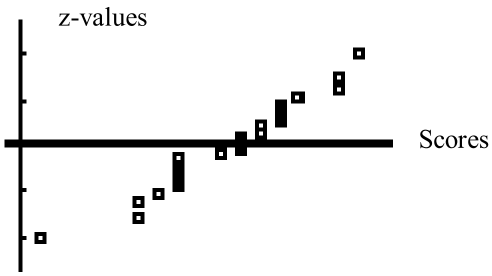

Figure 4.13 – Normal Probability Plot for Control Group

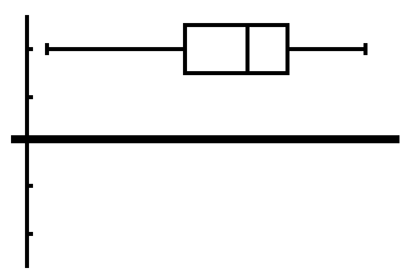

Figure 4.14 – Box Plot for Control Group

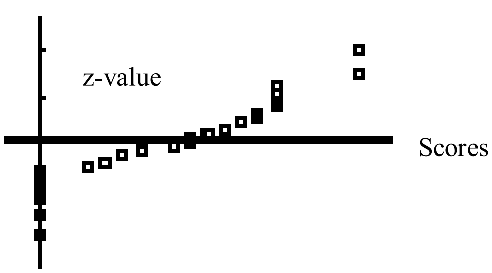

Figure 4.15 – Normal Probability Plot for Experimental Group

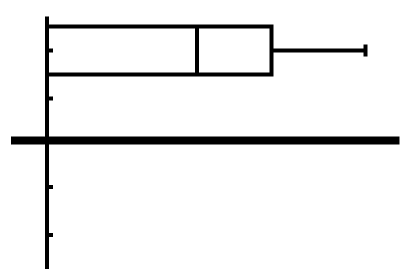

Figure 4.16 – Box Plot for Experimental Group

Questions 4 & 5. These questions focus on the idea of what a factor is. Students are given a polynomial as a product of factors and one of those factors. They are then asked to find the remaining factors of the polynomial. Students in both groups did not perform well in this section. The experimental group did not respond correctly to any of those questions and a small percentage of the control group answered those questions correctly. A t-test would be performed on the data. However, the data does not conform to a normal distribution. The experimental group's results are all 0%. Thus a t-test cannot be performed on the data. Thus the data is inconclusive based on the obtained results.

Table 4.10. Questions 4 & 5 Percentage Correct

QUESTION	CONTROL	EXPERIEMENTAL
#4	12%	0%
#5	8%	0%

Question 7. This question focuses on solving a quadratic equation by factoring. Many of the students will enroll in Advanced Algebra courses that require them to factor polynomial equations for solutions. The students in the control group performed better than the experimental group in Question 7A but not much better in Questions 7B and 7C according to the percentage of students who answered the question correctly. Once again, a t-test would be performed on the data to test the data. However, the data does not conform to a normal distribution and a t-test cannot be performed on the data. Again, the experimental group's results are 0%. Thus the data is inconclusive based on the observed results.

Table 4.11. Question 7 Percentage Correct

QUESTION	CONTROL	EXPERIEMENTAL
#7A	24%	0%
#7B	12%	0%
#7C	8%	0%

Discussion with Experimental Group

A discussion was held with the experimental group after completing the tutorials on NovaNET and completing the posttest. The discussion was used to get the feelings of students as to their experience using the computer as strictly a teaching tool. The discussion was also used to determine the prior experiences of students and to compare those experiences to their experience with NovaNET. The discussion questions are included in the appendix as are the comments of the students as noted by an impartial note-taker.

Question #1: *How much time do you spend per day at the computer?* Students responded with 15 minutes, 30 minutes, 90 minutes, and 2 hours. Some responded with none, unless required to do work. Another point is that many of the students used the computers in a keyboarding class and did not consider that as daily time spent on the computer.

Question #2: *How much time do you spend on the computer outside of class on a daily basis?* Many of the students responded with one hour. Some other responses included two minutes and two hours.

Question #3: *How much time do you spend on the computer with school work each day (excluding class time)?* Answers ranged from 15 minutes to two hours. Some students mentioned 2.5 hours and some mentioned spending no time on the computer.

Students also included in their responses that they tended to spend more than two hours on the computer when large projects were due for school.

Question #4: *What kind of experiences have you had with using computers to learn math?* Students responded with programs such as Math Blaster and Dyansoft. Students mentioned owning other mathematical tutorial packages but they did not use them. Many of those programs were drill and practice packages. Some students included games that involved mathematics like Blackjack. The researcher than expanded the question to include uses of the software mentioned. Student responses included extra practice after a lesson, rewards for doing problems, building memorization skills, and test mastery so to play the game that followed mastery of a concept. The question was expanded further to include how helpful or effective the software was. One of the first responses mentioned was the software presents one method or process to working with the material. Thus students were stuck learning that method when other methods were presented later that made better understanding. Time limits were also mentioned. Students considered the time limits a hindrance because it place pressure on them and cause them to rush through examples without complete thought. One student did say the time pressure improved his accuracy in problem solving. A comment that seemed positive was the instantaneous feedback. Students said they appreciated knowing their results immediately thus letting them know if they needed more practice.

Question #5: *What differences do you see between being taught by a human teacher and by a computer?* One of the largest comments made was the explanations generated by the software packages. Computer programs stick to the same explanation while teachers can implement other ideas and strategies. On a similar note one student said the answers students enter are either right or wrong. Another student said he tends to remember the voice of a teacher than the screen of a computer. Along with that idea, a student says he remembered the arrows the screen produced – there were very few words to associate. The students commented that the interaction with the computer is too limited. They wished they could interact more with the computer. For example, ask it questions about what was being taught. A student did mention that a combination of student and teacher would be great. The teacher can provide the necessary instruction while the computer is being used to reinforce what was taught.

Question #6: *What did you think about the mechanics of doing things? The mouse, key-strokes, etc?* This question dealt mostly with the mechanics of NovaNET. Students commented about using a touch-screen to proceed through the tutorials. Student noted the tutorial tended to freeze at certain points, meaning nothing would happen for a brief period of time. The keystrokes on NovaNET frustrated some of the students. To get an exponent, you had to press CONTROL and P. If you didn't do it right, or fast enough, it didn't work. Students mentioned that NovaNET was outdated and needed to be updated.

Question #7: *Do you have other comments you would like to share?* Students did not like the guide, Clever, through the tutorial. A student mentioned NovaNET does a good job explaining basic material. The material that gets more complicated should be taught by a teacher. One student felt she had learned nothing and was less prepared to take the North Carolina End-of-Course Exam.

Question #8: *Show hands if you would prefer to use computers only, combination of computers and teacher, or teacher only.* Three students said they preferred learning from the computer. Eight students said they would like to see a combination of the computer and teacher used in the classroom. Eleven students said they preferred having a teacher instruct them.

A final analysis of the quantitative data as well as the class discussion will be found in the final chapter.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to determine the effectiveness of computer-assisted instruction in mathematics against traditional instruction. This chapter discusses the results of the study as given by the research questions. The chapter will also include any limitations and recommendations for future study.

Summary

The study used an existing class of Algebra I students who received computer-assisted instruction using an online learning system called NovaNET and an existing class of Algebra I students who received traditional instruction. The study compared the results of a posttest and retention test administered to both classes at the end of the study. The experimental group participated in an open discussion about their experience with NovaNET. The two classes were selected to be equivalent in terms of the academic abilities and demographics of the students.

The two classes received an equal amount of instructional time during the study. The classes met on alternating days, but during the same time period of the school day. The experimental group received instruction on Factoring in Algebra I via NovaNET while the control group received traditional instruction from their regular classroom teacher. Both classes were administered a pretest, posttest, and retention test. The pretest was used to show the two classes were not different in instruction previously received. The posttest was used to show the effectiveness of type of instruction. The retention test was used to see the long-term effects of each type of instruction.

Description of the Control Group

The control group received traditional instruction from their assigned math teacher for the academic year. Traditional scenarios occurred in this class. Students received lecture from a teacher, guided practice each day, periodic quizzes, and a final test on the unit taught. Some students were absent on certain days of instruction for various reasons. Some students sought additional instructional assistance from their teacher or a private tutor. Students were assigned homework daily from their textbook and its resources. The teacher received the First-Year Teacher Award for the school district and was in her second year of teaching.

Students in the control group were in the same academic grade. Experience varied in the class with some repeating Algebra I for better understanding and some taking the course for the first time.

Description of the Experimental Group

The experimental group received instruction from a computer-assisted, online learning system. The class met in a computer lab on networked computers. The students worked for five school days on NovaNET receiving instruction on Factoring in Algebra I. There was no additional instruction provided by the teacher of this class. Students did receive an extra assignment to be completed at home for continued practice outside of the computer-based instruction. NovaNET did provide short assessments for students and a final unit test to assess student understanding of material. Students were assigned the one instructional unit on Factoring in Algebra I. Students were self-paced throughout the two weeks. Some students finished the material earlier than others.

Students in the experimental group were in the same academic grade. As with the control group, past experience varied in the class with some repeating Algebra I for fundamental understanding and some taking the course for the first time. The class was diverse according to race, gender, and socio-economic status.

Conclusions

Four general research questions were presented in the study. The results of each question will be addressed using quantitative and descriptive analysis.

Research Question #1

After studying similar units of instruction on factoring polynomials, will students who receive computer-assisted instruction outperform students who receive traditional classroom instruction on a test of basic skills and concepts related to factoring?

The posttest, administered to both classes at the end of the instructional period, was used to conduct the comparison between the classes. Looking at the results individually, the results of the experimental group varied between 19% and 73% correct while the results of the control group varied between 21% and 69% correct.

A 2-sample T-Test was performed between the two groups. The null hypothesis stated that there would be no difference between the two means of the samples in the study. Since the p-value of the test was greater than the significance level ($\alpha = 0.05$), there was a failure to reject the null hypothesis. From the analysis, we can conclude that there is no difference in the two means.

To provide this result in context, we need to consider that the students in the study had just returned from Spring Break. Both classes had similar experiences throughout the academic year. Thus the classes were on an equivalent level of learning. The phrasing of the questions on both tests should not have had any effect on the students' performance.

The pretest was the only experience that the two classes shared in seeing the similar phrasing of questions.

Research Questions #2

Will students who receive computer-assisted instruction outperform students who receive traditional instruction on a retention test of basic skills and concepts related to factoring polynomials?

The retention test was administered to both classes one month after the posttest. Its purpose was to compare the long-term effects of both types of instruction. The overall results were analyzed using a 2-Sample T-Test. The null hypothesis stated that there would be no difference between the two groups with respect to the retention test. Since the p-value was greater than the significance level ($\alpha = 0.05$), there was a failure to reject the null hypothesis. Therefore, we can conclude that there is no difference in the two means on the retention test.

If we investigate the dispersion of the data, we see that the range of percentages on the retention test were 9% to 67% correct for the experimental group while the control group ranged from 14% to 57% correct. The overall percentages were not too exceptional in either class.

Again, to put this into context, the retention test was administered on the last day of classes before final examinations. Perhaps students had this major event on their minds. The students in the experimental group had returned to instruction under their teacher and had the opportunity to receive additional instruction on factoring.

Research Question #3

Will students who receive computer-assisted instruction outperform students who receive traditional instruction on specific items from a test of basic skills and concepts related to factoring polynomials?

The posttest was written to collect information about specific skills of factoring that students should understand. One skill was basic factoring of polynomials, especially trinomials. Ten questions were asked regarding the different methods of factoring polynomials. The students in the control group clearly had a better understanding of such skills in five of the ten areas. 72% of the students in the control group correctly answered Question 6A, 56% correctly answered Question 6B, 80 % correctly answered Question 6C, 72% correctly answered Question 6D, and 52% correctly answered Question 6F. Compare the control group's percentages to the experimental group. 44% of the students in the control group correctly answered Question 6A, 32% correctly answered Question 6B, 52 % correctly answered Question 6C, 60% correctly answered Question 6D, and 24% correctly answered Question 6F. In these five cases, the students in the control group scored a higher percentage correct than the experimental group. The other five questions were more similar in results. In those questions, the control group had 16% correctly answer Question 6E, 28% correctly answer Question 6G, 16% correctly answer Question 6H, 0% correctly answer Question 6I, and 12% correctly answer Question 6J. Comparing these results to the experimental group, 20% correctly answer Question 6E, 36% correctly answer Question 6G, 20% correctly answer Question 6H, 0% correctly answer Question 6I, and 12% correctly answer Question 6J. For those five questions the percentages were low to begin. However, with the present data, a significant difference between the results could not be determined. The data did not conform to a normal probability distribution. So a t-test could not test the significance between the means of the data.

Another skill focused on the student's understanding of a factor and what to do if one factor is already given. Questions 4 and 5 on the posttest focused on this skill. The questions were designed to connect their skills from multiplying polynomials with factoring. The control group had 12% correctly answer Question 4 and 8% correctly answer Question 5. The low percentage of correct answers from the control group, along with the experimental group answering none correctly, shows that the students have a tough time connecting multiplication with factoring. There is not enough information to show a significant difference. The data is not normal in that the experimental group did not answer any questions correct. They may have omitted the questions or not had any exposure to the information. Thus a t-test could not be performed to test the significance of the means of the data.

The final skill analyzed deals with an application of factoring. Many of the students will be advancing to the next level of Algebra in the coming school year. Some will take Geometry and Trigonometry. In these future math classes, factoring is used as one method to solve equations. As an application, Algebra I classes use factoring to solve quadratic equations. Question 7 deals with this application. The students in the control group performed the best showing some percentages of correct answers. They had 24% for Question 7A, 12% for Question 7B, and 8% for Question 7C. The students in the experimental group did not answer any correct. The students may have skipped over the question because of not knowing what to do or they made an attempt to solve the equation and did not do it correctly. These results might show that students in the experimental group did not have any exposure to applications dealing with factoring. NovaNET may not provide applications in its lesson. But the control group seems to have had some level of exposure with solving equations using factoring. Because the data does not appear to be normal due to the experimental group's results, a t-test could not be performed on the data. Thus the data is inconclusive as to show a significant difference between the means of the data.

Research Question #4

Will students who receive computer-assisted instruction recommend similar instruction to future students learning about factoring polynomials?

The students that participated in the experimental group had the opportunity to discuss their experience with computer-assisted instruction and using NovaNET. The discussion included questions asking how much time did the students spend on a computer, how much time do you spend on the computer using homework, what kind of experiences have you had using a computer to learn math, and would you recommend using a computer for instruction in mathematics.

Students who spent time on the computer said they spent between 15 minutes to 2 hours per day on the computer. In spending that much time per day on the computer, responses varied as to what the students did on the computer during that time. Students said they spent around one hour per day using the computer for school related assignments.

Students were then asked questions about their experiences with computers and learning mathematics. Students were aware of different software packages that deal with mathematics instruction. Much of the software mentioned dealt with drill and practice packages and software that presented the material as a game. The software packages were commonly used for extra practice, building mastery of skills, and test preparation. Students had not used the computer to learn new material.

The question turned next to the effectiveness of the computer and the software used to instruct students. Students said the tutorials they saw, especially with NovaNET, used one method. If they did not understand the method being used, then they had difficulties learning the material. In many cases, it frustrated the students. Time was an area that received focus during the discussion. Some students did not like the time limits. They said it put an added pressure on them to perform. But another student the time limits actually improved his accuracy in mathematics. Students appreciated the fact that the tutorials provided instantaneous feedback. Students found the mechanics of the tutorials frustrating. Students had to use a combination of keystrokes to produce specific features, for example superscripts for exponents on NovaNET. These keystrokes were not easy to remember and the student had to do it every time.

Students were then questioned about the differences between computer-assisted learning and traditional instruction. Overwhelmingly, the student responses dealt with explanations. As mentioned above, tutorials tend to use one method to teach a topic. Students preferred traditional instruction for the multiple methods that teachers tend to provide. The students preferred traditional instruction for the feedback they received from teachers. Yes, the computer provides feedback and it tends to do it quicker than the teacher. But the feedback is not thorough. Teachers can tell the students what they did wrong and how to fix their mistakes. The students can also receive other methods to solve the problem. Some students said they preferred learning from a lecture rather than a computer while some said the computer provided them with better instruction.

When we look at the comments the students made during the discussion, we note a lot of mixed feelings. There appear to be more negative feelings for the computer-assisted learning. Students preferred the overall effectiveness of their instruction over the perks that might come from computers. They seem to feel traditional instruction provides the instruction they need to understand the material. One student said that traditional instruction should incorporate computers as a part of daily instruction. Thereby, students would receive the benefits of both styles of instruction.

Recommendations

The first recommendation discusses the use of NovaNET. It is only one example of computer-assisted instructional software. Perhaps there are other software packages that provide better instruction with factoring, or for that matter, better instruction in mathematics. It would be recommended to research other learning systems before computer-assisted instruction is determined to be a better, or poorer, form of instruction.

A second recommendation is to look at another topic of mathematics. Algebra is one area. Factoring is a smaller area. If one wants to look just at Algebra, then it is recommended to look at another topic in Algebra I. A study can be done using equation solving with one variable or graphing linear equations. Perhaps using computer-assisted learning in Geometry or in Trigonometry would produce better results. Studying one topic does not justify the results affecting all topics.

A couple of other recommendations need to be made. One recommendation is to compare students of different academic abilities with their results on performance tests. The reason is that the academic ability of students might influence their performance on studies that involve computer-assisted instruction. A second recommendation might be to look at time as a factor of performance. A thought might be that students who have more time in their instruction will perform differently than students who receive less time. This idea would include students who receive extra-assistance from a computer tutorial program or even a tutor.

A final recommendation is to look at combining computer-assisted learning with traditional instruction. Both appear to have advantages to instructing students in mathematics. Traditional instruction can provide answers that the computer may not be able to provide. The computer can provide the graphical details that traditional instruction tends to not produce as well.

Society is not close to seeing an end of computers in education. In fact, it might be said we are just beginning to see the emergence of what computer-assisted instruction can do for students. If we give educators and programmers enough time, then we could see computers making a stronger presence in the classroom.

REFERENCES

Armstrong, Alison & Casement, Charles (2000). *The child and the machine: how computers put our children's education at risk*. Beltsville, MD: Robins Lane Press.

Becker, Henry J. & Riel, Margaret M. (2000). *Teacher professional engagement and constructivist-compatible computer use. Teaching, Learning, and Computing.* Retrieved from http://www.crito.uci.edu/tlc/findings/report_7/startpage.html

Christensen, Carol A. and Gerber, Michael M. (1990). Effectiveness of computerized drill and practice games in teaching basic math facts. *Exceptionality*, 1, 149 – 165.

De Corte, E., Linn, M.C., Mandl, H., & Verschaffel, L. (1992). *Computer-based learning environments and problem solving*. Berlin, Germany: Springer-Vaerlag.

Erlwanger, S. H. (1973). Benny's conception of rules and answers in IPI mathematics. *Journal of Children's Mathematical Behavior*, 1(2), 7 – 26.

Heid, H. Kathleen (1995). *Algebra in a technological world*. Reston, Virginia: National Council of Teachers of Mathematics.

Karush, William (1989). *Webster's New World Dictionary of Mathematics*. New York: Macmillan General Reference.

Liao, Y. C. & Bright, G. W. (1991). Effects of computer programming on cognitive outcomes: A meta-analysis. *Journal of Educational Computing Research*, 7(3), 251 – 268.

Margolinas, C. (1991). Interrelations between different levels of didactic analysis about elementary algebra. *Proceedings of the 15th International Conference for the Psychology of Mathematics Education*, 2, 381 – 388.

Mastropieri, M. A., Scruggs, T. E., Shiah, R., and Mushinski Funk, B. J. (1995). Reflections on"the effects of computer-assisted instruction on the mathematical problem solving of students with learning disabilities." *Exceptionality*, 5(3), 189 – 193.

McArthur, David, Stasz, Cathy, Hotta, John, Peter, Orli, & Burdorf, Christopher (1988). Skill-oriented task sequencing in an intelligent tutor for basic algebra. *Instruction Science*, 17, 281 – 307.

McCoy, Leah P. (1996). Computer-based mathematics learning. *Journal of research on Computing in Education*, 28(4), 438 – 460.

Merriam-Webster's collegiate dictionary (10th ed.), (1993). Springfield, MA: Merriam-Webster.

Morrison, H., Gardner, J., Reilly, C., and McNally, H. (1993). The impact of portable computers on pupils' attitudes to study. *Journal of Computer Assisted Learning*, 9, 130 – 141.

National Council of Teacher of Mathematics (2000). *Principles and Standards for School Mathematics*. Reston, VA: Author.

National Council of Teacher of Mathematics (1995). *Assessment Standards for School Mathematics*. Reston, VA: Author.

National Council of Teacher of Mathematics (1989). *Curriculum and Evaluation Standards for School Mathematics.* Reston, VA: Author.

NovaNET NOW Instructor Training Workbook (2001). Tucson, AZ: NCS Pearson, Inc.

Phillips, R. J. & Pead, D. (1994). Multimedia resources in the mathematics classroom. *Journal of Computer Assisted Learning*, 10, 216 – 228.

Rauff, James V. (1994). Constructivism, factoring, and beliefs. *School Science and Mathematics*, 94(8), 421 – 426.

Roebuck, Kay I. Meeks (1997). A formula for factoring. *The Mathematics Teacher*, 90, 206 – 207.

Salpeter, Judy (2000). *What does the research say about technology's impact on education? Technology & Learning.* Retrieved from www.techlearning.com/db_area/archives/TL/062000/archives/becker.html.

Smith, Stanley A., Charles, Randall I., Dossey, John A., Keedy, Mervin L., & Bittinger (1994). *Algebra*. Menlo Park, CA: Addison-Wesley.

Sullivan, Michael & Sullivan, Michael, III (1998). *Precalculus: Graphing and data analysis*. Upper Saddle River, NJ: Prentice Hall.

Tilidetzke, Robert (1992). A comparison of CAI and traditional instruction in a college algebra course. *Journal of Computers in Mathematics and Science Teaching*, 11, 53 – 62.

Wilson, R., Majsterek, D., & Simmons, D. (1996). The effects of computer-assisted versus teacher-directed instruction on the multiplication performance of elementary students with learning disabilities. *Journal of Learning Disabilities*, 29(4), 382 – 390.

APPENDICIES

APPENDIX A

Pretest

PRETEST Name___________________
Factoring Date____________________

Answer the following questions to the best of your ability in the space provided.

1. (a) In your own words, what is a factor? (b) List all of the whole numbers that are factors of 60.

2. Rewrite $30ab^2c^3$ as a product of three factors.

3. List the prime factorization of $18p^3q^2$.

4. (a) In your own words, what is a multiple? (b) List the first 5 multiples of 15.

5. Multiply the following polynomials.

A. $-6(3x^2 - 5xy^2 + y^3)$
B. $2a(-5a^8b + a^2 - 12ab)$
C. $(4x+2)(x+12)$
D. $(x^2-3)(x-1)$
E. $(m^2n-5n)(m^2n+5n)$
F. $(5y-6)^2$

6. A rectangular garden (4 sides, with opposite sides having equal lengths and 4 right angles) measures $7x+3y$ in length and $5x-y$ in width. (a) Find the perimeter of the rectangle, if perimeter is the sum of all the sides of a figure. (b) Find the area of the rectangle, if area is the measure of the length times the width.

7. Find the binomial that multiplied to $4x-3$ produces $16x^2-9$.

8. Find the binomial that multiplied to $2y+7$ produces $2y^2-3y-35$.

9. $3x$ is a common factor to $9x^3-3x^2y+27xy^2$. What is the other factor to $3x$ that yields this product?

10. x^2+6x+8 is a product of two binomials multiplied together. What two binomials make this possible?

11. $y^2-3y-28$ is a product of two binomials multiplied together. What two binomials make this possible?

12. m^2-16 is a product of two binomials multiplied together. What two binomials make this possible?

13. Solve the following equations.

A. $x - 7 = 0$
B. $12 - y = 0$
C. $2m + 5 = 0$
D. $-3(6k - 7) = 0$

14. A ball is thrown into the air. The ball's height, *h*, in feet can be found using the equation $h = 64t - 16t^2$ where *t* is the time in seconds. (a) How high is the ball after 2 seconds? (b) When will the ball hit the ground? (c) What is the maximum height the ball attains?

APPENDIX B

Posttest

POSTEST Name____________________
Factoring Date____________________

Answer the following questions in the space provided.

1. (a) In your own words, what is a factor? (b) List all of the factors of 128 that are whole numbers.

2. Rewrite $48w^5x^2y^4$ as (a) a product of two factors and (b) as a product of three factors.

3. List the prime factorization of $90m^6n^3$.

4. The trinomial $2ax^2 - 2ax - 12a$ is found by the product of $2a$ and two binomials. Find the two binomials.

5. The trinomial $y^4 - 15y^2 + 36$ is found by the product of $y^2 - 3$ and what other binomial?

6. Factor the following polynomials completely.

A. $x^2 + 13x + 36$

B. $m^2 - 7m - 8$

C. $k^2 - 16k + 64$

D. $c^2 - 81$

E. $36w^2 - \frac{1}{25}$

F. $k^2 - 6kc - 27c^2$

G. $2y^2 + 7y + 6$

H. $5p^2 - 3pn - 8n^2$

I. $18h^2 - 8$

J. $2u^3 + 6u^2 + u + 3$

7. Solve the following quadratic equations by factoring. Show all work.

A. $m^2 - 12m + 35 = 0$

B. $k^2 + k - 4 = 38$

C. $2u^2 + 7 = 5 - 5u$

8. The management at the Four Seasons is planning to offer a special Winter Weekend at its resort hotel in the mountains. There will be special meals, entertainment, and outdoor recreation activities for the whole family, with all activities included for a fixed price per person. The problem is what to charge.

Market surveys suggest that the number of customers can be found from the equation $C = 450 - 2.5p$ where C is the number of customers and p is the price charged. After listing the expected costs, the management estimates that the profit can be found by the equation $F = -2.5p^2 + 600p - 27000$ where F is the profit and p is the price charged.

Answer the following questions:

A. If the price charged is \$100, how many customers will attend?

B. If the price charged is \$100, how much profit will be made?

C. If the Four Seasons wants 300 customers, how much will they need to charge?

D. If the Four Seasons wants a \$5000 profit, how much will they need to charge?

E. What price will have to be used in order for no customers to attend?

APPENDIX C

Retention Test

RETENTION TEST Name____________________
Factoring Date______________________

1. Rewrite $225a^2b^3c$ as a product of three factors.

2. Write the prime factorization for $72x^2y^4$.

3. The polynomial $3x^3 - 12x$ can be factored as 3 polynomials. One is $x-2$. Find the other two factors.

4. Factor the following polynomials completely.

A. $x^2 - 14x + 40$

B. $2k^2 + 2 - 60$

C. $4y^2 - 49$

D. $m^2 - 22m + 121$

E. $2u^2 - u - 15$

F. $ax^2 - 9a + bx^2 - 9b$

5. Solve $x^2 + 9x + 20 = 0$ for x. Show all work.

6. A rectangle has an area of $3p^2 - 5p - 2$. Find the length and width of the rectangle if its area is a product of the length and width.

APPENDIX D

Parental Consent Form

March 18, 2002

Dear Parents/Guardians,

Broughton High School has recently implemented the use of a computer software program called NovaNet. The program is currently being used to provide students with an opportunity to practice mathematics problems. The students receive feedback from the computer about whether they are solving these problems correctly or incorrectly. Students have improved their performance on assignments in their mathematics classes. Although the software program is currently being used for reinforcement and extra practice, it is also being used during school in a mathematics classroom. I would like to investigate the effects of this program on students' performance in mathematics when it is used in the context of a regular mathematics class. I am a mathematics teacher at Broughton High School and a graduate student pursuing a Masters degree in Mathematics Education at North Carolina State University (NCSU). I am interested in investigating the success of NovaNet in the classroom – specifically in an Algebra classroom. As technology becomes increasingly present in our schools, the community needs to be aware of the effects that using technology has on students' success in subject areas such as mathematics.

To better understand the effects that NovaNet has on students' performance in mathematics, my investigation will compare traditional class instruction to computer-assisted instruction using NovaNet. The investigation will take place over a 2 – 3 week period. The Algebra students will be studying the topic of Factoring. Students will be assessed three times during the study. There will be a pretest at the beginning of the unit and a post-test at the conclusion of the unit. Prior to final exams, a retention test will be administered assessing the amount of material retained from both forms of instruction. Two classes of Algebra I students will be involved during the study. Mrs. Heather Freeman's 5th period Algebra class will receive traditional instruction. Mr. Michael Clinkscales's 1st period class will receive instruction through NovaNet. Because Factoring is a topic under the North Carolina Curriculum for Algebra I, students will not lose any instructional time. During the study, I will be interviewing students about the instruction they received. The names of individual students or any information that could identify a student will not be used in any reports of this investigation.

I am asking your permission to allow your student to be involved in this study. By signing the attached sheet, you will be granting your child permission to participate in this study. If at any time you feel that your child's education is in danger, you may have the student removed from the study. If you have any questions about the study, please call Mr. Clinkscales at Broughton High School at 856 – 7810 or Dr. Karen Hollebrands at North Carolina State University at 513 - 0505. Thank you for your time and consideration.

Sincerely,

Michael J. Clinkscales
Math Teacher, Broughton High School

Diane Payne
Principal, Broughton High School

PERMISSION TO ASSIST IN RESEARCH STUDY

I allow my child to participate in the research study conducted by Michael Clinkscales at Broughton High School. I understand that student confidentiality will be maintained throughout the study and after the study has concluded. The study has been described and explained in the attached letter. I am aware that any questions may be asked during the study. I am also aware that my student will be removed at my request.

Student's Name____

Student's Signature____

Parent's Name____

Parent's Signature____

Date____

APPENDIX E

Discussion Questions

STUDENT DISCUSSION
Computer-Assisted Instruction

1. Control Group OR Experimental Group

2. How much time do you spend per day on the computer?

3. What experience(s) have you had using computers to help your learning of mathematics (excluding calculators)? Were they good or bad?

4. What differences do you see between being taught by a human teacher and by a computer?

5. Are these differences between human teachers and computers good or bad?

6. If you had the choice, would you prefer being taught by a human teacher or by a computer? Why?

7. Do you have other comments you would like to share?

APPENDIX F

Results from Pretest, Posttest, and Retention Test

PRETEST RESULTS

Experimental Group

STUDENT	PERCENT
1	26.19048
2	47.61905
3	45.2381
4	50
5	40.47619
6	54.7619
7	26.19048
8	71.42857
9	42.85714
10	57.14286
11	38.09524
12	38.09524
13	23.80952
14	26.19048
15	50
16	19.04762
17	61.90476
18	73.80952
19	42.85714
20	76.19048
21	47.61905
22	57.14286
23	26.19048
24	61.90476
25	57.14286

Control Group

STUDENT	PERCENT
1	42.85714
2	57.14286
3	54.7619
4	42.85714
5	42.85714
6	69.04762
7	23.80952
8	52.38095
9	35.71429
10	21.42857
11	28.57143
12	50
13	38.09524
14	59.52381
15	42.85714
16	50
17	38.09524
18	38.09524
19	30.95238
20	35.71429
21	45.2381
22	47.61905
23	38.09524
24	28.57143

POSTTEST RESULTS

Experimental Group

STUDENT	PERCENT
1	18.60465
2	16.27907
3	37.2093
4	60.46512
5	48.83721
6	51.16279
7	27.90698
8	51.16279
9	11.62791
10	53.48837
11	4.651163
12	4.651163
13	34.88372
14	11.62791
15	13.95349
16	6.976744
17	16.27907
18	67.44186
19	30.23256
20	72.09302
21	32.55814
22	39.53488
23	27.90698
24	44.18605
25	51.16279

Control Group

STUDENT	PERCENT
1	27.90698
2	62.7907
3	55.81395
4	34.88372
5	25.5814
6	48.83721
7	25.5814
8	48.83721
9	39.53488
10	44.18605
11	53.48837
12	16.27907
13	39.53488
14	30.23256
15	51.16279
16	81.39535
17	27.90698
18	62.7907
19	34.88372
20	39.53488
21	51.16279
22	37.2093
23	20.93023
24	37.2093
25	62.7907

RETENTION TEST RESULTS

Experimental Group

STUDENT	PERCENT
1	9.52381
2	9.52381
3	52.38095
4	42.85714
5	23.80952
6	38.09524
7	23.80952
8	42.85714
9	38.09524
10	19.04762
11	4.761905
12	42.85714
13	28.57143
14	23.80952
15	14.28571
16	0
17	33.33333
18	42.85714
19	38.09524
20	66.66667
21	52.38095
22	19.04762
23	14.28571
24	38.09524
25	52.38095

Control Group

STUDENT	PERCENT
1	28.57143
2	38.09524
3	28.57143
4	28.57143
5	14.28571
6	38.09524
7	19.04762
8	23.80952
9	0
10	19.04762
11	0
12	0
13	0
14	33.33333
15	28.57143
16	0
17	23.80952
18	47.61905
19	33.33333
20	38.09524
21	28.57143
22	38.09524
23	47.61905
24	57.14286
25	57.14286

APPENDIX G

Results from Item Analysis

RESULTS FROM ITEM ANALYSIS

Posttest – Question #6 (Out of 20 points)

Experimental Group

STUDENT	SCORE	PERCENTAGE
1	0	0%
2	0	0%
3	12	60%
4	14	70%
5	13	65%
6	13	65%
7	8	40%
8	14	70%
9	3	15%
10	14	70%
11	0	0%
12	0	0%
13	10	50%
14	4	20%
15	0	0%
16	0	0%
17	0	0%
18	19	95%
19	6	30%
20	19	95%
21	5	25%
22	9	45%
23	9	45%
24	11	55%
25	14	70%

Control Group

STUDENT	SCORE	PERCENTAGE
1	8	40%
2	16	80%
3	11	55%
4	6	30%
5	6	30%
6	14	70%
7	8	40%
8	13	65%
9	11	55%
10	16	80%
11	11	55%
12	1	5%
13	12	60%
14	8	40%
15	10	50%
16	17	85%
17	7	35%
18	13	65%
19	8	40%
20	11	55%
21	12	60%
22	8	40%
23	8	40%
24	13	65%
25	13	65%