Orchard

Targeted Educational Software

The Effects of Computer-Assisted Instruction on Middle School Mathematics Achievement

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Dedication

For the support and patience through a long and difficult process, I would like to dedicate this work to my family.

My parents taught me that a person is judged in life by what they give, not what they have. No child has ever been luckier to have the love and support that I was given. I pray that I will live my life in a way to honor them.

I hope my children will always believe that all things are available to them with education and enough hard work. Anything and everything is possible for them. Both are them are wonderful and I love them and will always be incredibly proud that they are mine.

All things in my life begin and end with my wife. Anything is possible as long as I have her. She has been my pillar of support and my inspiration to continue through this experience. With her, I will always feel that I am a success.

TABLE OF CONTENTS

ABSTRACT

Success in mathematics is central to a good education in the modern world. The better educated a society the more successful the society. The United States is behind the world in mathematics education and must do everything to develop effective pedagogies for its instructions.

Proponents of computer technology in education argue that it makes learning easier, more efficient, and more motivating (Schacter & Fagnano, 1999). Skeptics argue that there is a lack of experimental data obtained under rigorous scientific standards. Computer-assisted instruction (CAI) is an educational medium in which a computer delivers instructional content or activities. Many studies have been completed attempting to determine the effects of computer-assisted instruction on academic achievement. Frank Brown (2000) found a 17% increase in achievement in mathematics during a study in North Carolina. A recent study by Traynor (2003) found that utilizing computer-assisted instruction improved instruction over only using traditional methods. Traynor found a significant increase in academic achievement.

For this study, a cause-effect linkage was suspected between the use of computer-assisted instruction software and achievement in mathematics. A study was required to prove or disprove this relationship in which one can manipulate the variable of computer-assisted instruction. A quasi-experimental study was used with a two-group, pre-test post-test design. The control group was taught by traditionally accepted teaching methods throughout the study. The experimental group received the same traditional teaching methods plus one hour a week of computer assisted instruction in the form of Orchard software. The differences between the scores on the post-test and pre-test were calculated and the means of the differences from the experimental group and the control group were compared using a t-test. The results of the data analysis indicated that the use of computer-assisted instruction in addition to traditional teaching methods is more effective than traditional teaching methods alone. No difference was found between the genders of the subjects in the change of their academic achievement as measured by the difference from the pre-test to the post-test.

INTRODUCTION

Overview

Since the beginning of time, cultures and societies have recognized the importance of mathematics. Mathematics is more than a simple subject; it is a language that helps us describe ideas and relationships drawn from our environment. Mathematics is a tool of science and technology that enables people to explore concepts with idealized models before trying them in the real world (Clark and Fulton, 2003).

Despite the importance of mathematics, research has found that U.S. students rank lower than their peers from other countries. Students from the United States scored below the international average on the Third International Mathematics and Science Study. Twelfth grade students in the United States were the third country from the bottom on the test out of twenty-one nations tested (Lubell, 1998).

The world is firmly entrenched in a new century as well as a new millennium. In spite of the shortcomings of American students in mathematics, educators have been slow to embrace the rapid change that has engulfed other areas of our life. Enter most classrooms today and very little difference from a classroom of a hundred years ago would be observed in the methods of instruction. Despite the great amount of money that has been spent of technology, today's teachers still primarily convey information to students in the form of lecture. Several billion dollars has been spent in the United States to ensure access to technology for all students (Johnson, 2000). Between the years 1997 and 2000, the federal government alone spent 1.25 billion dollars on the Technology Literacy Challenge Fund that provides funding for new computers, software, and teacher training (Johnson, 2000). Many groups have championed the cause for computers in America's schools including the federal government. In March of 1997, the President's Committee of Advisors on Science and Technology recommended the federal government should spend 6 to 28 billion each year on a program to increase computer infrastructure, teacher training, and research (Panel on Educational Technology, 1997). Research indicates that the use of technology, especially computer-assisted instruction is superior to traditional methods of instruction alone. The research demonstrates that the benefit of computer-assisted instruction is generally true of different ages and abilities and for learning in different curricular areas (Cotton, 1991).

Mathematics instruction is too important to not utilize all available resources to their full potential. America has invested large amounts of money on technology. We must ensure that the use of technology in instruction is effective in increasing student academic achievement. Research conducted on the effectiveness of computer-assisted instruction has not been extensive or conclusive. Further research is required to determine if the vast amounts of money spent is warranted.

Significance of the Study

Mathematics equips pupils with a uniquely powerful set of tools to understand and change the world. These tools include logical reasoning, problem-solving skills, and the ability to think in abstract ways. Mathematics is important in everyday life, many forms of employment, science and technology, medicine, the economy, the environment and development, and in public decision-making (Clark and Fulton, 2003). The special emphasis on achievement in mathematics reflects the fact that competencies in these areas have important economic consequences for indi-

viduals and for the United States. For the individual, strong mathematics competencies improve the likelihood of employment, result in higher wages once employed, and improve on-the-job productivity. The overall productivity of a society's citizens, in turn, has an important influence on the standard of living of members of that society.

Well-educated and economically productive citizens normally enjoy good living conditions. Given the important link between competencies in mathematics and economic outcomes, it is in the best interest of the United States to develop a world-class educational system in mathematics (Geary and Hamson, 2004). Generally, the higher the levels of education the higher the likelihood of employability and higher wages once employed. The benefits associated with education tend to increase with increases in the technical complexity of the associated school-taught competencies. In technologically complex societies, such as the United States, there is a particular premium associated with math-intensive skills (Geary and Hamson, 2004). Strong quantitative competencies influence employability and productivity in many blue collar and white collar jobs, above and beyond the influence of intelligence, reading ability, years of schooling, race, and gender (Geary and Hamson, 2004). Poor mathematical competencies restrict college major and later career choices for individuals pursuing post-secondary education. Moreover, the more math-intensive the occupation, the higher the entry-level and subsequent wages. These relatively high-paying occupations include engineering and the math-intensive physical sciences (Geary and Hamson, 2004).

Strong academic competencies in mathematics improve the chances of employment and result in higher wages and higher on-the-job productivity once employed. Not only do strong mathematical competencies influence the economic well-being of individuals, through their relation to employability and wages, they also have wider social consequences, as noted above. For instance, it has been estimated that the poor mathematical and literacy of the workforce will cost the U.S. economy nearly 170 billion dollars each year by the year 2000. Thus, a first-rate educational system provides individual and general social benefits (Geary and Hamson, 2004).

Educational outcomes in mathematics would appear to be especially important and beneficial in societies, such as the United States, where many jobs require some level of technical sophistication. With this in mind, it is important to consider how the mathematics education of our children rate in terms of international standards. The first systematic cross-national assessment of mathematical competencies was conducted in 1964 and included 13- and 17-year-olds from 12 industrialized nations. The results of this study indicated that American adolescents were among the most poorly educated mathematics students in the industrialized world. Of the 12 participating nations, the American 13-year-olds ranked 10th and 11th, across two comparisons. The assessment of the 17-year-olds was based on students who were enrolled in a math-intensive college preparatory high school curriculum, that is, each country's best prepared students. The American 17-year-olds ranked last (New York State United Teachers , 2004).

The most recent cross-national study, conducted in 1994 and 1995, compared primary, middle, and high-school students in mathematics achievement across 45 nations. The assessment of 8th graders included 8 of the 12 nations that participated in the first multi-national assessment. Of these, U.S. 8th graders ranked 7th. American children and adolescents have scored below the international average in mathematics achievement for more than 30 years. In the most recent

study, about three out of five U.S. 7th and 8th graders scored below the international average in mathematics. Or, stated differently, just over two out of five U.S. students scored above the international average. However, only about 1 out of 100 U.S. students scored as well as the average student in the top-ranked nation, Singapore. Thus, while this most recent study indicates that U.S. middle-school students are not substantially below the international average, they are far from being the best in the world (New York State United Teachers , 2004).

In all, while the rank of American children and adolescents is disturbingly low in mathematics, the real significance of these studies is found in the large gap between the mathematical competencies of America's students and their peers in most other nations. The mathematical competencies of the typical American student are below international standards and even the best educated mathematics students in the United States are, in most comparisons, no match for the best educated students in many other industrialized nations (Geary and Hamson, 2004).

Research on the effects of computers on student academic achievement began in the 1960s. The early research that was done was inconclusive in determining the effectiveness of computers. Skinner (1965) felt that the use of computers could build confidence in education (p. 19). Lumsdaine (1965) warned that an evaluation of computer-assisted instruction should be undertaken in many areas. These evaluations included how many students started and completed the program, average completion time, average level of performance on pre-test and post-test of achievement, and the variability of these measures (Lumsdaine, 1965). More recent studies are not any more conclusive than the early studies. Baker (1999), in a study of research done on computer-assisted instruction, claims there is a lack of controlled studies. Baker found that the majority of studies were conducted by surveying students' and teachers' attitudes and opinions toward computers. The surveys were not conducted in an experimental fashion with a control group and experimental group.

In 1997, Harold Wenglinsky of the Educational Testing Service published a major study on computers and academic achievement. Wenglinsky used data obtained from the 1996 National Assessment of Educational Progress (NAEP) mathematics examination. He found that while a positive effect of computer technology did exist, students who only used computers for drill and practice, as opposed to using them in ways that would develop higher order, thinking, did worse on the NAEP test than the students who had not used the computers at all. The need for a study utilizing a control group is evident. Few studies have been conducted to demonstrate a relationship between computer-assisted instruction and increase in academic achievement. Christmann, Badgett, and Lucking (1997) suggested that further research is necessary to determine whether or not computer-assisted instruction is more effective in different subject areas. This study should reveal if computer-assisted instruction is more effective than traditional teaching methods in the teaching of middle school mathematics.

Statement of the Problem

The importance of mathematics education to America in a progressively more competitive world makes it imperative that all possible is done to ensure the best instruction available. Many educators and non-educators believe that the use of computer-assisted instruction as part of the curriculum is superior to other pedagogies (Kulik, 1994). This study is intended to determine the

effect of computer-assisted instruction on student achievement in mathematics as compared to classes using only traditional teaching methods. The study will concentrate on the mathematics modules. The quasi-experimental study will determine whether or not the effectiveness of computer-assisted instruction is effective in improving middle school mathematics achievement as compared to traditional teaching methods.

If a positive relationship is found between the use of computer-assisted instruction and achievement in mathematics, further investment in technology would be indicated. Too many school systems have implemented large amounts of technology not as a solution to improving learning but as a public relations ploy to reassure parents and the public that the system is cutting edged (Trautman, 2002). Money and time have been invested in the development of software and hardware for schools and the utilization of software in class. The school system in which the study was conducted spent $10,426,000 between the years of 1998 and 2002 on computers alone. Another $7,350,000 has been spent on peripheral devices, such as, scanners, digital cameras, and large screen televisions and staff development (Rutherford County Schools Technology Plan, 2003).

Purpose of the Study

The purpose of this study was to determine if instruction including computer-assisted instruction in mathematics produces higher levels of academic achievement than traditional teaching methods alone. Mathematics instruction has changed very little over time. Mathematics teachers today use the same methods as their ancestors (Shellard & Moyer, 2002). Students have a concept introduced to them by the teacher; the students then practice the concept, and are tested. All students are expected to progress at the same rate. American students have continued to fall behind their counterparts throughout the world (TIMSS, 2003). Results on the Third International Mathematics and Science Study, which tests eighth-graders, placed U.S. students 28th out of 41 countries in math (TIMSS, 2003). Great amounts of time, money, and efforts have been invested in computer usage in education.

Research Questions

The following research questions guided the study.

1. Will the use of a computer-assisted instructional software package once per week produce a higher level of academic achievement in mathematics by middle school students as measured by tests provided by the textbook publisher as compared to students that received only traditional teaching methods?

2. Is there a difference in academic gains in mathematics as based on race or gender from the use of computer-assisted instruction as compared to students that receive only traditional teaching methods?

Null Hypotheses

H1 There will be no statistically significant differences between the level of achievement in mathematics as measured by pre-test and post-tests of an experimental group of middle school students who received computer-assisted instruction compared to a control group.

H2 There will be no statistically significant difference in mathematics achievement as measured by pre-test and post-tests of students based on their ethnicity of students that received computer-assisted instruction.

H3 There will be no statistically significant difference in mathematics achievement as measured pre-test and post-tests of male and female students that received computer-assisted instruction.

Limitations and Delimitations

1. The results of the study may not generalize to other settings due to only two schools being involved. The schools have very similar socio-economic and racial makeup.

2. The limited number of schools will also limit the sample to approximately 400 students. A larger sample would increase the ability to generalize and possible eliminate some extraneous variables.

3. The computer skills of the students may not be equal. Some students may not benefit to the same degree by the use of the computers due to their struggles in using them.

4. The groups were obtained by random cluster sampling. A truly random sample is impossible in the school setting. This prevents the sample from being generalized to a greater extent.

5. The study was conducted over a twelve-week period. A longer period would give greater validity to the results and would eliminate some environmental factors. The longer period of time would ensure that the treatment of the study was the cause of any change.

Definition of Terms:

Bandwidth describes information-carrying capacity. Bandwidth is most accurately measured in cycles per second, or hertz (Hz), which is the difference between the lowest and highest frequencies transmitted (Computer Desktop Encyclopedia).

Computer infrastructure is the hardware, software, and necessary wiring to ensure connectivity on a wide area or local area network.

Computer-assisted instruction (CAI) is an educational medium in which instructional content or a computer delivers activities. Students learn by interacting with the computer and appropriate feedback is provided. Several acronyms represent the use of computers in educating students. These are:

CAI: Computer-assisted Instruction

CAL: Computer-assisted Learning

CaI: Computer Aided Instruction

CaL: Computer Aided Learning

CBI: Computer Based Instruction

CBL: Computer Based Learning (Mundane)

Learner directed instruction is when the student sets the pace, the direction, and depth of the instruction.

Lecture method of instruction is a way of teaching in which the teacher in an oral method presents the majority of the course content.

A network is a group of two or more computer systems linked together to allow sharing of software (Computer Desktop Encyclopedia).

The traditional method of mathematics instruction involves the teacher presenting the material in a lecture method. The material is then reviewed by samples from the textbook or worksheets derived by the teacher, the textbook, or both. The teacher through observations, quizzes, and tests determines mastery of the material.

LITERATURE REVIEW

Overview

The importance of academic achievement in mathematics indicates that any method that is successful should be encouraged. The limited amounts of funding available for education requires that no money should be wasted. Computer-assisted instruction has been hailed as a major step forward in education. Billions of dollars have been spent on technology in schools. The research on the effectiveness of computer-assisted instruction on academic achievement as compared to effects on achievement by traditional teaching methods is sparse and, in some cases, not of good quality (North Central Regional Laboratory, 2004).

Proponents of computer technology in education argue that it makes learning easier, more efficient, and more motivating (Schacter & Fagnano, 1999). Skeptics argue that there is a lack of experimental data obtained under rigorous scientific standards. An argument is made that if the experiments were done using a more scientific method, the instructional

method would prove to be the controlling factor and not the media of the instruction (Clark, 1983; Neal 1998). This chapter will provide information on the history of computers in education and the costs associated with this technology. Finally, a review of other research on the effects of computer-assisted instruction on student achievement will be provided.

Brief History of Computers in Education

Computer use in classrooms has changed greatly since the inception of the medium. A great deal of the early computer-assisted instructional software was developed by Patrick Suppes at Stanford University during the 1960s. Dr Suppes systematically analyzed arithmetic courses and other subject courses. He designed highly structured computer systems that allowed for learner feedback, branching of the material, and student record keeping (Coburn et al. 1982).

Before the early 1980s, computers were too expensive to be used in K-12 education. The introduction of the Apple II and the Radio Shack TRS-80 allowed more widespread use. The computer was considered a subject area. Computers were a topic to be studied and not integrated into all areas of the curriculum. Students were taught computer literacy as well as BASIC computer language (Kinnaman 1990). The principal use of computers in school was record keeping.

The late 1980s saw a marked reduction in the cost of computers. Schools began to budget money for technology. Computers were still not fully implemented into the curriculum due to many factors. Money was not budgeted for teacher training or computer maintenance and limited software applications for education were available. The future need in the job place for skills associated with the use of technology was not yet determined (Christman & Badgett, 2000). The educational community had only begun to herald computers as being an effective teaching methodology (Christman & Badgett, 2000).

The emergence of computer-assisted instruction and incorporation of technology into all aspects of the curriculum began in the early 1990s. The Internet led to a quick proliferation of computers in the home. Students were more comfortable using computers allowing for a greater integration into their day. Computer-assisted instruction moved beyond simple drill and prac-

tice. Software became more effective by being more adaptive to each individual student's needs (Christman & Badgett, 2000). The increased emphasis on the individual student and their learning requirements caused a greater interest in computer-assisted instruction. As more research was completed on student learning, it was found that students benefited from the learning-centered environment that computers made possible. The focus of computer use in the classroom shifted to quality of learning. Product based learning became more prevalent in the educational arena. Product based learning has a project as part of the assignment such as a research paper or presentation (North Central Regional Laboratory, 2004).

Mastery Learning

One of the basis for computer-assisted instruction is the theory that everyone can learn given enough time and personal attention (Bloom, 1984). Bloom's model of Mastery Learning calls for students to receive individualized instruction as necessary until they master all the course material (Bloom, 1984). Mastery learning does not focus on content, but on the process of mastering it. Major objectives representing the course or unit define mastery of the subject. The material is divided into smaller, sequentially organized units. Mastery learning should include numerous opportunities for feedback to the instructor. Each unit is preceded by brief diagnostic test. The results of the diagnostic tests are used to determine supplementary instruction to help the students overcome problems. The students must demonstrate mastery of the individual units before moving on to other units (Huet, 1996).

Another model of mastery learning is Keller's Personalized System of Instruction (Keller, 1968). Keller's model has four distinguishing characteristics. First, the instructor presents the information utilizing more written materials than the traditional lecture method. Instead of the oral method of instruction the teacher selects and creates appropriate reading materials as well as provides the student with learning objectives and study questions. Secondly, students finish assignments at their own pace. Third, students must demonstrate their mastery of objectives before they are allowed to proceed. Finally, the teaching resources are devoted to helping students overcome their deficiencies (Keller, 1968).

The concept of mastery learning has been further enhanced by the use of computers in education. The computer allows for very individualized instruction. Each child can work at his or her own pace. This is one of the cornerstones of mastery learning (Vockell, 1990). Computers allow for a great amount of testing and analysis of the data gained from the test. Each child can be tested before a concept is covered in the class. The students' mastery of individual concepts in the lesson can be determined. This allows the teacher to concentrate on the shortcomings of the students. The time factor for the testing is greatly shortened. The information concerning the learner's needs is easily accessible and understood by the instructor (Vockell, 1990). Mastery of a topic is easily determined by the computer. After the student has mastered the objective or concept the learner can continue on to the next topic.

Computer-Assisted Instruction

Computer-assisted instruction (CAI) is an educational medium in which a computer delivers instructional content or activities. The Association for Educational Communications and Technology defined computer-assisted instruction as a method of instruction in which the computer is

used to instruct the student and contains the instruction designed to teach, guide, and test the student until a desired level of proficiency is attained (Association for Educational Communications and Technology, 1977). The level that the computer assists the learning process varies among programs. Students learn by interacting with the computer while using computer-assisted instruciton (Parr, 2003). The computer analyzes the students' responses and supplies proper feedback to the students. More advanced software packages adjusts the level and direction of the instruction to best suit the individual user's needs.

The general belief is that computer technology allows educators more options for communicating, facilitating the lesson, and enhancing the teaching and learning. Proponents claim that computer technology makes learning easier, more efficient, and more motivating (Schacter & Fagnano, 1999). These beliefs are supported by research that has found that learning with computer-assisted instruction added to the traditional teaching methods produces a higher level of academic achievement than traditional teaching methods only (Fletcher-Flinn & Gravatt, 1995).

Traynor (2003) suggests that computer-assisted instruction affects cognitive processes and increases motivation by the following ways:

1. personalizing information

2. animating objects on the screen

3. providing practice activities that incorporate challenges and curiosity

4. providing a fantasy context

5. providing a learner with choice over his/her own learning

The act of personalizing information allows computer-assisted instruction to increase learner interest in the given tasks (Padma and Ross, 1987). Another benefit is that new information can be more easily integrated into existing learning if a student's name or other familiar contexts appear in a problem. The cognitive load on the learner's memory is decreased by the animation of objects thus increasing learning thereby allowing the learner to perform search and recognition processes and to make more informational relationships (Reiber, 1991). One of the simplest ways a computer aids in the learning process is that the computer makes it easy to provide challenges and increase curiosity. These activities are found to increase personal satisfaction and promote a positive perspective on lifelong learning (Kinzie, 1998). Parker and Lepper found that a fantasy context such as computer programs that produce an action-packed game environment instead of simple rote recitation of facts increased learning by placing the learner in a situation that was intrinsically motivating (1992). Finally, providing students with a choice over their own learning provides learner with controlled instruction that contributes to motivation (Kinzie, 1998; Traynor, 2003).

Researchers first divided computer-assisted instruction into four subcategories through the works of Atkinson (1968) and Watson (1972). The first is drill and practice sessions. Researchers suggested that the computer can be an addition to the drill and practice method of traditional

instruction through relevant practical exercises. Drill and practice sessions provide feedback and practice on a topic taught to the student at a previous time. The computer has many advantages over the worksheet method of drill and practice. The computer can provide different questions for each at the proper developmental level. It can decrease the time required for the lesson by grading and providing more instantaneous feedback. The computer can increase the number of questions available for the lesson.

The second major category is tutorial sessions. The tutorial mode is a method for presenting new information to the student and then reinforcing it with appropriate questions. The student interacts with the computer much as a student would interact with a tutor in a one-to-one session. Concepts are presented to the student, the student's grasp of the material is measured, and the computer then provides more instruction or remedial instruction based upon his or her response.

The third category is games. Games are a valuable way to teach concepts such as spelling and mathematics. Games allow students to learn repetitive material in different ways to elevate the tedium.

The final category is simulations. Computers can be used to simulate scenarios in which students can experience situations that are too dangerous or expensive for real life. The sciences and fine arts benefit most from simulation software (Mundane, 1996).

A study by Kitao on the effects of computer-assisted instruction on language classes in Japan found several advantages to computer-assisted instruction. The study was conducted by surveying the students' attitudes in English classes. Kitao found that students study in a more active way when using a computer. The students could not passively sit in class and listen to the teacher. They were forced to be involved. Immediate feedback was indicated as one of the major benefits of computer-assisted instruction. The instruction is individualized. Each student progresses at his/her own pace (1993).

Studies of the Effects of Computer-Assisted Instruction

Research on computers in education began in earnest in the 1960s. In a book by Skinner in 1965, he stated that using computers to teach could build "confidence in education" (p. 19). Controlled studies on the use of CAI to teach mathematics to K-12 students are very hard to find (Kulik, 1994). A 1997 report by Coley, Cradler, and Engel on the use of technology in the classroom was unable to cite one study on the effectiveness of CAI using a control group. Government studies such as those conducted by the National Science Foundation and the U.S. Department of Education suggest potential advantages from the use of technology in the classroom but cite no research to support their conclusions (Hoffer, Moore, Wuin, and Suter, 1996).

Several large-scale studies of computer-assisted instruction were conducted in the late 1960s and 1970s. The studies reported a gain of from one to eight months over students in control groups that received traditional instruction (Alderman, 1978; Atkinson, 1968; Suppes & Morningstar, 1968).

Another meta-analysis conducted during the 1970s assessed the effectiveness of drill-and-practice, problem solving, simulation, and tutorial computer-assisted instruction programs. The study

found that computer-assisted instruction plus traditional instruction was more effective than traditional instruction alone (Jamison, Suppes, and Wells, 1974). The study found that students at the elementary level benefited from a combination of the traditional teaching methods with computer-assisted instruction. Another conclusion found in the study was that economically disadvantaged students benefited to an even greater extent academically from their more affluent peers (Jamison, Suppes, and Wells, 1974).

A meta-analysis by Niemiec and Walberg (1987) reviewed sixteen major studies between the years 1978 and 1985. The study found that students that received computer-assisted instruction as well as traditional instruction scored at the 66th percentile on tests of achievement compared to the control subjects who scored at the 50th percentile. The study suggested that computer-assisted instruction is approximately twice as effective as peer tutoring (Niemiec and Walberg, 1987).

Dalton and Hannafin (1986) conducted a study involving junior high students. The study found that computer-assisted instruction was the most effective instructional delivery system compared to video alone. In 1988, a large project integrating technology with the curriculum was studied. The study involved grades one through eight. All grades met the goals set forth in the study while several grades exceeded the predicted increase (Lore and Chamberlain, 1988).

John Kulik used meta-analysis to aggregate the findings from more than 500 individual research studies of computer-based instruction. He drew several conclusions from his 1994 work. Kulik determined that students who used computer-assisted instruction scored at the 64th percentile on tests of achievement compared to students in the control conditions without computers who scored at the 50th percentile. He also found that students learn more in less time when they receive computer-based instruction. Finally, Kulik found that students like their classes more and develop more positive attitudes when their classes contain computer-assisted instruction (Kulik 1994).

Christman, Badgett, and Lucking (1997) conducted a study comparing the academic achievement of students in grade six through twelve who received traditional education only was compared to students of the same age that received traditional teaching methods supplemented with computer-assisted instruction. Students who received the computer-assisted instruction attained a higher academic achievement than 58.2% of the students only receiving traditional instruction (Christman, Badgett, and Lucking, 1997). Christman, Badgett, and Lucking (1997) also compared achievement of students across a twelve-year period. One group of secondary students received instruction utilizing computers while the other group did not. On average the secondary students that received computer-assisted instruction made greater gains in academic achievement than 57% of the students who only receiving traditional instruction (Christman, Badgett, and Lucking, 1997).

Another study on the effects of computer-assisted instruction on students was published by Abbas Johari (Johari, 1998). Johari's subjects were 98 college undergraduate students in two sections of a computer literacy class. The students were randomly assigned to one of two treatment groups to study linear function. One group received substantially more computer instruction. The other group was taught in the traditional lecture method. Johari gave each group a pre-test

and a post-test. The group that received the computer instruction scored significantly higher on the post-test. No significant difference was found on the pre-test. The students in the group receiving computer instruction scored significantly higher on posttests than the group that did not receive the computer instruction. The author draws the conclusion that a relationship exists between the use of computer-assisted instruction and a higher level of academic achievement (Johari, 1998).

Computers have been widely touted as a way to increase student motivation. Fox found in a survey of current research in England that the most frequently cited motivating aspects of computer-assisted instruction include the novelty of working with a new medium (Fox, 1998). A study conducted by Relan on the effects of computer-based instruction found the individualized nature of the instruction as a major reason for the increase of motivation (Relan, 1997). Two other studies also found a significant increase in motivation but found the chief cause as the opportunities for learner-directed instruction (Hicken, et al, 1992; Kinzie, et al 1998). The opportunities for rapid feedback were found to be a reason for improved motivation by two other studies (Armour-Thomas, et. al, 1997; Waldrop, 1996).

A study by Warschauer of the University of Hawaii supports these findings. Warschauer conducted a study on student attitude toward learning. Warschauer studied 167 English as second language students in twelve universities academic writing courses in Hong Kong, Taiwan, and the United States.   He found significant increases in motivation of students using computers. One of the findings indicated that the greater the extent of computer-use in the class, the greater the increase in motivation. The study cited the greatest benefit in motivation obtained through the use of computer-assisted instruction as the increase in personal empowerment of the students (Warschauer, 1996).

A study by Lafayette Parish in Lafayette, Louisiana during the 1996-1997 school year and released in 1998. Louisiana found that effective use of computer-assisted instruction can be utilized with a minimum of time. The school system has a program that allows for pullout of low-achieving students. The program allows students to utilize a computer-assisted software program for ten minutes per day. In the initial stages of the program, the system allowed one group to use the software while another group did not. After a period of two months the school system found that the students using the program had increased in mathematics achievement by a statistically significant level as measured by a locally developed test. (Johnson, 2000)

A study conducted by High in 1998 supports this conclusion. He studied a group of students enrolled in introductory statistics at a four-year college in Long Island, New York. Four sections of the same basic statistics class were used in the study. The professors for two of these sections utilized software to supplement their teaching. The students in these classes were required to carry out a series of computer exercises and projects during the semester as part of their assignments for the class. The remaining two classes were taught in the traditional lecture method. The students were surveyed one week before the final exam on their attitudes toward the class and their expected grade for the course. After the final exam, the survey responses and the grades were compared. A significant relationship was found between the student's mathematics average and their anticipated grade in the course for both groups. The class receiving the

computer instruction scores significantly higher on the final exam and had a much more positive feeling toward the class than the group receiving only the traditional lecture method of instruction (High, 1998).

Another study of similar type was conducted by Sivin-Kachala in 1998. Sivin-Kachala reviewed 219 research studies from 1990 to 1997 to assess the effect of technology on learning and achievement across all learning domains and all ages of learners. From these analyses, the researcher reported that students in technology-rich environments experienced positive effects on achievement in all major subject areas. Sivin-Kachala also stated that students in technology rich environments showed increased achievement in preschool through higher education for both regular and special needs children. He found students' attitudes toward learning and their own self-concept improved consistently when computers were used for instruction (Sivin-Kachala 1998).

Brown (2000) conducted one of the more complete studies of the effect of computer-assisted instruction on learner achievement. Brown conducted a scientific study of the effect of computer-assisted instruction on mathematics achievement. The study was conducted in a large urban North Carolina public school system. The system had an enrollment of approximately 100,000. Overall 42% of the students in the school system were black, 50% were white, and 8% were from other racial and ethnic groups. The study divided the students into two groups, an experimental group that used the CAI program and a control group of students who were not exposed to the CAI program. The study involved students from three schools in eleven different classes. All the schools and teachers volunteered to participate in the study.

The effectiveness of the program was evaluated by making statistical comparisons of students' mathematics achievement on the State of North Carolina's required end of grade and end of course test. The study was conducted over a two-year period of 1997-1998 and 1998-1999. The majority of the use of the software occurred before school began for the day. Students were allowed access to the lab as soon as they arrived at school. The CAI program studied was FUNdamentally Math. It was chosen because of favorable reviews it received by independent evaluators in two journals published by the National Council of Teachers of Mathematics. The software covered all areas of mathematics except calculus and probability. Pretest and posttest scores on the state end of grade examination for the students were collected. The author of the study utilized a two-tailed T test to determine if a significant difference was present.

The study demonstrated that the students who utilized the computer-assisted instruction scored significantly higher than the students who did not participate. The algebra students using the CAI made a 17% jump in scores (Brown, 2000).

A recent study by Traynor (2003) found that utilizing computer-assisted instruction improved instruction over only using traditional methods. The study compared the effects on many types of learners including special education, non-English proficient, and regular education. The students showed significant pretest-posttest gains (Traynor, June 2003).

Another recent meta-analytic study on the effects of computer-assisted instruction found that students who received instruction supplemented by CAI attained higher academic achievement

than did 63.31% of those receiving only traditional instruction. The study was a meta analysis (Christman and Badgett, 2003).

A very recent study by Powell, Aeby, and Carpenter, (2003) studied the effects on achievement of computer-based instruction as compared to instruction without the computer-based instruction. The experimental design included a pretest and posttest. The study used subjects that were characterized as disruptive by their school. The authors found that an improvement in the subjects' academic achievement was found by the use of computer-based instruction (Powell, Aeby, and Carpenter, February 2003).

Cost of Implementing Technology

The use of computers has increased greatly in the last five years. A recent study by the United States government, as part of the 2000 census, indicated that in the United States there are 46.5 million youth between the ages of 6 and 17, and 32 million of them are using the Internet (U.S. Census, 1998). The report also indicates that 68.8% of school age children have access to computers outside of school. In school, the numbers are even higher. Another survey of schools in America indicates that 90% of public schools and 70 % of private schools have access to the Internet (Market Data Retrieval 1999). The use of computers in the classroom has increased dramatically in the last few years. One study in 2001 by the United States Department of Education of American schools indicates that today 69% of teachers use computers on a daily basis in their classrooms. This number is up from 22% in 1998 (Johnson, 2000). Research indicates a large increase in computer use by students in the last decade. The use by students at school was only 27.4% in 1984. This number had grown significantly by 1997 to 74.7% (US Census, 1998).

The greater use of technology in the classroom has taken place at a large financial cost. One study indicated that school districts spent $4.8 billion on instructional technology and $895 million on administrative technology in 1997-98 (Quality Education Data 1999). This cost is only the hardware purchased. Research shows that the cost of technology in our schools represents over one percent of the total educational spending per child (Coley, Cradler, Engel 1997). A recent article in Electronic-School.com titled Taking TCO to the Classroom: A School Administrator's Guide to Planning for the Total Cost of New Technology listed several areas that must be taken into consideration when studying the total cost of implementing technology (Electronic-School.com, 1999).

Professional development is a major component of the cost of implementing technology. The United States Department of Education recommends 30% of technology expenditures should be in the area of staff development.   If staff members are not properly trained, teachers will not understand how to integrate technology into the curriculum, support staff will not be up to date on hardware and software improvements, and the district will fail to achieve the maximum return on its technology investment.

Technical support is another consideration in the cost of implementing technology. By its very nature, technology is rapidly changing and becoming outdated. School systems must provide proper funding to maintain and replace computer technology as it becomes outdated or inoperable (Fitzgerald, 1999).

Another consideration is connectivity. Enough funds must be budgeted in order to ensure proper bandwidth for proper functioning. As software becomes more complicated a large bandwidth is required for proper functioning. The system must also retrofit older buildings to take advantage of the latest advancements in the Internet, as well as, local area networks (Fitzgerald, 1999).

One of the most important investments is software. A great deal of study and thought must be placed into the proper selection of software for the specific needs of the system. Software must address the objectives needed to be covered and be easy to use (Fitzgerald, 1999).

Summary

Computer usage has increased tremendously over the last several years (Market Data Retrieval, 1999). Many billions of dollars have been spent on computers and related technology (Quality Education Data, 1999). Computers have great promise in education. The area with possibly the most promise for academic achievement is computer-assisted instruction. Computer-assisted instruction is an educational medium in which a computer delivers instructional content or activities. The software has advanced quickly in the last few years from simply offering drill and practice to a level that is adaptive for each child's needs (Mundane, 1996).

Research generally shows a positive relationship between the use of computer-assisted instruction and student achievement (Christman and Badgett, 2003, Brown 2000, & Johari, 1998)). A need for more quantitative research exists. Trautman's work in 2000 suggests that more scientific methods should be utilized in the studies on computer-assisted instruction (Trautman, 2002).

RESEARCH DESIGN

Overview

Computers and computer-assisted instruction have been touted as the future of education in America and the world. However, limited scientific research has been done on the effectiveness of computer-assisted instruction on student achievement in mathematics. This study attempted to determine if the use of computer-assisted instruction in mathematics classes at two Middle Tennessee middle schools produced a significant effect on the differences in mathematics achievement as measured by a pre-test post-test design utilizing tests provided by the publisher of the textbook. Due to the importance of achievement in mathematics and the amount of money and time that is being invested in technology, the results of the study are extremely important to the school and the school system in this study.

Research Design

A cause-effect linkage was suspected between the use of computer-assisted instructional software and achievement in mathematics. A study was required to prove or disprove this relationship in which one can manipulate the variable of computer-assisted instruction. A quasi-experimental study was

used due to the great limitations in the school setting of obtaining a random sample. The quasi-experimental research has the benefits of experimental research with the exception of the determination of the random sample. A two-group treatment, pre-test post-test design was used (Charles 1998). The following research questions will be answered and the following null hypotheses will be proved or disproved.

Null Hypotheses

H1 There will be no statistically significant differences between the level of achievement in mathematics as measured by pre-test and post-tests of an experimental group of middle school students who received computer-assisted instruction compared to a control group.

H2 There will be no statistically significant difference in mathematics achievement as measured by pre-test and post-tests of students based on their ethnicity of students that received computer-assisted instruction.

H3 There will be no statistically significant difference in mathematics achievement as measured pre-test and post-tests of male and female students that received computer-assisted instruction.

Population and Sample

The population represented in this study is students in Middle Tennessee grades 6th – 8th. All students in the study ranged in age from 11 to 14 years. A majority of the subjects in the study live in a suburb of Nashville, Tennessee.

The subjects were chosen by a random clustered sampling method. Subjects were obtained from two Middle Tennessee middle schools consisting of grades 6 through 8. The sample was drawn from a pool of 1,733 students.

School A had an enrollment of 760 students. School A is located outside of Murfreesboro which is a suburb of Nashville. The school population consists of rural students as well as suburban. The student body was 85.8% white, 9.3% African American, 1.8% Hispanic, 2.7% Asian, and 0.3% Native American. The school had 19.4% of its students qualify for free or reduced lunch during the school year of the study, 2004.

School B consisted of a student body of 973 students. School B is located within the city limits of Murfreesboro a suburb of Nashville, a large Southern city. Virtually all of the students reside within the city limits of Murfreesboro. The student body was 79.3% white, 16.7% African American, 2.4% Hispanic, 1.3% Asian, and 0.2% Native American. The school had 19.9% of its students qualify for free or reduced lunch during the school year of the study, 2004.

The sample consisted of 328 subjects. Ten sections of mathematics were chosen at School A and four sections were chosen at school B representing all levels of mathematics offered except Algebra and Geometry. These courses were omitted due to the limited sampling size. Students were placed in sections by the respective administration of the schools with the aid of Horizon, a school management software package. The sections of classes were chosen with regard to the time of day at which the meet.

The teachers selected for this study were determined to have sufficient computer skills to utilize the software to be studied. This was determined with the aid of the principal at each of the two schools. The teachers in this study had received instruction by the school system's technology department in the use of the software packages. Five teachers participated at School A and two teachers participated in the study at School B.

Procedure

The study lasted for eleven weeks. The dates of the study were from August 9, 2004 until October 22, 2004. This time period was chosen to coincide with the grading periods at the schools where the study was conducted. The study was approved by the Assistant Superintendent for Curriculum and Instruction for Rutherford County Schools. The graduate school of Tennessee State University also approved the study.

A pre-test was administered at the beginning of the study by the teachers of each section. The pre-test consisted of fifty multiple choice questions. The questions tested mastery of the objectives that were taught during the time of the study.

The experimental group was given one hour each week of computer-assisted instruction. The software used in this study adapts to the student's achievement and reports progress for each student to the teacher (Orchard, 2004).

The Orchard software allows for more personal lessons for the students that target their particular needs while reinforcing their strengths.   The software adapts as a student answers to target individual weaknesses of the student. The software also increases the difficulty of the questions as correct answers are given.

23

The remainder of the week the experimental group received traditional instructional methods. The control group received only traditional teaching methods. At the end of the study, a post-test was administered by the teacher of the section. The difference of each of the subjects scores on the post-test and the pre-test was calculated. The mean of this difference was then compared by the use of a t-test between the control group and the experimental group. A determination was made if the difference was statistically significant.

Instrumentation

The pre-test and post-tests were criterion-referenced tests developed by Prentice Hall, the publisher of the mathematics textbook used by the classes participating in the study. The tests were developed for the 1999 publication of their texts, Middle Grade Math, Tools for Success; Course 1, Middle Grade Math, Tools for Success; Course 2, and Middle Grade Math, Tools for Success; Course 3. Prentice Hall conducts research to ensure the validity of the tests. Research was conducted longer-term research based on scientific, experimental designs under actual classroom conditions. This research identifies what works and what can be improved in revisions. Research was conducted involving longitudinal and control-group research. The test was also validated by research conducted by independent, third-party research using quasi-experimental and experimental research designs (Prentice Hall, 2004).

The pre-test and post-test consisted of 50 multiple-choice items each. The tests were developed with the goal of testing the objectives that will be part of the curriculum during the time period of the study. Each test was intended to test for mastery in the following areas: integers, fractions, decimals, measurement, algebraic operations, order of operations, number and number relations, rounding, computation in context, statistics, and problem solving strategies. The text and the test are currently being used by approximately 45% of the school systems in Tennessee.

Internal Validity

Internal validity is the extent that an experiment shows a cause-effect relationship between the independent and dependent variables (Grant, Mah, and Polson, 2003). Many factors exist that affect the internal validity of a study. Care was given to eliminate as many of these factors as possible.

In order to limit experimental mortality, students were not allowed to change sections at any time during the study to limit the possible effects on the results. Students were not added to these sections except in extreme cases to limit added variables to the study.

Attention was given in the choice of levels of mathematics to participate in the study. The sections chosen were selected due to having the same teacher in common and the time of day at which they meet. The effect of the teacher will be limited by having the sections selected at each level taught by the same teacher. The students in the experimental group will be compared to students in the control group that have the same teacher.

 The teachers in the experimental and control groups were required to submit weekly lesson plans that detail the daily occurrences in the class. The lesson plans were checked to ensure that the experimental group was receiving the computer-assisted instruction and that the experimental

group was receiving the same traditional teaching with the exception of the computer-assisted instruction. The classes were monitored daily to ensure adherence to the lesson plans. The classes were monitored daily for any event that would possibly interfere with the study. Maturation was not considered as a factor of concern due to the relatively short nature of the experiment.

Statistical Techniques

Statistical significance was determined for the research data. The difference was calculated and a t test was used to analyze the data to determine if any statistically significant difference exists between the class sets of data. The results of the t test was analyzed to determine if there is a statistically significant difference the difference between the pretest and posttest scores of the experimental group that received computer-assisted instruction once a week and the control group that only received traditional teaching methods (Charles 1998).

SPSS was utilized to determine if a statistically significant difference exists between the scores of members of the different genders in the experimental group and the control group. SPSS was also utilized to determine if a statistically significant difference exists between the scores of students of different races in the experimental group and the control group.

FINDINGS

Mathematics is the cornerstone for a good education (Clark and Fulton, 2003). The United States' economic prosperity is dependent on a population well educated in mathematics (Geary and Hamson, 2004). The students in the United States do not do well when compared to other students throughout the world, the students of the United States scored well below average on the last international test (Lubell, 1998). Every effective method for the teaching of mathematics must be utilized. The purpose of this study was to determine if instruction including computer-assisted instruction in mathematics produces higher levels of academic achievement than traditional teaching methods alone.

A cause-effect linkage was suspected between the use of computer-assisted instructional software and achievement in mathematics. A quasi-experimental study was conducted. A two-group treatment, pre-test post-test design was used (Charles 1998). The control group received only traditional classroom instruction. The experimental group's traditional instruction was supplemented with one hour each week of computer-assisted instruction. The subjects were given a pre-test at the start of the study. The subjects

were then given a post test at the end of the study. The differences between the pre-test and post-test were compared using a t-test to determine if the experimental group scored statistically significantly different than the control group. The differences were compared between genders also using a t-test to determine if a statistically significant difference existed between the test scores of males and females. A determination was to be made if ethnicity played a role in the difference between the pre-test and the post-test. Not enough subjects of different ethnic backgrounds were used in the study to determine if a difference existed between ethnic groups

Table 1 gives the number of subjects in the control group. The table also gives the minimum and maximum values as well as the mean and standard deviation for the differences in the pre-test and post-test.

Table 1. Basic Statistics of the Control Group

	N	Minimum	Maximum	Mean	Std. Deviation
Difference	162	-12	64	21.04	13.32

Table 2 gives the number of subjects in the experimental group. The table also gives the minimum and maximum values as well as the mean and the standard deviation for the differences in the pre-test and post-test.

Table 2. Basic Statistics of the Experimental Group

	N	Minimum	Maximum	Mean	Std. Deviation
Difference	166	-12	60	24.78	13.33

Null Hypothesis

H1 There will be no statistically significant differences between the level of achievement in mathematics as measured by pre-test and post-tests of an experimental group of middle school students who received computer-assisted instruction compared to a control group.

The null hypothesis H1 was rejected. The results of the data analysis showed that a statistically significant difference was found between the difference of the scores from the pre-test and the post-test of the control group and the experimental group. The differences in the pre-test and post-test were found for the control and experimental group. A t-test was then performed on the data. The p value of 0.011 indicates that the difference in the means is greater than could be expected by chance and that there is a statistical probability that them difference was caused by the treatment used in the research project.

Table 3 gives the value of correlation as determined by an unpaired-sample t test of the difference from the pre-test and the post-test for the experimental group and the control group. The value indicates a significance that is high enough to indicate that the differences in the mean is greater than could be expected by chance and that there is a statistical probability the difference was caused by the treatment of the research project, the use of computer-assisted instruction.

Table 3. Results of the t-Test Comparing the Mean of the Difference from the Pre-test to the Post-test of the Control and Experimental Groups

Variables	N	M	SD	t	p
Control	162	21.04	13.32	-2.542	0.011
Experimental	166	24.78	13.33		

H2 There will be no statistically significant difference in mathematics achievement as measured by pre-test and post-tests of students based on their ethnicity of students that received computer-assisted instruction.

This null hypothesis could not be rejected or accepted to any degree of confidence due to the extremely limited number of subjects of ethnic groups other than white. Further research should use more subjects of varying ethnic backgrounds to increase the statistical significance. The "digital divide", or lack of computers in the homes of minorities, was thought to cause an unfamiliarity within those groups.

Table 4 gives the percentage gain of each race represented in the study. The samples were not large enough for further comparisons. It was found that the Hispanic subjects did have a greater gain from the pre-test to the post-test than the other ethnic groups. The subjects that were classified Asian had the smallest gain. White and Black subjects had similar gains during the course of the study.

Table 4. Percentage Gain of Each Ethnic Group

Race	Percentage Gain
White	47.54
Black	52.67
Hispanic	79.34
Asian	43.39

H3   There will be no statistically significant difference in mathematics achievement as measured pre-test and post-tests of male and female students that received computer-assisted instruction.

Table 5 gives the mean of the difference from the pre-test and the post-test for each gender. The female subjects did increase slightly more than the males but not to a statistically significant level. An unpaired t-test was performed, the p value indicates a significance that is not high enough to indicate that the differences in the mean is greater than could be expected by chance and that there is no statistical probability the difference was caused by the treatment of the research project, the use of computer-assisted instruction. The increase in computer usage by females in the last few years probably prevented any difference between these groups from occurring.

Table 5. Results of the t-Test Comparing the Mean of the Difference of the Female Subjects and the Male Subjects

Variables	N	M	SD	t	P
Female	87	25.06	13.61	0.926	0.482
Male	79	24.47	13.09		

In summary, a statistically significant difference was found to exist between the control group and the experimental group. The subjects that were exposed to computer-assisted instruction one hour each week of the study did have higher academic gains than the students that only had traditional mathematics instruction. Not enough subjects of ethnic groups other than whites participated in the study to make a statistically significant determination if ethnic background affected the level of increase in academic achievement. No significant difference in increases in academic achievement was found between females and males subjects participating in the study. All increases in academic achievement was found by comparing the scores on a pre-test to the scores on a post-test. The means of the scores were compared by the use of a t test.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Success in mathematics is central to a good education in the modern world. In general, the higher the level of education of an individual, the higher the likelihood of employability and as a result higher wages (Clark and Fulton, 2003). The better educated a society, the more successful the society will be. Mathematics gives people tools that include logical reasoning, problem-solving skills, and the ability to think in abstract ways (Clark and Fulton, 2003). Poor mathematical competencies restrict college major and later career choices for individuals pursuing post-secondary education. As a result, the more math-intensive the occupation, the higher the entry-level and subsequent wages (Geary and Hamson, 2004). It has been estimated that the lack of math and literacy competency in the United States will cost the economy of the country 170 billion dollars each year. Given the inarguable link between math competency and economic prosperity, it is in the best interest of everyone to develop an educational system that takes advantage of all available methods of instruction (Geary and Hamson, 2004).

Even though the importance of mathematics is readily apparent, the students of the United States do not do well when compared to their peers throughout the world. Students from the United States scored below the average of other countries on the Third International Mathematics and Science Study (Lubell, 1998). Only about 1 out of 100 students in the United States scored as well as the average student in the top-ranked nation, Singapore (New York State United Teachers, 2004).

Billions of dollars have been spent on the inclusion of technology in the schools of the United States. Between the years 1997 and 2000, the federal government alone spent 1.25 billion dollars on funding for new computers, software, and teacher training (Johnson, 2000). In March of 1997, the President's Committee of Advisors on Science and Technology recommended the federal government should spend 6 to 28 billion each year on a program to increase computer infrastructure, teacher training, and research (Panel on Educational Technology, (1997).

Computer-assisted instruction is an educational medium in which a computer delivers instructional content or activities. The Association for Educational Communications and Technology defined computer-assisted instruction as a method of instruction in which the computer is used to instruct the student and contains the instruction designed to teach, guide, and test the student until a desired level of proficiency is attained (Association for Educational Communications and Technology, 1977). Traynor (2003) suggests that computer-assisted instruction affects cognitive processes and increases motivation by the following ways:

1. Personalizing information;

2. Animating objects on the screen;

3. Providing practice activities that incorporate challenges and curiosity;

4. Providing a fantasy context; and

5. Providing a learner with choice over his/her own learning

Research on the effectiveness of computers on student academic achievement began as early as the 1960s (Skinner, 1965). The early research was inconclusive. More recent studies have varied in their results. Baker (1999) makes the claim that there is a lack of controlled studies. Baker found that most studies centered on students' and teachers' attitudes and opinions toward computers. Kulik (1994) found that controlled studies conducted in a scientific manner on the effects of computers on students' academic achievement are hard to find. A report by Coley, Cradler, and Engel on the use of technology in the classroom was unable to cite one study on the effectiveness of computer-assisted instruction using a control group (Coley, Cradler, and Engel, 1997).

The research that has been conclusive generally indicates a positive relationship between the use of computer-assisted instruction and student academic achievement. A meta-analytic study conducted in 1987 reviewed sixteen major studies. The study found that students receiving computer-assisted instruction scored at the 66th percentile on tests while the control group scored at the 50th percentile (Niemiec and Walberg, 1987). Another study found that students in grades sixth through twelfth that received computer-assisted instruction attained higher levels of academic achievement that 58.2% of students only receiving traditional teaching methods (Christman, Badgett, and Lucking, 1997). One of the most thorough studies was conducted by Frank Brown. Brown studied students in a large urban North Carolina public school system. The population of the system was 50% white, 42% black, and 8% other. The subjects were divided into a control group that was not exposed to CAI and an experimental group utilizing CAI. The study analyzed the results from the North Carolina end of the course test. A 17% higher level of achievement was found in the group that was exposed to computer-assisted.

For this study, a cause-effect linkage was suspected between the use of computer-assisted instruction software and achievement in mathematics. A study was required to prove or disprove this relationship in which one can manipulate the variable of computer-assisted instruction. Due to limitations in obtaining a random sample, a quasi-experimental study was used. A two-group, pre-test post-test design was used in the study (Charles, 1998).

The study was conducted between the dates of August 9th, 2004 and October 15th, 2004. The control group was taught by traditionally accepted teaching methods throughout the study. This consisted of primarily lecture with the addition of worksheets, quizzes, and other teacher directed activities. The experimental group received the same traditional teaching methods plus one hour a week of computer-assisted instruction in the form of Orchard software.

A pre-test was given to subjects involved in the study. The pre-test was appropriate to the level of mathematics in which the subject was enrolled. (Appendix III). The pre-test consisted of fifty multiple choice questions that tested the mastery of the objectives covered during the study. A post-test was given at the end of the study to all subjects involved in the study. The post-test was also appropriate for the level of mathematics in which the subjects were enrolled. (Appendix IV). The post-test consisted of fifty multiple choice questions that determined the mastery of the objectives covered during the study.

The differences between the scores on the post-test and pre-test were calculated. The means of the differences from the experimental group and the control group were compared using a t-test

to determine if a statistically significant difference existed. The differences were also calculated by gender. These differences were compared using a t-test to determine if a statistically significant difference existed between the genders of the subjects. The sample did not have enough subjects of different ethnicities to make a statistically significant determination of whether different ethnic groups would have their mathematics achievement affected differently by the addition of computer-assisted instruction. Only nine Hispanic and eleven Asian subjects were included in the study. Fifty-six black subjects participated in the study. 251 of the subjects were white.

The results of the data analysis data analysis resulted in the rejection of H1. The data indicated that the treatment of the study, the use of computer-assisted instruction, did cause a statistically significant level of difference between the pre-test and the post-test of the control group and the experimental group. The results of the data analysis resulted in the acceptance of H3. The data indicated that the difference in change between subjects of different gender was not statistically significant. H2 could not be accepted or rejected with any level of confidence due to the limited sample size of different ethnic groups other than white.

Conclusion

The research indicates that the use of a computer-assisted instructional software package once per week did produce a higher level of academic achievement in mathematics by middle school students. There was a statistically significant difference between the control group and the experimental group. The p value of 0.011 indicates a high level of confidence that the treatment in the study was responsible for any gain made. The conclusion that the treatment, the use of computer-assisted instruction for one hour a week in addition to traditional teaching methods, caused the increase in academic achievement was found to a level exceeding the 0.05 confidence level. The analysis of the data disproved the null hypothesis, H1.

The research study indicated that the female subjects made greater gains than the male subjects, but the difference was not statistically significant enough to ensure that the difference was caused by the treatment of the study and not chance. The p value of 0.77 did not indicate any statistical significant difference in achievement gains by males or females to a 0.05 level. The null hypothesis, H3, was retained.

 Not enough subjects of different ethnic groups were used in the study to determine to any level of statistically significance if the differences in scores could be attributed to the treatment of the study. It was found that the Hispanic subjects that participated in the study had academic gains of 79.34%. This was higher than the other ethnic groups. Black subjects had gains of 52.67% while white subjects gained 47.54%. Asian students had the lowest gains of any ethnic group that participated in the study of 43.35%.

Recommendations for Future Research

Further study is intended. A larger sample size would be preferred to eliminate the effects of random occurrences. A more ethnically varied population must be used to allow for a statistically significant determination of differences between ethnic groups. A greater number of schools should be used. Care should be taken to ensure that urban, suburban, and rural schools are represented to allow for greater generalization of the findings.

Future studies should include background information on the subjects such as prior levels of computer usage. This would help determine if the novelty of using a computer increased or decreased its effectiveness as a teaching tool. A determination could also be made as to whether having a greater comfort level with the computer affects its effectiveness at increasing student achievement.

The subjects past scores in mathematics should also be included in future studies. With this information, a determination of whether different amounts of increase would be found at different levels the academic spectrum.

A survey to determine learning style should also be utilized. This would allow a comparison of the change in levels of academic achievement in the different learning styles. A determination could be made if certain learning styles benefited from the use of computer-assisted instruction more than others.

Recommendations for the Profession

The research project produced even greater differences between the control group and the experimental group than expected. The cause of the higher gains was determined to be attributed to the treatment in the study, the use of computer-assisted instruction, with a high degree of confidence. As technology is increasingly added to schools the use of the computer-assisted instruction becomes more available and practical. The study indicates that computer-assisted instruction should be a more widely used pedagogy in middle schools. The investment in technology should include monies for not only the software for computer-assisted instruction but training for the proper use in all areas of the curriculum.

A great amount of resources have been invested in the addition of computers and other types of technology to classrooms. The research in this study offers promise and suggests that this investment was well spent. Computer-assisted instruction offers differentiated education that is easy to plan and implement. It offers opportunities for remediation and reinforcement of concepts and ideas. Computer-assisted instruction is effective for both genders and indications are that it is effective for different ethnic groups. Computer-assisted instruction is an effective way to personalize instruction to ensure that all subgroups are reached.

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Control Group's Scores and Demographic Information

The following table lists the subjects in the control group's scores on the pre-test and post-test as well as the difference in the scores and the demographics of the subjects.

Subject	Pre-Test	Post-Test	Difference	Race	Economically Challenged	Gender
B255C1	56	86	30	White	No	Male
B255C2	42	88	46	Black	Yes	Male
B255C3	68	96	28	Black	No	Male
B255C4	46	68	22	White	No	Female
B255C5	28	58	30	White	No	Female
B255C6	38	65	27	White	No	Male
B255C7	48	75	27	White	No	Male
B255C8	34	84	50	White	Yes	Male
B255C9	46	92	46	White	No	Female
B255C10	22	76	54	White	Yes	Female
B255C11	52	74	22	Black	No	Female
B255C12	54	76	22	White	No	Female
B255C13	24	64	40	White	No	Female
B255C14	36	76	40	White	No	Male
B255C15	56	92	36	White	No	Male
B255C16	42	80	38	White	No	Female
B255C17	18	46	28	Black	No	Male
B255C18	24	46	22	White	No	Male
B255C19	56	82	26	White	No	Female
B255C20	12	76	64	White	No	Male
B255C21	54	76	22	White	No	Male
B255C22	56	70	14	White	No	Female
B255C23	62	84	22	White	No	Male
C32C1	40	66	26	White	No	Male
C32C2	50	66	16	White	No	Male

Subject	Pre-Test	Post-Test	Difference	Race	Economically Challenged	Gender
C32C3	38	56	18	White	No	Female
C32C4	58	86	28	White	No	Female
C32C5	50	80	30	White	No	Male
C32C6	40	70	30	White	Yes	Male
C32C7	64	66	2	White	Yes	Male
C32C8	66	85	19	Black	Yes	Female
C32C9	54	70	16	White	Yes	Male
C32C10	66	94	28	White	No	Female
C32C11	38	36	-2	White	No	Female
C32C12	44	88	44	White	No	Female
C32C13	36	92	56	White	No	Female
C32C14	32	66	34	White	No	Male
C32C15	70	86	16	Hispanic	No	Male
C32C16	54	90	36	White	No	Female
C32C17	48	66	18	White	No	Female
C32C18	50	76	26	White	No	Female
J32C1	50	66	16	White	No	Female
J32C2	72	86	14	White	No	Female
J32C3	76	82	6	White	No	Male
J32C4	22	46	24	White	No	Male
J32C5	42	62	20	White	Yes	Male
J32C6	54	86	32	White	No	Male
J32C7	34	72	38	White	Yes	Male
J32C8	38	74	36	White	No	Female
J32C9	66	76	10	White	No	Male
J32C10	44	64	20	White	No	Female
J32C11	28	46	18	White	No	Female
J32C12	32	64	32	White	No	Female
J32C13	36	48	12	White	No	Male
J32C14	72	84	12	White	No	Male
J32C15	62	84	22	White	No	Male
J32C16	70	86	16	White	No	Male
J32C17	38	48	10	White	No	Male
J32C18	60	86	26	Black	No	Male
J32C19	40	62	22	White	No	Male
J32C20	72	96	24	White	No	Male
J32C21	40	42	2	Black	No	Male

Subject	Pre-Test	Post-Test	Difference	Race	Economically Challenged	Gender
J32C22	48	72	24	White	No	Female
J32C23	34	44	10	White	No	Female
J32C24	42	72	30	White	No	Male
J32C25	24	62	38	Black	No	Female
S11C1	24	58	34	White	No	Male
S11C2	50	84	34	White	No	Female
S11C3	56	100	44	White	No	Female
S11C4	40	70	30	White	No	Female
S11C5	44	68	24	White	No	Female
S11C6	60	66	6	White	No	Male
S11C7	40	72	32	Black	Yes	Male
S11C8	44	78	34	White	No	Female
S11C9	44	58	14	White	No	Female
S11C10	40	62	22	White	No	Male
S11C11	32	48	16	White	No	Male
S11C12	44	88	44	White	Yes	Female
S11C13	38	72	34	White	Yes	Female
S11C14	46	88	42	White	No	Female
S11C15	38	84	46	White	No	Female
S11C16	32	58	26	White	No	Female
S11C17	40	80	40	White	No	Female
S11C18	38	64	26	White	No	Male
S11C19	54	84	30	Hispanic	No	Female
S11C20	38	66	28	White	No	Male
R24C1	58	68	10	White	No	Female
R24C2	60	76	16	Black	No	Female
R24C3	62	82	20	White	No	Female
R24C4	56	86	30	Black	No	Female
R24C5	62	60	-2	White	No	Male
R24C6	44	64	20	Black	No	Male
R24C7	70	82	12	White	No	Female
R24C8	60	98	38	White	No	Male
R24C9	76	92	16	Black	No	Male
R24C10	76	88	12	White	Yes	Female
R24C11	74	84	10	White	No	Female
R24C12	46	74	28	White	No	Female
R24C13	48	82	34	White	Yes	Male

Subject	Pre-Test	Post-Test	Difference	Race	Economically Challenged	Gender
R24C14	42	80	38	White	No	Male
R24C15	26	46	20	White	Yes	Male
R24C16	64	78	14	White	No	Female
R24C17	46	66	20	White	No	Male
R24C18	60	62	2	White	No	Female
R24C19	48	56	8	White	No	Male
R24C20	36	66	30	White	No	Female
R24C21	56	64	8	White	No	Male
R24C22	66	94	28	White	No	Female
R24C23	72	98	26	White	Yes	Male
R24C24	56	76	20	White	No	Female
R24C25	72	92	20	White	No	Male
R24C26	50	84	34	White	No	Male
R24C27	66	76	10	White	No	Female
Bo32C1	50	65	15	Asian	Yes	Female
Bo32C2	48	78	30	Asian	No	Male
Bo32C3	82	84	2	White	No	Female
Bo32C4	80	92	12	White	No	Female
Bo32C6	20	32	12	Black	Yes	Male
Bo32C7	48	62	14	Asian	No	Male
Bo32C8	66	78	12	White	Yes	Female
Bo32C9	82	84	2	Hispanic	No	Male
Bo32C10	44	74	30	Black	No	Female
Bo32C11	52	74	22	White	No	Male
Bo32C12	62	60	-2	White	Yes	Male
Bo32C13	32	48	16	Black	Yes	Male
Bo32C14	42	58	16	Black	Yes	Female
Bo32C15	46	66	20	White	No	Female
Bo32C16	50	66	16	White	No	Male
Bo32C17	48	44	-4	White	No	Female
Bo32C18	82	86	4	White	No	Female
Bo32C19	80	84	4	Hispanic	Yes	Female
Bo32C20	20	46	26	Hispanic	No	Male
Bo32C21	48	62	14	White	No	Male
Bo32C22	66	76	10	Black	No	Male
Bo32C23	82	88	6	Black	Yes	Male
Bo32C24	44	58	14	White	No	Female

Subject	Pre-Test	Post-Test	Difference	Race	Economically Challenged	Gender
	52	72	20	White	Yes	Female
Ca32C1	40	64	24	White	Yes	Female
Ca32C2	36	38	2	White	Yes	Male
Ca32C3	36	48	12	White	No	Male
Ca32C4	40	72	32	White	Yes	Male
Ca32C6	40	52	12	Asian	Yes	Female
Ca32C7	52	66	14	White	Yes	Male
Ca32C8	40	56	16	White	Yes	Female
Ca32C9	48	62	14	White	Yes	Male
Ca32C10	40	48	8	White	No	Female
Ca32C11	60	62	2	White	No	Female
Ca32C12	48	52	4	White	No	Male
Ca32C13	60	68	8	Asian	No	Male
Ca32C14	24	24	0	White	No	Female
Ca32C15	28	60	32	Black	Yes	Female
Ca32C16	44	48	4	Hispanic	Yes	Female
Ca32C17	36	62	26	Black	No	Female
Ca32C18	60	48	-12	Black	Yes	Female
Ca32C19	48	62	14	Black	No	Male
Ca32C20	40	44	4	White	No	Male
Ca32C21	44	52	8	White	No	Female
Ca32C22	60	58	-2	Black	Yes	Male
Ca32C23	48	68	20	White	No	Female
Ca32C24	40	54	14	Black	No	Male
Ca32C25	44	48	4	White	No	Male
Ca32C26	38	36	-2	White	No	Male

Experimental Group's Scores and Demographic Information

The following table lists the subjects in the experimental group's scores on the pre-test and post-test as well as the difference in the scores and the demographics of the subjects.

Subject	Pre-Test	Post-Test	Difference	Race	Economically Disadvantaged	Gender
B26E1	66	96	30	White	Yes	Male
B26E2	76	84	8	White	Yes	Male
B26E3	50	78	28	Black	Yes	Male
B26E4	46	82	36	White	No	Male
B26E5	38	42	4	White	No	Male
B26E6	58	74	16	White	No	Male
B26E7	66	88	22	White	Yes	Female
B26E8	42	76	34	Black	No	Male
B26E9	50	78	28	White	Yes	Female
B26E10	60	86	26	Asian	Yes	Female
B26E11	52	82	30	White	Yes	Male
B26E12	62	70	8	White	Yes	Male
B26E13	48	72	24	Hispanic	No	Male
B26E14	60	74	14	White	Yes	Female
B26E15	76	86	10	White	Yes	Male
B26E16	68	94	26	White	No	Male
B26E17	74	88	14	White	Yes	Male
B26E18	46	66	20	White	No	Female
B26E19	44	52	8	Hispanic	No	Male
B26E20	62	78	16	White	No	Male
B26E21	58	100	42	White	No	Female
B26E22	54	64	10	White	No	Female
B26E23	66	88	22	White	No	Male
B26E24	52	62	10	White	No	Female
B26E25	50	80	30	Black	Yes	Female
B26E26	58	46	-12	White	Yes	Female
C34E1	68	88	20	White	No	Male
C34E2	50	76	26	White	No	Female
C34E3	46	44	-2	Black	Yes	Female

Subject	Pre-Test	Post-Test	Difference	Race	Economically Disadvantaged	Gender
C34E4	56	84	28	White	Yes	Male
C34E5	52	72	20	White	No	Male
C34E6	40	70	30	White	No	Female
C34E7	48	94	46	White	No	Female
C34E8	36	42	6	White	No	Female
C34E9	46	80	34	White	Yes	Male
C34E10	70	84	14	White	Yes	Male
C34E11	44	64	20	White	Yes	Male
C34E12	52	78	26	White	No	Male
C34E13	68	80	12	White	No	Female
C34E14	40	86	46	White	Yes	Female
C34E15	40	76	36	White	No	Female
C34E16	66	82	16	White	No	Female
C34E17	46	72	26	Hispanic	No	Female
C34E18	42	54	12	White	Yes	Female
C34E15	48	48	0	White	Yes	Male
C34E16	44	70	26	White	No	Female
C34E17	44	68	24	White	No	Male
C34E18	72	100	28	White	Yes	Female
C34E19	66	92	26	White	Yes	Female
C34E20	68	84	16	White	No	Female
J33E1	70	88	18	Black	Yes	Male
J33E2	22	33	11	White	No	Male
J33E3	44	64	20	Black	No	Male
J33E4	60	62	2	White	Yes	Female
J33E5	66	60	-6	White	Yes	Female
J33E6	74	100	26	Black	Yes	Female
J33E7	50	74	24	White	No	Female
J33E8	48	82	34	White	No	Female
J33E9	82	100	18	Asian	No	Male
J33E10	80	96	16	White	No	Male
J33E11	20	44	24	White	No	Male
J33E12	48	62	14	Black	No	Female
J33E13	66	82	16	White	No	Male
J33E14	82	100	18	White	No	Female
J33E15	44	50	6	White	No	Female
J33E16	52	78	26	White	No	Female

Subject	Pre-Test	Post-Test	Difference	Race	Economically Disadvantaged	Gender
J33E17	62	100	38	White	Yes	Male
J33E18	42	48	6	White	Yes	Female
J33E19	72	96	24	White	No	Female
J33E20	56	92	36	White	No	Female
J33E21	64	84	20	White	No	Male
S13E1	60	74	14	White	No	Female
S13E2	58	88	30	Black	No	Male
S13E3	54	78	24	White	No	Female
S13E4	46	94	48	White	No	Male
S13E5	26	86	60	White	No	Female
S13E6	42	84	42	White	No	Male
S13E7	40	56	16	White	No	Male
S13E8	42	62	20	White	No	Female
S13E9	48	92	44	White	Yes	Male
S13E10	52	88	36	White	Yes	Female
S13E11	54	78	24	White	Yes	Male
S13E12	42	62	20	White	No	Female
S13E13	44	84	40	White	Yes	Female
S13E14	44	72	28	White	Yes	Male
S13E15	36	62	26	White	No	Female
S13E16	44	84	40	White	No	Male
S13E17	38	62	24	White	No	Male
S13E18	36	40	4	Black	No	Male
Bo31E1	76	96	20	White	Yes	Female
Bo31E2	54	76	22	White	No	Male
Bo31E3	74	98	24	White	Yes	Male
Bo31E4	38	48	10	White	No	Female
Bo31E6	38	64	26	White	Yes	Female
Bo31E7	50	78	28	Black	Yes	Female
Bo31E8	54	86	32	Black	No	Male
Bo31E9	28	62	34	White	Yes	Male
Bo31E10	32	38	6	White	Yes	Male
Bo31E11	48	68	20	White	No	Male
Bo31E12	66	96	30	Black	No	Female
Bo31E13	72	100	28	Hispanic	No	Female
Bo31E14	44	88	44	White	Yes	Male
Bo31E15	36	66	30	Black	Yes	Female

Subject	Pre-Test	Post-Test	Difference	Race	Economically Disadvantaged	Gender
Bo31E16	38	78	40	White	No	Male
Bo31E17	44	94	50	White	No	Female
Bo31E18	32	86	54	White	No	Female
Bo31E19	24	78	54	Black	Yes	Male
Bo31E20	70	92	22	Black	No	Male
Bo31E21	64	84	20	White	No	Female
Bo31E22	38	76	38	White	No	Male
Bo31E23	56	90	34	White	No	Female
Bo31E24	40	84	44	White	No	Female

Pre-Test 7th and 8th

1. Subtract: $\dfrac{17}{16} - \dfrac{3}{16}$

   [A] $\dfrac{7}{16}$ [B] 1   [C] $\dfrac{13}{32}$ [D] $\dfrac{7}{8}$

2. Estimate. $65.2 \div 8.06$

   [A] 56   [B] 9   [C] 8   [D] 80

3. $\dfrac{5}{36} + \dfrac{57}{36} - \dfrac{8}{36} =$

   [A] $\dfrac{3}{2}$ [B] $\dfrac{13}{36}$ [C] $\dfrac{35}{18}$ [D] $-\dfrac{13}{9}$

4. Simplify: $-\dfrac{2}{8} - \dfrac{1}{4}$

   [A] $\dfrac{1}{12}$ [B] $-\dfrac{1}{32}$ [C] $\dfrac{1}{4}$ [D] $-\dfrac{1}{2}$

5. Divide: $10 \div (-5)$

   [A] $-\dfrac{1}{2}$ [B] $\dfrac{1}{2}$ [C] -2 [D] 2

6. Multiply: $(8)(1)(10)$

   [A] 80   [B] -80 [C] 19   [D] -19

7. Estimate. $31.2 \div 4.95$

   [A] 6   [B] 7   [C] 25   [D] 60

8. Estimate: 89% of 72

   [A] 63   [B] 72   [C] 13   [D] 54

9. Estimate: 31% of 52

   [A] 15   [B] 12   [C] 18   [D] 6

10. 80% of 80 equals which of the following?

    [A] 64　　　　　　　[B] 1　　　　　　　[C] 100　　　　　　[D] 80

11. Which is equivalent to $4^3 \times 4^7$?

    [A] 4^{21}　　　　　[B] 16^{10}　　　　[C] 4^{10}　　　　　[D] 16^{21}

12. Write as a power: $3 \times 3 \times 3 \times 3 \times 3$

    [A] $(5)^3$　　　　　[B] 3^6　　　　　[C] 3^{-5}　　　　[D] 3^5

13. $2.55 \div 5 =$

    [A] None of these　　[B] 0.501　　[C] 5.01　　[D] 0.51　　[E] 5.1

14. $3.66 \div 6 =$

    [A] 6.01　　[B] 0.61　　[C] None of these　　[D] 6.1　　[E] 0.601

Multiply:

15. 0.07×4.9

    [A] 0.0343　　　　　[B] 0.00343　　　　[C] 0.343　　　　[D] 3.43

16. 0.003×4.1

    [A] 0.0123　　　　　[B] 0.123　　　　　[C] 0.00123　　　[D] 0.000123

17. 0.007×2.4

    [A] 0.0168　　　　　[B] 0.00168　　　　[C] 0.168　　　　[D] 0.000168

18. 0.04×3.4

    [A] 1.36　　　　　　[B] 13.6　　　　　[C] 0.136　　　　[D] 0.0136

19. Estimate. $31.2 \div 4.95$

    [A] 7　　　　　　　[B] 25　　　　　　[C] 6　　　　　　[D] 60

Multiply:

20. 0.07×5.4

    [A] 0.00378   [B] 0.0378   [C] 0.378   [D] 3.78

21. 0.005×3.5

    [A] 0.175   [B] 0.00175   [C] 0.000175   [D] 0.0175

22. $\dfrac{38}{40} + \dfrac{21}{40} - \dfrac{11}{40} =$

    [A] $\dfrac{17}{40}$ [B] $\dfrac{6}{5}$ [C] $\dfrac{49}{40}$ [D] $\dfrac{7}{4}$

23. $\dfrac{4}{10} + \dfrac{25}{10} - \dfrac{4}{10} =$

    [A] $\dfrac{4}{5}$ [B] $\dfrac{5}{2}$ [C] $-\dfrac{21}{10}$ [D] $\dfrac{33}{10}$

24. Estimate: 89% of 72

    [A] 13   [B] 54   [C] 63   [D] 72

25. $\dfrac{9}{8} + \dfrac{13}{8} - \dfrac{10}{8} =$

    [A] 4   [B] $\dfrac{19}{8}$ [C] $-\dfrac{1}{2}$ [D] $\dfrac{3}{2}$

Multiply:

26. $\dfrac{3}{8} \cdot \left(-\dfrac{5}{6}\right)$

    [A] $-\dfrac{9}{20}$ [B] $-\dfrac{5}{16}$ [C] $\dfrac{5}{16}$ [D] $-\dfrac{1}{24}$

27. $\dfrac{2}{3} \cdot \left(-\dfrac{7}{4}\right)$

    [A] $\dfrac{7}{6}$ [B] $-\dfrac{7}{6}$ [C] $-\dfrac{8}{21}$ [D] $-\dfrac{5}{12}$

28. Multiply: $\frac{9}{5} \cdot \left(-\frac{3}{7}\right)$

    [A] $\frac{6}{35}$ [B] $-\frac{27}{35}$ [C] $-\frac{21}{5}$ [D] $\frac{27}{35}$

29. All of the following statements are true EXCEPT

    [A] $-15 + 34 = 34 + (-15)$ [B] $-22(18 - 7) = -22(11)$

    [C] $8 \cdot 9 + 3 = 8 \cdot 3 + 9$ [D] $-9(13 - 4) = -9(9)$

30. Subtract: $(-7) - (-1)$

    [A] –8   [B] –6   [C] 6   [D] 8

31. All of the following statements are true EXCEPT

    [A] $78 \cdot (-7) = 70(-7) + 8(-7)$ [B] $12 \cdot (-3) + 6 = 12 \cdot 6 + (-3)$

    [C] $8 + (-6) \cdot 5 = 8 + 5 \cdot (-6)$ [D] $24 \cdot (-6) = 20(-6) + 4(-6)$

32. Subtract: $(-10) - (-8)$

    [A] –2   [B] 18   [C] –18   [D] 2

33. Which of the numbers below is the closest estimate for the value of $x^2 - b^4$ when $x = 1.1$ and $b = 1.93$?

    [A] –7   [B] –15   [C] 17   [D] 9

34. Subtract: $(-2) - (-4)$

    [A] –6   [B] 2   [C] –2   [D] 6

35. Round 0.437892 to the tenths place.

    [A] 0.4   [B] 0.3   [C] 0.45   [D] 0.44

36. Estimate: $15.28 + $17.70

    [A] $31   [B] $33   [C] $27   [D] $37

37. Estimate: $3\frac{4}{9} + 2\frac{1}{6}$

    [A] 7   [B] 6   [C] 1   [D] 3

Subtract:

38. 19.52 – 1.558

    [A] 17.494   [B] 17.962   [C] 16.962   [D] 18.962

39. 18.55 – 2.417

    [A] 15.638   [B] 15.133   [C] 17.133   [D] 16.133

40. 8.16 – 0.851

    [A] 8.309   [B] 7.309   [C] 7.165   [D] 6.309

41. 7.38 – 0.347

    [A] 8.033   [B] 6.033   [C] 6.691   [D] 7.033

42. $0.9\overline{)6.03}$

    [A] 67   [B] 0.607   [C] 6.7   [D] 0.67

43. 3.05 ÷ 5 =

    [A] 0.601   [B] 0.61   [C] 6.1   [D] 6.01   [E] None of these

44. 3.55 ÷ 5 =

    [A] 0.71   [B] None of these   [C] 7.01   [D] 0.701   [E] 7.1

Add:

45. $7\frac{3}{10} + 7\frac{6}{10}$

    [A] $14\frac{9}{10}$ [B] $15\frac{1}{5}$ [C] $14\frac{1}{5}$ [D] $13\frac{9}{10}$

46. $2\frac{1}{2} + 7\frac{1}{2}$

    [A] 9   [B] $10\frac{1}{2}$ [C] $9\frac{1}{2}$ [D] 10

Simplify:

47. $\dfrac{2}{15} + \dfrac{1}{5}$

[A] $\dfrac{3}{20}$ [B] $\dfrac{3}{10}$ [C] $\dfrac{1}{25}$ [D] $\dfrac{1}{3}$

48. $\dfrac{2}{4} - \dfrac{1}{2}$

[A] 0 [B] $-\dfrac{1}{2}$ [C] $\dfrac{3}{8}$ [D] $-\dfrac{3}{2}$

49. $\dfrac{36}{40} + \dfrac{15}{40} - \dfrac{3}{40} =$

[A] $\dfrac{21}{40}$ [B] $\dfrac{6}{5}$ [C] $\dfrac{39}{40}$ [D] $\dfrac{27}{20}$

50. $\dfrac{33}{60} + \dfrac{52}{60} - \dfrac{13}{60} =$

[A] $-\dfrac{19}{60}$ [B] $\dfrac{23}{30}$ [C] $\dfrac{49}{30}$ [D] $\dfrac{6}{5}$

Post-Test 7th and 8th

1. Subtract: $\dfrac{17}{22} - \dfrac{7}{22}$

   [A] $\dfrac{5}{11}$ [B] $\dfrac{6}{11}$ [C] $\dfrac{5}{22}$ [D] $\dfrac{9}{44}$

Estimate.

2. $31.2 \div 4.95$

   [A] 60   [B] 7   [C] 25   [D] 6

3. $31.2 \div 4.95$

   [A] 6   [B] 7   [C] 25   [D] 60

4. $\dfrac{18}{16} + \dfrac{44}{16} - \dfrac{14}{16} =$

   [A] 3   [B] 2   [C] $\dfrac{19}{4}$ [D] $-\dfrac{13}{8}$

5. Simplify: $-\dfrac{3}{9} + \dfrac{1}{3}$

   [A] $-\dfrac{2}{27}$ [B] $-\dfrac{1}{3}$ [C] 0   [D] $-\dfrac{1}{6}$

6. Divide: $-27 \div 3$

   [A] $\dfrac{1}{9}$ [B] 9   [C] $-\dfrac{1}{9}$ [D] –9

7. Multiply: $(-3)(2)(-5)$

   [A] 6   [B] –30   [C] –6   [D] 30

8. 80% of 80 equals which of the following?

   [A] 64   [B] 1   [C] 100   [D] 80

9. Estimate: 31% of 52

   [A] 15   [B] 12   [C] 18   [D] 6

10. Estimate: 89% of 72

    [A] 63   [B] 72   [C] 13   [D] 54

11. Write as a power: $5 \times 5 \times 5 \times 5 \times 5$

    [A] 5^5 [B] 5^6 [C] $(5)^{10}$ [D] 5^{-5}

12. Which is equivalent to $4^3 \times 4^7$?

    [A] 4^{21} [B] 16^{10} [C] 4^{10} [D] 16^{21}

13. $2.79 \div 3 =$

    [A] 9.03   [B] 0.903   [C] 0.93   [D] 9.3   [E] None of these

14. $3.05 \div 5 =$

    [A] None of these   [B] 6.01   [C] 0.61   [D] 6.1   [E] 0.601

Multiply:

15. 0.05×2.6

    [A] 1.3   [B] 0.013   [C] 0.13   [D] 0.0013

16. 0.004×5.4

    [A] 0.216   [B] 0.00216   [C] 0.0216   [D] 0.000216

17. 0.08×3.5

    [A] 0.0028   [B] 2.8   [C] 0.028   [D] 0.28

18. Estimate. $31.2 \div 4.95$

    [A] 7   [B] 25   [C] 6   [D] 60

Multiply:

19. 0.06×7.8

    [A] 46.8   [B] 0.468   [C] 4.68   [D] 0.0468

Multiply:

20. 0.004×8.4

   [A] 0.336   [B] 0.00336   [C] 3.36   [D] 0.0336

21. 0.02×4.7

   [A] 0.094   [B] 0.94   [C] 9.4   [D] 0.0094

22. $\dfrac{34}{36} + \dfrac{26}{36} - \dfrac{12}{36} =$

   [A] $\dfrac{4}{3}$ [B] $\dfrac{23}{18}$ [C] 2   [D] $\dfrac{2}{9}$

23. $\dfrac{11}{15} + \dfrac{9}{15} - \dfrac{2}{15} =$

   [A] $\dfrac{13}{15}$ [B] $\dfrac{22}{15}$ [C] $\dfrac{6}{5}$ [D] $\dfrac{2}{15}$

24. $\dfrac{11}{16} + \dfrac{32}{16} - \dfrac{3}{16} =$

   [A] $-\dfrac{21}{16}$ [B] $\dfrac{23}{8}$ [C] $\dfrac{5}{2}$ [D] $\dfrac{7}{8}$

Multiply:

25. $\dfrac{2}{7} \cdot \left(-\dfrac{5}{4}\right)$

   [A] $-\dfrac{5}{14}$ [B] $\dfrac{5}{14}$ [C] $-\dfrac{3}{28}$ [D] $-\dfrac{8}{35}$

26. $\dfrac{7}{6} \cdot \left(-\dfrac{4}{3}\right)$

   [A] $\dfrac{1}{6}$ [B] $-\dfrac{7}{8}$ [C] $\dfrac{14}{9}$ [D] $-\dfrac{14}{9}$

27. Multiply: $\frac{4}{5} \cdot \left(-\frac{7}{4}\right)$

    [A] $-\frac{3}{20}$ [B] $-\frac{16}{35}$ [C] $-\frac{7}{5}$ [D] $\frac{7}{5}$

Subtract:

28. $(-9) - (-5)$

    [A] 14   [B] 4   [C] –4   [D] –14

29. $(-10) - (-6)$

    [A] –16   [B] –4   [C] 4   [D] 16

30. $(-8) - (-1)$

    [A] –7   [B] 7   [C] 9   [D] –9

31. All of the following statements are true EXCEPT

    [A] $-15 + 34 = 34 + (-15)$ [B] $-22(18 - 7) = -22(11)$

    [C] $8 \cdot 9 + 3 = 8 \cdot 3 + 9$ [D] $-9(13 - 4) = -9(9)$

32. All of the following statements are true EXCEPT

    [A] $78 \cdot (-7) = 70(-7) + 8(-7)$ [B] $12 \cdot (-3) + 6 = 12 \cdot 6 + (-3)$

    [C] $8 + (-6) \cdot 5 = 8 + 5 \cdot (-6)$ [D] $24 \cdot (-6) = 20(-6) + 4(-6)$

33. Estimate: 89% of 72

    [A] 13   [B] 54   [C] 63   [D] 72

34. Which of the numbers below is the closest estimate for the value of $x^2 - b^4$ when $x = 1.1$ and $b = 1.93$?

    [A] –7   [B] –15   [C] 17   [D] 9

35. Round 0.166537 to the tenths place.

    [A] 0.18   [B] 0.1   [C] 0.2   [D] 0.17

36. Estimate: $18.45 + $11.69

    [A] $24   [B] $28   [C] $34   [D] $30

37. Estimate: $3\frac{1}{8} + 2\frac{3}{4}$

    [A] 6   [B] 3   [C] 7   [D] 1

Subtract:

38. 18.22 − 1.408

    [A] 15.812   [B] 16.614   [C] 16.812   [D] 17.812

39. 10.7 − 0.537

    [A] 10.163   [B] 9.533   [C] 9.163   [D] 11.163

40. 17.98 − 0.546

    [A] 16.434   [B] 18.434   [C] 17.434   [D] 16.552

41. 7.52 − 1.247

    [A] 5.805   [B] 6.273   [C] 7.273   [D] 5.273

42. $0.7\overline{)4.06}$

    [A] 5.8   [B] 0.508   [C] 0.58   [D] 58

43. 3.24 ÷ 4 =

    [A] 0.801   [B] None of these   [C] 8.01   [D] 8.1   [E] 0.81

44. 3.66 ÷ 6 =

    [A] 0.61   [B] 6.1   [C] 0.601   [D] None of these   [E] 6.01

Add:

45. $9\frac{3}{10} + 7\frac{1}{10}$

    [A] $16\frac{3}{10}$ [B] $17\frac{3}{10}$ [C] $15\frac{2}{5}$ [D] $16\frac{2}{5}$

46. Add: $2\frac{1}{2} + 4\frac{1}{2}$

    [A] $6\frac{1}{2}$ [B] 7   [C] $7\frac{1}{2}$ [D] 6

Simplify:

47. $\frac{3}{9} + \frac{2}{3}$

    [A] 1   [B] $\frac{5}{6}$ [C] $\frac{5}{12}$ [D] $\frac{5}{27}$

48. $\frac{2}{6} - \frac{2}{3}$

    [A] $-\frac{4}{9}$ [B] $-\frac{4}{3}$ [C] $\frac{2}{9}$ [D] $-\frac{1}{3}$

49. $\frac{65}{36} + \frac{10}{36} - \frac{3}{36} =$

    [A] $\frac{17}{9}$ [B] 2   [C] $\frac{55}{36}$ [D] $\frac{13}{6}$

50. $\frac{27}{24} + \frac{22}{24} - \frac{9}{24} =$

    [A] $\frac{5}{24}$ [B] $\frac{5}{3}$ [C] $\frac{29}{12}$ [D] $\frac{3}{2}$

Pre – Test 6th

1. Find the mean of 99, 96, 16, 98, and 16.

   [A] 58   [B] 70   [C] 16   [D] 65

2. Find the median of 98, 55, 41, 74, and 41.

   [A] 40   [B] 61.8   [C] 55   [D] 41

3. Find the mode of 68, 53, 12, 65, and 12.

   [A] 12   [B] 42   [C] 53   [D] 52

4. Which month had the most cloudy days?

Cloudy Days
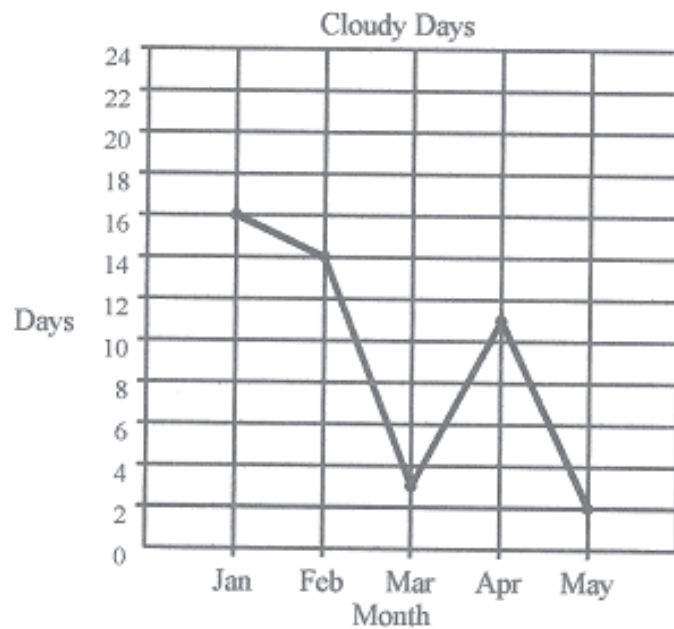
   [A] February   [B] January   [C] March   [D] May

5. The table below shows the number of games each team won last season. Choose the bar graph that best represents the data.

Team	Games Won
A	16
B	9
C	6

[A]

Wins for the Season

[B]

Wins for the Season

[C]

Wins for the Season

[D]

Wins for the Season
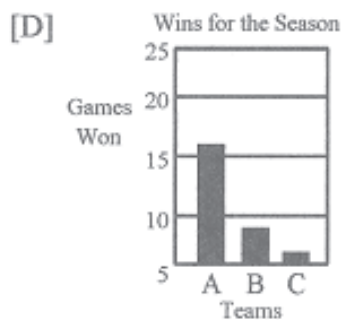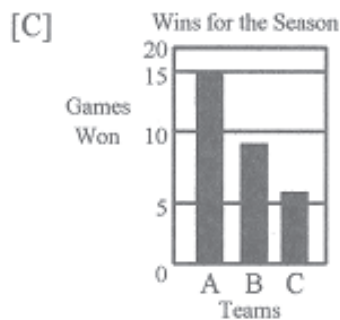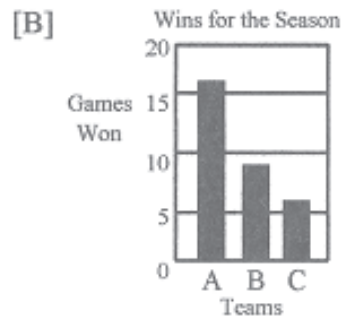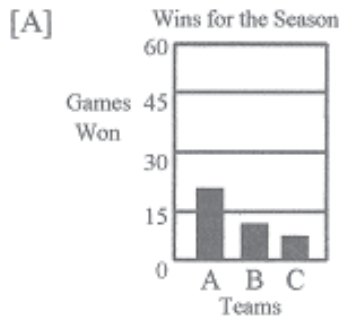
6. Assuming that the pattern continues, write the next 3 terms.
18, 23, 28, ___, ___, ___

[A] 33, 38, 43   [B] 38, 43, 48   [C] 32, 37, 42   [D] 34, 39, 44

7. Write 439,408,516 in words.

   [A] four hundred thirty-nine thousand, four hundred eight thousand, five hundred sixteen

   [B] four hundred thirty-nine billion, four hundred eight million five hundred sixteen thousand

   [C] four hundred thirty-nine million, four hundred eight thousand, five hundred sixteen

   [D] four hundred thirty-nine million, and four hundred eight thousand, and five hundred sixteen

8. Arrange from smallest to largest:
   7.04 7.004 7.042

   [A] 7.042 , 7.004 , 7.04   [B] 7.004 , 7.042 , 7.04

   [C] 7.004 , 7.04 , 7.042   [D] 7.042 , 7.04 , 7.004

9. Choose the difference the model shows.
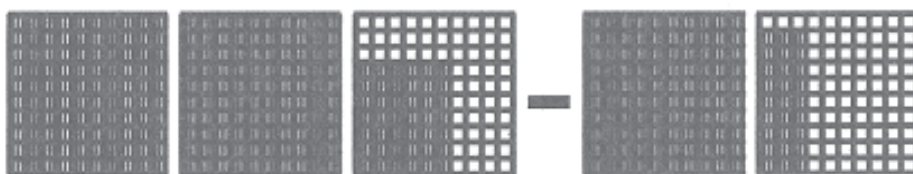
   [A] 1.15   [B] 3.7   [C] 3.69   [D] 1.4227

10. Use the data in the chart below. How much more sugar is in $\frac{1}{2}$ c of sherbet than in one 4-oz. glass of orange juice? Estimate your answer to the nearest tenth.

FOOD	SUGAR CONTENT
Orange Juice (4 oz)	0.417 oz
Plain Granola Bar	0.333 oz
Raisins (7 oz)	0.75 oz
Sherbet $\left(\frac{1}{2} \text{ cup}\right)$	1.166 oz
Yogurt (8 oz)	1 oz

    [A] 1.1   [B] 1.917   [C] 1.083   [D] 1.9

11. Estimate the difference using front-end estimation. $49.42 - 32.51$

    [A] 40   [B] 30   [C] 25   [D] 20

12. If you place the digits 1–7 in these boxes □ □ .□ □ + □ □ .□ to give the greatest possible sum, the digit in the second box must be:

    [A] 6   [B] 4 or 5   [C] 4   [D] 5

13. If you place the digits 1–7 in these boxes □ □ .□ □ + □ □ .□ to give the greatest possible sum, the digit in the second box must be:

    [A] 6   [B] 5   [C] 4   [D] 4 or 5

14. A _____ would weigh about 3 kg.

[A] professional football player   [B] nine-year-old boy

[C] mother whale   [D] newborn baby

15. You want to find the mass of your math book. Which unit is most appropriate?

[A] liter   [B] meter   [C] kilogram   [D] milligram

16. If it is afternoon, what time will it be in 1 hour and 35 minutes ?

[A] 5:15 p.m.   [B] 6:15 p.m.   [C] 5:08 a.m.   [D] 3:15 a.m.

17. Estimate the product by rounding. 2.63 × 4.65

[A] 18   [B] 7   [C] 15   [D] 23

18. The chart below shows the lengths of 6 different bridges. Use the information to estimate how long a bridge would be if it was:
a. 4 times as long as the Lake Washington Bridge.
b. 3 times as long as the difference in length between the Quebec Bridge and the Lake Washington Bridge.
c. $\frac{1}{2}$ as long as the Rockville Bridge.

Year Completed	Name of Bridge	Length (km)
1981	Humber Estuary Bridge (UK)	1.4
1964	Verrazano – Narrows Bridge (USA)	1.3
1917	Quebec Bridge (CDA)	0.9
1977	New River Gorge Bridge (USA)	0.52
1963	Lake Washington Bridge (USA)	3.8
1901	Rockville Bridge (USA)	1.2

19. 4.13
    × 4

   [A] 1.662   [B] 16.52   [C] 1.652   [D] 16.62

20. 4.97
    × 9

   [A] 44.63   [B] 4.473   [C] 4.463   [D] 44.73

21. Thomas worked 16 hours more than Mary Ellen during the month of July. What more do you need to know to find how many hours Thomas worked in July?

   [A] the number of hours Mary Ellen worked in August

   [B] the number of hours Mary Ellen worked in July

   [C] the number of hours Thomas worked in June

   [D] the number of hours Thomas worked in August

22. Thomas worked 24 hours more than Hercules during the month of June. What more do you need to know to find how many hours Thomas worked in June?

   [A] the number of hours Thomas worked in May

   [B] the number of hours Thomas worked in July

   [C] the number of hours Hercules worked in June

   [D] the number of hours Hercules worked in July

23. Which factor tree is correct?

   I.   6   II.   64
       / \   / \
      3   3   32   2
                     / \
                    4   8

   [A] I & II   [B] II   [C] I   [D] Neither

64

24. Wendy has a cold and an ear infection. The doctor told Wendy to take 1 teaspoon of her medicine every four hours and an aspirin every eight hours. Wendy's mother gave her both the medicine and an aspirin at 6:00 a.m. Monday morning. List the times that Wendy will take both the medicine and the aspirin at the same time on Monday.

[A] 6 a.m., 2 p.m., 10 p.m.　　　　　[B] 6 a.m., 10 a.m., 2 p.m., 6 p.m., 10 p.m.

[C] 6 p.m., 2 a.m., 10 a.m.　　　　　[D] 6 a.m., 10 a.m., 12 a.m., 4 p.m.

25. If $\frac{18}{6}$, $\frac{17}{8}$, $\frac{14}{5}$, and $\frac{16}{7}$ are placed in order from smallest to largest which would be first?

[A] $\frac{16}{7}$　　　　　[B] $\frac{14}{5}$　　　　　[C] $\frac{18}{6}$　　　　　[D] $\frac{17}{8}$

26. Write 3.35 as a fraction in simplest form.

[A] $\frac{335}{100}$　　　　　[B] $\frac{37}{10}$　　　　　[C] $\frac{7}{20}$　　　　　[D] $\frac{67}{20}$

27. Write the word phrase that describes the expression. $5p + 8$

[A] a number p increased by five　　　　　[B] a number p decreased by five

[C] five times a number p decreased by eight

[D] five times a number p increased by eight

28. Simplify. $4^7 \div 4^2 \times 4^4$

[A] 16^9　　　　　[B] 4　　　　　[C] 16^1　　　　　[D] 4^9

29. Multiply: 0.58×0.6

[A] 3.48　　　　　[B] 3.88　　　　　[C] 0.388　　　　　[D] 0.348

30. Find the mean of 92, 72, 53, 90, and 53.

[A] 72　　　　　[B] 53　　　　　[C] 74　　　　　[D] 65

31. A teacher allows her students to decide whether to use the mean, median, or mode to determine their test averages. One student determined that he will receive the highest average if he uses the mean. Which set of test scores are his?

[A] 81, 85, 73, 82, 76　　　　　[B] 92, 83, 76, 76, 93

[C] 72, 83, 95, 70, 85　　　　　[D] 81, 85, 70, 72, 85

65

32. Which pair of numbers, when included with the set of data, will raise the value of BOTH the mean and median?
6, 8, 10, 14, 18

[A] 1, 10   [B] 7, 15   [C] 8, 14   [D] 14, 15

33. The students' scores on a math test are shown on the following frequency table:

Score	16	17	18	19	20	21	22	23	24	25
Number of Students	1	4	3	3	4	2	4	3	2	1

How many students scored below 22?

[A] 8   [B] 16   [C] 4   [D] 17

34. The students' scores on a math test are shown on the following frequency table:

Score	16	17	18	19	20	21	22	23	24	25
Number of Students	2	3	2	2	2	0	4	4	4	1

How many students scored below 22?

[A] 8   [B] 14   [C] 4   [D] 11

35. The numbers below represent the scores on a biology test. Make a line plot and find the range of the data.
33, 36, 32, 33, 34, 31, 40, 36, 37, 37

[A]   range= 9
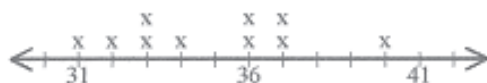
[B]   range= 3
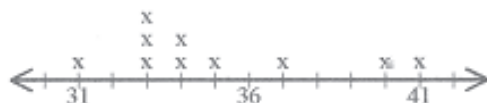
[C]   range= 40
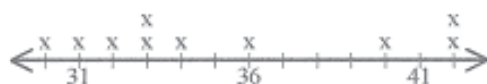
[D]   range= 31
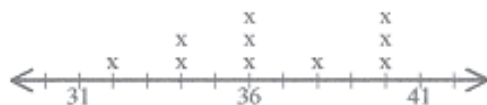
36. The numbers below represent the number of gallons of water used daily by ten people. Make a line plot and find the range of the data.
48, 47, 50, 48, 52, 52, 45, 45, 49, 48

[A]   range= 52
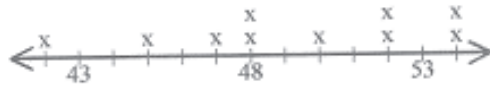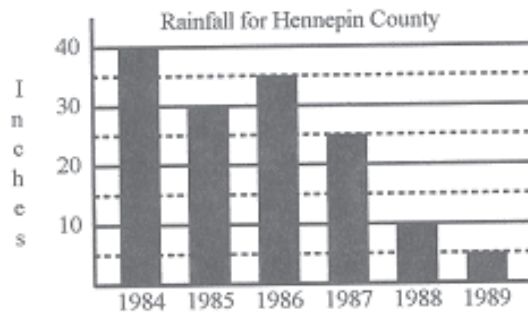
[B]   range= 12
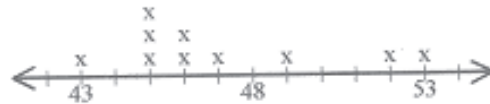
[C]   range= 7
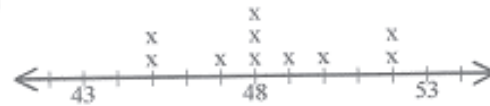
[D]   range= 45
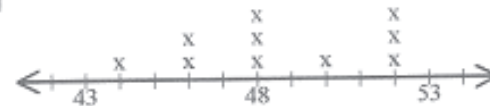
37. The graph below shows the yearly rainfall in inches in Hennepin County for 1984-1989. Find the rainfall for 1985.

[A] 35 inches   [B] 25 inches   [C] 30 inches   [D] 10 inches

38. $(8 \times 9) - 3 \times 5 + 8 =$

[A] 65   [B] 33   [C] 49   [D] 353

Write <, >, or = between the two expressions to make a true statement.

39. $(2 \times 1) \div (9 + 1 - 1)$ _____ $2 \times 1 \div 9 + 1 - 1$

    [A] <   [B] >   [C] =

40. $(1 \times 7) \div (6 + 5 - 6)$ _____ $1 \times 7 \div 6 + 5 - 6$

    [A] >   [B] <   [C] =

41. Write the word phrase that describes the expression. $8x - 8$
    [A] a number x decreased by eight   [B] a number x increased by eight
    [C] a number x multiplied by eight   [D] eight times a number x decreased by eight

42. Estimate the product by rounding. 6.25×9.73
    [A] 60   [B] 76   [C] 66   [D] 30

43. Estimate: $57 \div 7.05$
    [A] 9   [B] 8   [C] 80   [D] 49

44. $1.23 \div 3 =$
    [A] 4.1   [B] 0.401   [C] 0.41   [D] 4.01

45. $2.49 \div 3 =$
    [A] 8.3   [B] 0.83   [C] 8.03   [D] 0.803

46. Divide: $1.52 \div 0.04$
    [A] 380   [B] 0.038   [C] 3.8   [D] 38

47. The graph below shows the yearly rainfall in inches in Ramsey County for 1982-1987. Find the rainfall for 1985.

Rainfall for Ramsey County
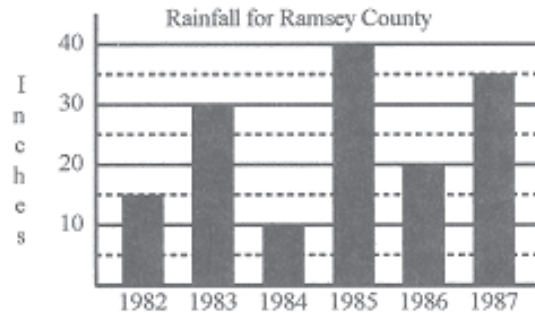
[A] 40 inches   [B] 20 inches   [C] 35 inches   [D] 15 inches

48. Which of the following makes the equation true?
$3 = 8 - x$

[A] $x = 5$ [B] $x = 11$ [C] $x = -11$ [D] $x = -5$

49. Which of the following makes the equation true?
$11 = 14 - x$

[A] $x = 3$ [B] $x = 25$ [C] $x = -25$ [D] $x = -3$

50. What number is represented by _____ in the problem: $522 - 129 =$ _____ $+ 93$

[A] 600   [B] 200   [C] 300   [D] 400

Post-Test 6th

1. Find the mean of 66, 46, 30, 48, and 30.

   [A] 53   [B] 30   [C] 44   [D] 47

2. Find the mode of 86, 61, 43, 73, and 43.

   [A] 61   [B] 61.2   [C] 60   [D] 43

3. Find the median of 97, 76, 44, 83, and 44.

   [A] 44   [B] 76   [C] 69.8   [D] 68.8

4. Mimo and Stan went to the ice cream parlor for some frozen yogurt. They wish to leave the waitress a tip. Mimo has 5 coins in his pocket: a penny, a nickel, a dime, a quarter, and a half-dollar. If he uses exactly three coins for the tip, how many different tips are possible?

   [A] 10   [B] 5   [C] 20   [D] 15

5. Crystal wants to put a fence around her vegetable garden. Her garden is 5 ft wide and 4 ft long. She plans to put a post at each corner and at every foot. How many fence posts will Crystal need?

   [A] 19   [B] 18   [C] 14   [D] 20

6. Which month had the most cloudy days?

Cloudy Days
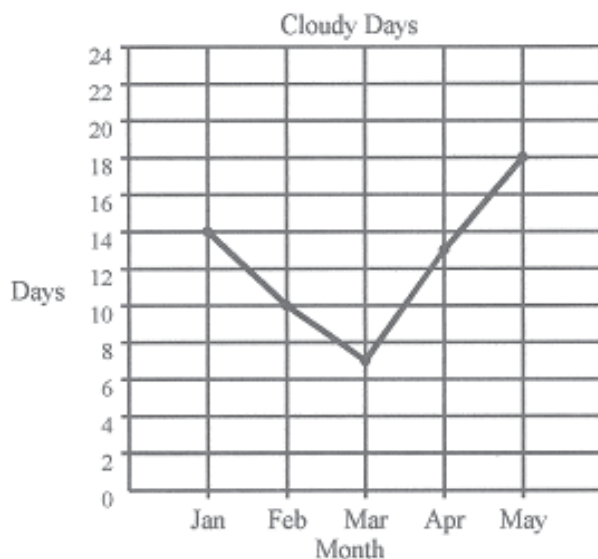
   [A] January   [B] February   [C] April   [D] May

7. The graph below shows the number of cards Americans purchased in 1990. Use the graph to find the mean number of cards purchased in 1990 that were not Valentine's Day cards.
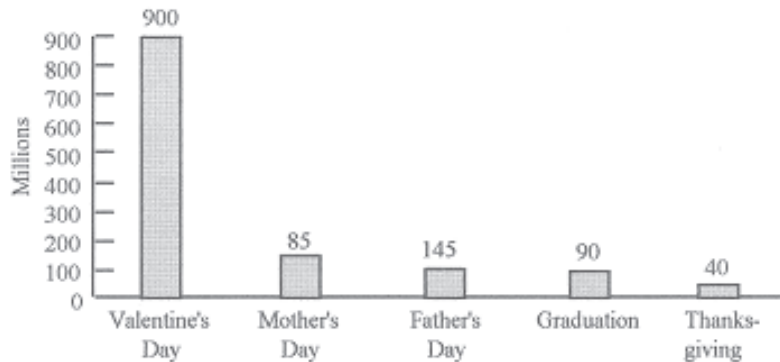

[A] 360   [B] 540   [C] 1260   [D] 90
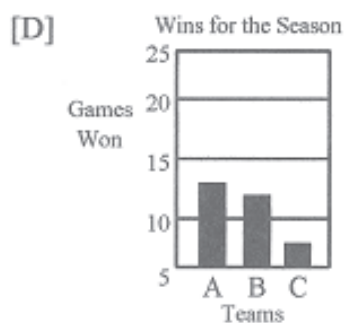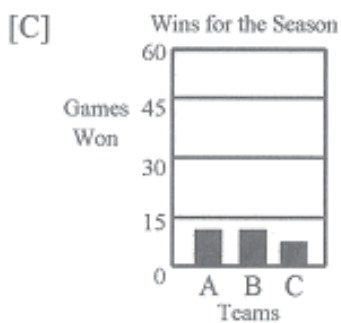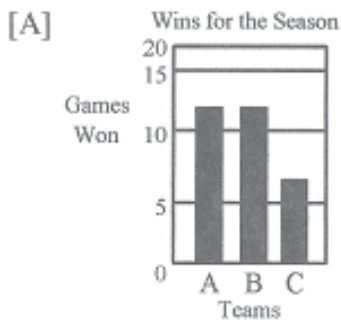
8. Refer to the graph of Week 1 sales.

On Monday the sales for week 2 were $125 less than the sales for Monday of week 1. On Tuesday and Wednesday of week 2 the sales were $75 more than the sales for Thursday of week 1. The sales for Thursday were the same for both weeks. The sales for Friday of week 2 were $150 less than the sales for Friday of week 1. Which bar graph shows the amount of sales for week 2?

[A]

[B]

[C]

[D]
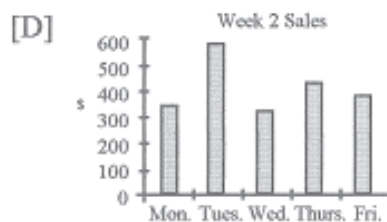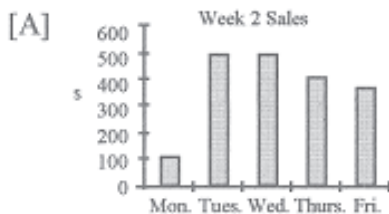
9. The table below shows the number of games each team won last season. Choose the bar graph that best represents the data.

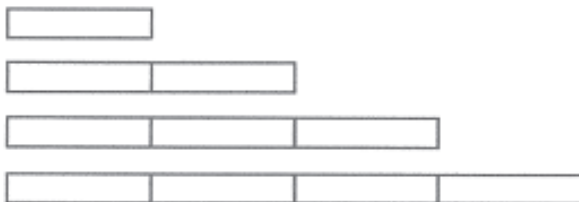| Team	Games Won
A	13
B	12
C	7

[A]

Wins for the Season

[B]

Wins for the Season

[C]

Wins for the Season

[D]

Wins for the Season

10. Assuming that the pattern continues, write the next 3 terms.
    27, 29, 31, ___, ___, ___

    [A] 34, 36, 38   [B] 33, 35, 37   [C] 32, 34, 36   [D] 35, 37, 39

11. Use the pattern of designs below to form a number pattern showing the total number of rectangles at each step in the pattern.

    [A] 1, 3, 6, 10   [B] 1, 3, 5, 9   [C] 1, 3, 4, 5   [D] 1, 2, 3, 4

12. Choose a word expression that represents the decimal 0.85.

[A] eighty-five hundredths   [B] eight and five hundredths

[C] eighty-five hundred   [D] eighty-five tenths

13. How many tenths are in 0.35?

[A] thirty   [B] three   [C] thirty-five   [D] five

14. Write 508,200,039 in words.

[A] five hundred eight thousand, two hundred thousand, thirty-nine

[B] five hundred eight billion, two hundred million thirty-nine thousand

[C] five hundred eight million, and two hundred thousand, and thirty-nine

[D] five hundred eight million, two hundred thousand, thirty-nine

15. What decimal numbers are at points A, B, and C?
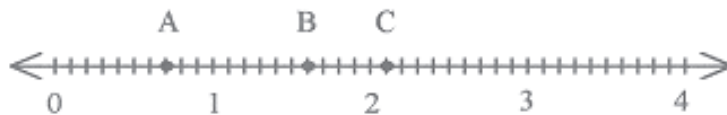
[A] 0.7, 1.06, 2.1   [B] 0.07, 1.06, 2.01   [C] 0.7, 1.6, 2.1   [D] 0.007, 1.6, 2.1

16. Arrange from smallest to largest:
7.04 7.046 7.004

[A] 7.004 , 7.046 , 7.04   [B] 7.046 , 7.04 , 7.004

[C] 7.046 , 7.004 , 7.04   [D] 7.004 , 7.04 , 7.046

17. The local library had a sale to get rid of books that were slightly damaged. It sold paperback books for $2.00 and hard-cover books for $5.00. The library raised $271 and sold 89 books. How many hard-cover books were sold?

[A] 70   [B] 155   [C] 58   [D] 31

18. The sum of two numbers is 27 and the product of these numbers is 182. One of the numbers is _____.

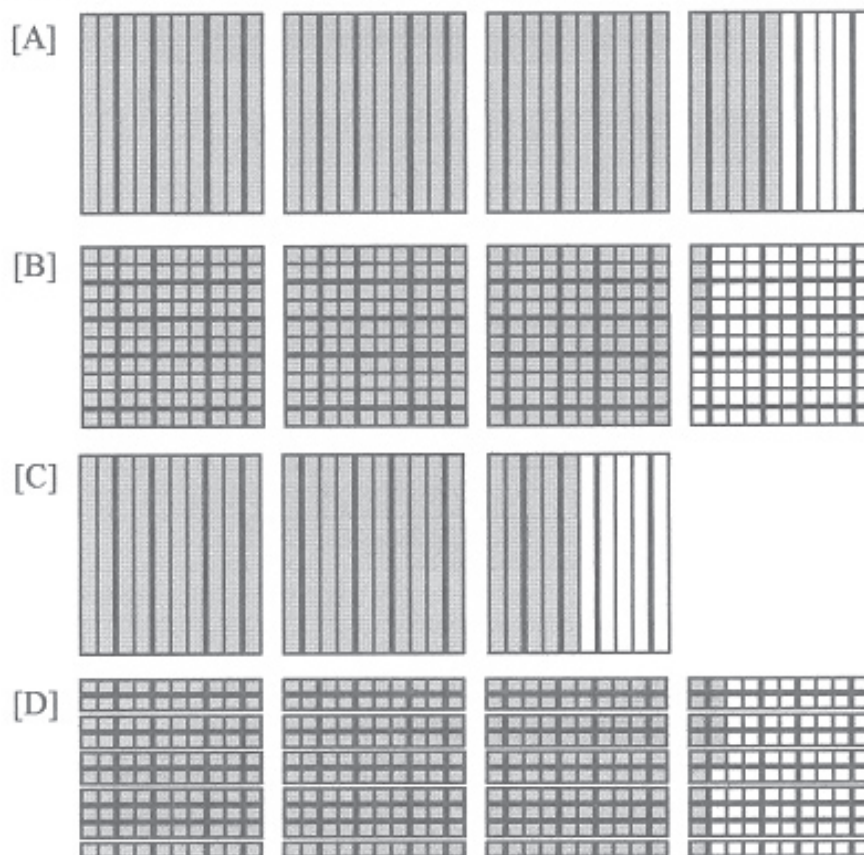[A] 13   [B] 16   [C] 10   [D] 12
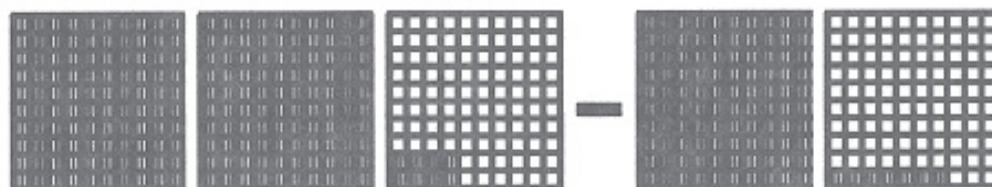
19. Choose the sum shown by the model below.
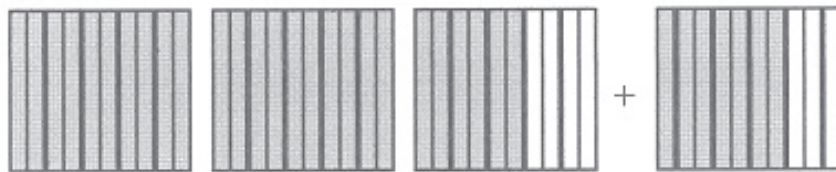
[A] three and three tens

[B] three and thirteen tenths

[C] three and three hundredths

[D] three and three tenths

20. Choose the model below that shows the sum of 2.8 and 0.7.

[A]

[B]

[C]

[D]

21. Choose the difference the model shows.

[A] 1.7   [B] 1.01   [C] 1.87   [D] 3.15

22. Use the data in the chart below. How much more sugar is in $\frac{1}{2}$ c of sherbet than in one 4-oz. glass of orange juice? Estimate your answer to the nearest tenth.

FOOD	SUGAR CONTENT
Orange Juice (4 oz)	0.417 oz
Plain Granola Bar	0.333 oz
Raisins (7 oz)	0.75 oz
Sherbet $\left(\frac{1}{2} \text{ cup}\right)$	1.166 oz
Yogurt (8 oz)	1 oz

[A] 1.9   [B] 1.1   [C] 1.083   [D] 1.917

23. Estimate the difference using front-end estimation. $69.30 - 33.87$

[A] 60   [B] 40   [C] 50   [D] 55

24. A low estimate of $16 and a high estimate of $18 is a good range for which of the following sums?

[A] $2.81 + $8.05 + $6.98   [B] $3.52 + $10.31 + $5.01

[C] $12.56 + $4.91 + $0.98   [D] $8.56 + $2.25 + $6.50

25. If you place the digits 1–7 in these boxes □ □ .□ □ + □ □ .□ to give the greatest possible sum, the digit in the second box must be:

[A] 4 or 5   [B] 4   [C] 5   [D] 6

26. If you place the digits 1–7 in these boxes □ □ .□ □ + □ □ .□ to give the greatest possible sum, the digit in the second box must be:

[A] 5   [B] 4 or 5   [C] 4   [D] 6

27. Suppose you want to subtract 2.5 from 13.98. Choose the answer that shows an estimate and the exact answer.

[A] Estimate: 8; Actual: 11.48   [B] Estimate: 11; Actual: 11.48

[C] Estimate: 15; Actual: 16.48   [D] Estimate: 16; Actual: 16.48

28. Suppose each step you take is 0.5 m. How many steps will it take you to walk around a square room with a side of 4 m?

   [A] 16 steps   [B] 4 steps   [C] 20 steps   [D] 32 steps

29. Tell which measure makes sense for the length of a swimming pool.

   [A] 80 m   [B] 1 km   [C] 800 cm

30. A _____ would weigh about 3 kg.

   [A] mother whale   [B] nine-year-old boy

   [C] newborn baby   [D] professional football player

31. You want to find the mass of your math book. Which unit is most appropriate?

   [A] milligram   [B] liter   [C] kilogram   [D] meter

32. You want to find the mass of your math book. Which unit is most appropriate?

   [A] liter   [B] meter   [C] kilogram   [D] milligram

33. Choose the best estimate of the mass of a basketball.

   [A] 550 m   [B] 5 kg   [C] 5 L   [D] 550 g

34. If it is afternoon, what time will it be in 1 hour and 35 minutes ?

   [A] 5:15 p.m.   [B] 6:15 p.m.   [C] 5:08 a.m.   [D] 3:15 a.m.

35. Estimate the product by rounding. 2.63 × 4.65

   [A] 18   [B] 7   [C] 15   [D] 23

36. The chart below shows the lengths of 6 different bridges. Use the information to estimate how long a bridge would be if it was:

a. 4 times as long as the Lake Washington Bridge.

b. 3 times as long as the difference in length between the Quebec Bridge and the Lake Washington Bridge.

c. $\frac{1}{2}$ as long as the Rockville Bridge.

Year Completed	Name of Bridge	Length (km)
1981	Humber Estuary Bridge (UK)	1.4
1964	Verrazano – Narrows Bridge (USA)	1.3
1917	Quebec Bridge (CDA)	0.9
1977	New River Gorge Bridge (USA)	0.52
1963	Lake Washington Bridge (USA)	3.8
1901	Rockville Bridge (USA)	1.2

37. 2.03
    × 3

[A] 6.09   [B] 0.609   [C] 6.29   [D] 0.629

38. 2.56
    × 4

[A] 10.24   [B] 10.34   [C] 1.024   [D] 1.034

39. Hercules worked 19 hours more than Henry during the month of June. What more do you need to know to find how many hours Hercules worked in June?

[A] the number of hours Hercules worked in May

[B] the number of hours Hercules worked in July

[C] the number of hours Henry worked in July

[D] the number of hours Henry worked in June

77

40. Thomas worked 22 hours more than Tanya during the month of May. What more do you need to know to find how many hours Thomas worked in May?

    [A] the number of hours Thomas worked in June

    [B] the number of hours Tanya worked in May

    [C] the number of hours Thomas worked in April

    [D] the number of hours Tanya worked in June

41. Which factor tree is correct?

    I.   7

    II. 64
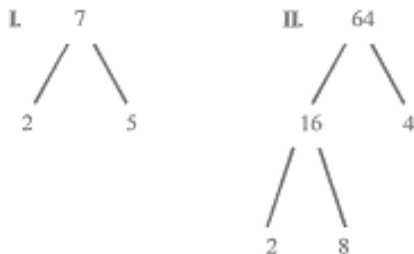
    [A] I & II   [B] II   [C] I   [D] Neither

42. Robert served a 12-ft hero sandwich at his birthday party. Six feet of the sandwich was left over. Robert divided the leftovers equally among his friends to take home. If each friend took home $1\frac{1}{2}$ ft of the sandwich, how many friends were at Robert's birthday party?

    [A] 5   [B] 4   [C] 2   [D] 3

43. Joseph mows the lawn every two weeks and weeds the garden every three weeks. Joseph stops his schedule on November 1st. How many days from June to October did Joseph mow the lawn and weed the garden? Assume that there are four weeks in one month.

    [A] 5   [B] 4   [C] 3   [D] 6

44. Wendy has a cold and an ear infection. The doctor told Wendy to take 1 teaspoon of her medicine every four hours and an aspirin every eight hours. Wendy's mother gave her both the medicine and an aspirin at 6:00 a.m. Monday morning. List the times that Wendy will take both the medicine and the aspirin at the same time on Monday.

    [A] 6 a.m., 2 p.m., 10 p.m.   [B] 6 a.m., 10 a.m., 2 p.m., 6 p.m., 10 p.m.

    [C] 6 p.m., 2 a.m., 10 a.m.   [D] 6 a.m., 10 a.m., 12 a.m., 4 p.m.

45. If $\dfrac{18}{5}, \dfrac{11}{3}, \dfrac{11}{6}$, and $\dfrac{10}{2}$ are placed in order from smallest to largest which would be first?

 [A] $\dfrac{11}{6}$ [B] $\dfrac{11}{3}$ [C] $\dfrac{10}{2}$ [D] $\dfrac{18}{5}$

46. Write 3.3 as a fraction in simplest form.

 [A] $\dfrac{18}{5}$ [B] $\dfrac{3}{10}$ [C] $\dfrac{33}{10}$ [D] $\dfrac{330}{100}$

47. Vivian is making cupcakes for the school bake sale. The recipe calls for $2\dfrac{3}{4}$ cups of flour. Vivian has 4.35 cups of flour in a bowl. After Vivian completes the recipe, how much flour is left in the bowl? Express your answer as an improper fraction.

 [A] $\dfrac{8}{5}$ cups [B] $4\dfrac{7}{20}$ cups [C] $\dfrac{11}{42}$ cups [D] $1\dfrac{3}{5}$ cups

48. Write the word phrase that describes the expression. $v + 7$

 [A] a number v increased by seven
 [B] a number v divided by seven
 [C] a number v multiplied by seven
 [D] seven times a number v increased by ten

49. Simplify. $7^9 \div 7^7 \times 7$

 [A] 7^3 [B] 49^1 [C] 49^3 [D] 7

50. Multiply: 0.39×0.5

 [A] 1.95 [B] 2.35 [C] 0.195 [D] 0.235