Improving students' math problem-solving skills in a computer-assisted learning environment

Yongjian Zhen

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IMPROVING STUDENTS' MATH PROBLEM-SOLVING SKILLS
IN A COMPUTER-ASSISTED LEARNING ENVIRONMENT

A Project
Presented to the
Faculty of
California State University,
San Bernardino

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts
in
Education: Instructional Technology Option

by
Yongjian Zhen
September 1999
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This project examines the positive effects on high school students' math problem-solving skills in a computer-assisted learning environment. The project was conducted at Century High School in Riverside, California. The project includes the following phases: goal investigation, requirement analysis, design of the program, development, implementation, analysis, and evaluation. The proposed idea is based upon the review of literature on why a student's performance could be improved in a technology-integrated learning and teaching environment. The paper also includes information on how students improved their math learning motivation, problem-solving skills, and the effects of computer technology in the math classroom.
ACKNOWLEDGEMENTS

For their assistance in allowing me to complete my Master's Degree, I would like to thank the following people: Dr. James Monaghan for his guidance and support over the past two years, Dr. Kenneth Lane for his time and precious instruction on this project, Dr. Margaret Cooney for her great assistance and helpful comments in all stages of this study, and Mr. Michael Stepp for his commitment and enthusiasm throughout the program. Thanks also go to the students and faculty at Century High School for their participation in this project. My special thanks go to the teachers and students in the AVID classes and SAT class, which were observed.

Finally, I would like to thank my mother, Zhaoming Liu, and my sister, Patricia Song, for all their love, patience, and encouragement.
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CHAPTER ONE
INTRODUCTION

I. Context of Mathematics Learning

For whatever reason, learning mathematical concepts and developing mathematical skills have been difficult if not impossible for some students at both the middle school and high school levels. Many studies have indicated that the task of learning mathematical concepts is not difficult for students when they start learning math. However, when the concepts become complex and students experience difficulty in demonstrating math skills, they then begin to show signs of frustration and boredom. The more frustrated they become, the less interested they are in learning math (Buerk, 1982; Farrell & Farmer, 1985; Stodolsky, Salk, & Glaessner, 1991). Stodolsky, Salk, and Glaessner (1991) point out that in the elementary grades, math is one of the most liked subjects and is rated most important at all levels of schooling. Yet, as students get older, fewer students report liking math and a larger percentage find it difficult.

There is a historical record of the negative, anxious attitudes of many students toward mathematics (NCTM, 1930). When students with such an attitude are asked to trace the origin of their anxiety, they will usually identify one or more of the following: too much memorization, little or no attempt to relate the subject to the real world, and the
rigid attitude of the teacher toward alternative approaches (Buerk, 1982).

The consequence of this attitude towards math learning is obvious. One consequence is that tests of students in geometry classes by various cognitive development measures show that a minimum of 30% of these students reason at the concrete operational level and another 30% to 40% were assessed as transitional reasoners (Farrell & Farmer, 1985). However, students at this level should be able to hypothesize, reason deductively, understand the role of mathematical models, and understand the difference between defining and deducing (Lindquist & Shulte, 1987). The above tested students represent a transitional group and it is particularly important to realize that these transitional students are in a developmental gap and need the stimulation of activities that vary gradually from concrete to abstract, in order to avoid stagnating at concrete operational level and transitional reasoners level.

Student difficulties and anxieties in learning math concepts were evident to me when I was tutoring at Century High School in Riverside, California, in January 1999. This was reflected when two students came to me with a word problem and said, "I don't even know where to start." Another one indicated, "I did follow the steps of solving a problem, but I have no idea which formula is supposed to be used for this problem." Then they both said, "Math is
boring." One student even asked me, "I don't think we'll use this in the future. Why do we have to learn it?" These student concerns gave me the idea for this project in which I would explore whether or not computer-assisted learning could improve a student's ability to demonstrate math skills.

II. The Demands for New Teaching Methodology

Exploratory teaching methods to motivate students' interest for learning need to be developed (Farrell & Farmer, 1985). One such method is Advancement Via Individual Development Program (AVID), which is part of the methodology that was introduced on a nation-wide basis to alleviate difficulty in learning with the traditional teaching.

AVID is an instructional program developed by Mary Catherine Swanson in 1980 at Clairemont High School in the San Diego Unified School District. In the classroom, students studying the same subject but in different grades form small groups and study individually under the teacher's and tutors' help. Students choose what to study based on the problems they encounter and students may tutor each other on various problems. According to the high school's AVID booklet (Swanson, 1996), AVID is to ensure that all students, especially students performing at average levels capable of completing a college preparatory path, will succeed in the most rigorous curriculum, enter mainstream activities of the school, increase their enrollment in four-
year colleges, and become educated and responsible participants and leaders in a democratic society. The program has had great achievement results and was recognized as one of the best programs for high school students in the nation (Swanson, 1996).

Other studies (Webb, 1994) also show that instructional programs, focused on improving students' ability to help others in cooperative small groups, can have significant positive effects on their behavior and learning outcomes. The strong results for Latino and African-American students suggest that this kind of program may also be successful for improving the learning experiences and outcomes of traditionally underachieving groups in high school mathematics.

The AVID program has been adopted by Century High School as part of teaching methodology since 1996 and has produced expected achievements. Ms. Champion, Coordinator of AVID Program at Century High School, said that the program helped her students to increase their enrollment in four-year colleges. However, she pointed out that students' problem-solving skills, interest, and attitude toward math learning improved, but not as remarkably as other subjects such as science, literature, history, or language. The sign of frustration and boredom just described still exists.
III. Study on Effect of Computer-Assisted Learning Environment

1. Purpose of the Study

The purpose of this study is to find out if using instructional technology when teaching mathematics will improve students' problem-solving skills. This project will investigate whether or not a computer-assisted learning environment facilitates students' interest and abilities in mathematics.

This study will examine the effect of computer-assisted teaching on improving students learning math concepts and the subsequent demonstration of math skills. The major goal of this project is to explore if students become more effective mathematical problem solvers by involving them in a computer-assisted learning environment. It is assumed that, if found effective, the methods studied could be adopted into and enrich the instructional programs such as AVID. This is to be cost-effective for restructuring the teaching method because the required computer hardware is already available in this school.

2. Selected Software for the Project

To measure the improvement in students' math problem-solving skills by having students participate in computer-assisted learning environment, the Personal Trainer SAT (Davidson, 1993) was selected. The Personal Trainer SAT is commercial interactive software designed for high school
students who need to take the SAT. The SAT is a required comprehensive test for students who want to attend a four-year private college and/or university. The test consists of eight sections: four math sections and four verbal sections.

Before starting the use of the Personal Trainer SAT, students are required to take a sample SAT diagnostic pretest. The result of the pretest is used to evaluate students' problem-solving level. The information gathered from the pretest will be used by Personal Trainer SAT to personalize training schedules based on each students performance and is combined with the time that students desire to devote to their SAT training. Personal Trainer SAT is structured in two sessions. The first session includes intensive strategy and tutorial material in each of eight test areas: verbal analogies, sentence completions, critical reading, and vocabulary problems, arithmetic, algebra, geometry, and special math problems.

In this project, I will only study the math part of the Personal Trainer SAT. The strategy session provides step-by-step tips on how to approach each type of question. It also includes technical advice for students, such as how to best utilize calculators during the examination. The strategies are interactive, which allows students to respond to the trainer's suggestions in many effective ways.

The second session of the Personal Trainer SAT contains extensive workouts. The workouts are online databanks that
contain more than 750 SAT questions (including some which were licensed directly from Educational Testing Service—the organization which prepares the SAT). The workouts are practice problems available to build up students' skills for the real test. There are eight workouts corresponding to the eight strategy sessions.

To increase students' learning interest and alleviate their pressure, Personal Trainer SAT provides computer games (called Big Game) within the system. The games are provided as a reward for work well done. It addresses general SAT strategies with fun. This helps learners practice their SAT strategies.

Once all the workouts have been completed students take a posttest. The computer will score the result and compare the students' respective pretest scores so students will be able to find out how much progress they have made and continue to work on areas needing improvement.

The overall design of the Personal Trainer SAT is nonlinear and user friendly. Students can go anywhere according to their interest. Simulation and feedback design are very complete. Features like the pencil cursor, calculator, training schedule, paging arrows, passages button, difficulty level indicator, review strategy, answer bubbles, scoreboard in the Big Game. Main Screen access make the design vivid and user friendly.
3. Selection of School Site

I selected Century High School in Riverside to complete the study because the school has implemented the AVID program for about three years and has produced positive results. I implemented a computer-assisted learning environment into the AVID program at this school with the purpose of effectively improving the program. With the help of the Personal Trainer SAT (Davidson, 1993), students in the AVID program at Century High School improved their ability to solve actual SAT problems and their math learning skills increased as measured by the post-test.

4. Justification of the Study

This is an important project because it enhanced the current instruction program and students' math learning. Many students lack the ability to solve higher math problems because they do not have the basic math skills. It is very difficult to discover effective ways to improve students' skills in solving higher level math problems such as those found in geometry and/or trigonometry. Technology, a tool proven to be effective in assisting teaching and learning (Thompson, Simonson, & Hargrave, 1996), may assist students. It is very important to determine whether we need computer-assisted instruction in teaching mathematics and its effectiveness on improving students' math learning.

Thompson, Simonson, and Hargrave (1996) stated that the future of our world will depend on preparing and educating
students for the demands of the twenty-first century. Improved teaching methodologies will make students become creative problem solvers, which will prepare them to have the ability to become successful and contributing members to society.

Through my observation, I noticed that the current teaching methods applied in the AVID program at Century High School in Riverside were similar to group-self-study. Thompson, Simonson, and Hargrave (1996) proved that the computer technology assisted learning environment will stress math problem-solving skills and interpersonal skills for students. Robyler (1988) also confirmed, through her research, that computer applications were more effective for teaching mathematics than reading and language skills. Robyler further noted that using computer applications for teaching cognitive skills (problem-solving and critical thinking) yielded about the same effects as for mathematics. If the computer technology-assisted learning environment were established along with the existing program, the math problem-solving and interpersonal skills of students would be remarkably enhanced.

5. Research Hypothesis

The hypothesis of this project is that in a computer-assisted learning environment, the math problem-solving skills of the high school students will be enhanced, their learning interest will be increased, and their classroom
behavior will be improved.

IV. Project Overview

This project examined the effects of computer-assisted learning on students' demonstration of learned math concepts. It was conducted at Century High School in Riverside, California, with students from all academic levels.

The proposed objective of this research is based on my personal observation of students' math learning needs which was also reflected in the Review of the Literature. The goal of this project is to utilize the technology present at Century High School to create and develop a computer-assisted learning environment. The project will integrate the constructivism approach in curriculum design and will include the following phases: pre-project phase, on-site conduction phase, needs analysis, implementation, development, the data analysis phase, evaluation, findings, and conclusion.
CHAPTER TWO

REVIEW OF THE LITERATURE

This review of the literature will focus on three areas: 1) the importance of learning mathematics; 2) computer technology in math education; and 3) teacher training on educational technology.

The Importance of Learning Mathematics

As to mathematical education, Times Educational Supplement provides a typical headline, "Low Scores in Math's Test"; this covers a short paragraph of statements such as "sixty percent of the pupils could not write 4.867 to two decimal places." These anxieties and complaints probably owe as much to social and cultural factors as they do to the realities of mathematical attainment. It is also part of a worldwide trend (Bell, Costello, & Kuchemann, 1983).

How do some students feel about math content learning with regular teaching and learning methods? Frick (1991) found out the following feelings of students:

- Subject matter is meaningless and disconnected from real life.
- Learning is mostly passive--listening, reading, watching, or solving problems.
- Some content is abstract and hard to understand.
- They feel bored with, or alienated from, the subject matter they are expected to learn.
They feel incompetent in mastering learning objectives since the rate of learning is externally paced much of the time.

Can we get rid of mathematical learning and teaching? Zaslavsky (1994) argued that everybody needs math. Increasingly, the jobs in today's economy require knowledge of mathematics. New technology will call for the ability to apply mathematics and science in practical ways, and rapid changes will demand that workers learn new skills throughout their lives. In other words, lifelong learning is the pattern of the society. Using mathematics on the job or as preparation for a career is only a small portion of the influence of mathematics on the way we live. More importantly, the ideas of mathematics affect us on many different perspectives in our life. Zaslavsky (1994) summarized the following aspects of mathematics that will evolve into and reshape the way we think and act:

- Practical--figuring unit prices in the supermarket, understanding the effects of inflation, balancing a bank account, etc.
- Civic--understanding such public policy issues as tax rates, the education budget, health care, preserving the environment, and the effects of racism, sexism and other forms of discrimination.
- Professional--applied to fields ranging from business management and health care to machinist and physicist.
By now, there are few fields of work that do not involve computers.

- Leisure—games of chance and games of strategy, puzzles, and prediction and analysis of sports events.
- Cultural—all societies throughout the ages have developed mathematical ideas and interests. Mathematics is a universal part of human culture.

**Is Math Difficult to Understand?**

Viewing the importance of mathematics and its incredible power in influencing our daily life, many students still reject math learning (Zaslavsky, 1994). What is the reason for this rejection? As statistics shows, 80% of high school students who try to avoid math learning believe that math is difficult to understand and it is one of the most stressful subjects of the curricula. Is there any intrinsic reason why mathematical understanding is so hard to achieve? Is it reasonable to assume that harder work by students and by teachers could achieve sufficiently good results to satisfy the complainants? The answer to the first question is "yes" while the answer to the second is generally "no." Zaslavsky (1994) pointed out that in the traditional teaching and learning environment, the achievements do not comply with the hard work of teachers and students.

Mathematics is challenging because it deals with abstract relationships. Some parts of it look easy because
they consist of symbol-manipulations which is possible to learn without understanding the underlying operations to which they refer. This requires abstract thinking in which students are sometimes confused (Zaslavsky, 1994). The implementation of a computer-assisted learning environment is able to provide the learners with more understandable instruction with animated designs which turn the abstraction into vividness. Therefore, the difficult part of mathematics become much easier to understand. Without the confusion of abstract thinking, students will accept mathematics more quickly, which will ultimately build up confidence for students. In the computer-assisted learning environment, both teachers and students will achieve good results effectively.

Mathematics Education

Zaslavsky (1994) argued that real mathematics education should fulfill the conditions of humanistic and liberating education. It should equip people with the knowledge and tools that will enable them to examine and criticize the economic, political, and social realities of their lives. It should help them to understand and try to find solutions to some of the hard questions that affect them such as "How can we clean up our polluted environment and stop further pollution?" (Zaslavsky, 1994). It is our teachers' responsibility to fulfill this task.
The distinction of teaching methods of mathematics should be made between skills, concepts and general strategies as different kinds of teaching objectives and appropriate methods (Bell, Costello, & Kuchemann, 1983). In traditional learning environments, students enter class expecting to sit and passively listen to an instructor, who controls both the flow and the content of the class. Contrary to this, in constructivist situations, students must take active roles in learning. Getting students to change their roles in learning may not be easy. Many students are successful (success defined by grades) within the traditional system, but they need a comfortable learning situation where they are able to learn through the experimentation, collaboration and sometimes failure which are often components of constructivist learning environments (Carr, Jonassen, Litzinger, & Marra, 1998).

**Constructivism in Mathematical Learning**

Constructivism is the most popular, yet most controversial educational theory in America (Carr, Jonassen, Litzinger, & Marra, 1998). In a constructivist learning environment, the focus shifts from the teacher to the learner. This learning environment is more motivating, encourages critical thinking, accommodates diverse learning styles, and supports natural inquiry (Carr, Jonassen, Litzinger, & Marra, 1998). Therefore, constructivism becomes
the theoretical orientation of building a computer-assisted learning environment.

The constructivist view of mathematical learning differs considerably from traditional approaches in that children are considered to be active reorganizers of their mathematical experiences. Mathematical learning involves both the personal construction of meaning and the negotiation of the taken-as-shared meaning of the community (Cobb, 1990). Clements and Battista (1990) provide a summary of the general underlying assumptions of this perspective which include the following:

- Knowledge is actively created by children and is not passively received from the environment (Piaget, 1980).
- Children create new mathematical knowledge by reflecting on their physical and mental actions. In addition, children's actions are viewed as rational to them and reflect their current understanding (Labinowicz, 1987).
- Mathematical ideas are cooperatively established by the members of a culture (Bruner, 1990).
- Opportunities for learning occur during social interaction involving collaborative dialogue, explanation and justification, and negotiation of meaning (Voigt, 1985).

Although a constructivist view of learning mathematics has been commonly accepted by researchers and mathematics
educators alike (NRC, 1989), learning mathematics in school still continues to be dominated by the traditional transmission view of knowledge (Wood, Cobb, & Yackel, 1991). **Traditional Method and New Way of Math Teaching**

Traditional teaching methods (Figure 1) should change (Branson, 1997). Math instruction tends to follow a pattern in which the norm is teacher explanation of concepts and algorithms to the whole class, followed by sessions of individual student practice through seat-work exercises (Stodolsky, Salk, & Glaessner, 1991). In the new way of math teaching, computer technology is integrated into the teaching and learning environment (Figure 2). Stodolsky, Salk, and Glaessner concluded that the integration significantly increased the teaching and learning efficiency by diversifying math teaching methods and stimulating students' learning motivation.

Traditional math teaching methods result in learning rules and procedures without developing the essential conceptual understanding (Perry, Church, & Goldin-Meadow, 1988). However, the core of mathematical instruction should address training students with flexible thinking and analytical skills—the various possible ways of writing down a problem, the possible ways of thinking about it, and the possible ways of getting a solution (Feynman, 1965). This contradiction has been the focus of a call for reform in mathematics education at all levels of schooling (National
Figure 1. Traditional view of teaching

The traditional view of teaching in which the teacher presents and controls the sequence of information delivered to a class based on personal knowledge and experience.

Figure 2. New method of teaching

The new method provides the opportunity for asynchronous, random access to stored knowledge and learning materials for all learners. Performance support systems facilitate the work of students, teachers, and other members of the staff (Branson, 1997). Instructors and computer technology provides communication, knowledge database, learning support system, and staff support system.
Technology has made calculations, constructions, and graphing quicker and easier, through changing the nature of problems and tasks important to mathematics and the techniques used to investigate them. The dynamic and interactive capability of various software packages improves the somewhat static environment that has traditionally existed in classrooms using paper-and-pencil procedures and routines (Anderson, 1997). In the activity described in Anderson’s article, students used Algebra Xpresser, a piece of graphing software to explore what volume means as a function and as a medium for exploring the generated formula. The activity provided students with an environment to explore an even wider range of mathematics problems than ever imagined, and it allowed them to visualize the connections among various mathematics topics by using graphs to further understanding. Anderson (1997) noticed that as students engaged in investigating the conditions of the task and solution methods, technology became a medium through which students not only conceptualized the task further but also extended it to greater depth. The questions were easily modeled with the computer and further explored by students. Anderson (1997) concluded that the computer along with appropriate software facilitates students' problem-solving
processes. A computer can help eliminate obstacles in doing mathematics—particularly problems involving formulas and calculations. The students certainly benefited from computer use. In addition, the computer allowed a much deeper exploration of mathematical concepts that were previously explored only algorithmically. The depth of the explorations added substantially to the quality of mathematical understanding that students developed.

The computer is widely applied in every aspect of public education now. More and more public schools are spending money to equip their classrooms with computer technology. The next step is to fully utilize the most advanced technology equipment in the world to improve the learning environment and teaching method. Siegel (1994) reports that the United States leads the world in the number of computers in its schools; 99% of all elementary and secondary schools have installed computers. Also, 93% of the students use them during the school year. Siegel also states that American students are less computer-knowledgeable than students in Austria, Germany, and the Netherlands. This alerts teachers to have students keep pace with the increasing use of computer equipment.

The computer makes it possible to provide an environment that responds to the learner in prescribed, but not inflexible ways. It also can record the learner's choices and map one's progress through the material. It is
therefore an apt instrument for research on teaching and learning. The computer has also inspired theory building and experiment based on the view of the human learner as an information-processor.

In their study, Wise, Spiegel, and Bruning (1999) concluded that the more we integrate technology, especially graphing calculators and computers, into the curriculum to enhance our teaching mathematics the more interested students will be. Through their study, in the computer-technology assisted environment, students changed their attitude and class behavior tremendously.

In a computer-assisted learning environment, students will become more actively engaged in learning by interacting with technological learning materials. These types of materials would give students numerous opportunities to provide feedback. They would also have more control over the pace of their own learning. Computer-based teaching programs can allow the learner to proceed at one's own pace, and to select which parts of the teaching materials to learn first. In one experiment, a group using a program-controlled route through the material (which was regulated by individual performance levels) performed better on post-tests than a group who could access material as they wished, even though the latter gave higher ratings of satisfaction and stimulation (Bell, Costello, & Kuchemann, 1983).
Computer Software Used in Mathematics Teaching and Learning

Bell, Costello, and Kuchemann (1983) pointed out that a well-documented principle, which is important for the management of learning practice, is the influence of feedback. However, in the human learning situation, the prime importance of feedback is not as a mode of reinforcement, but as a way of providing information to enable the student to correct errors. Studies show that various computer software can carry out this task very flexibly and effectively (Anderson, 1997; Diggs, 1997; McClinlock, & Jiang, 1997). Computer software on the market is mostly interactive designed with feedback. The type of feedback varied between 'passive' and 'active' types (Bell, Costello, & Kuchemann, 1983). The passive type simply gave a feedback message, then continued with the next question. The active type took the pupil through the question, requiring him/her to try each step again until he/she succeeded. Through their study, they found that the active was more effective for the less able pupils, but for the more able, the two types were more or less equivalent (but significantly better than no feedback).

Holliday (1991) states that "Graph theory affords the high school student every opportunity to participate actively in the mathematics process and experience and understand many different proof techniques for important real-world applications." Using technology to help study
graph theory has made this statement even more reasonable. After discovering what a dynamic geometry-software package could do for geometry teaching, Quinn (1997) realized that this type of technology also had much to offer for teaching graph theory in her discrete-mathematics course. She used the Geometer's Sketchpad 3 (Jackiw, 1995) with her students to build the learning environment. Students could improve their reasoning by making conjectures and verifying them on the computer. Insights from the computer led to insights that helped them develop proofs, something that is never simple for high school students. Jackiw concluded that Geometer's Sketchpad 3 supplies a tool to create sketches that are tedious to draw and redraw or that are hard for students to visualize, but it also gives students insight during class discussions as we try to prove or disprove whether certain graphs are isomorphic, bipartite, or planar. Classroom use of this type of technology is consistent with our attempts to implement the NCTM's curriculum and evaluation standards for school mathematics (NCTM, 1991).

Diggs (1997) states that computer technology provides a means of communication that students understand. Computer technology can be an exciting tool in the right hand both in teaching and in learning, and it can give life and vigor to otherwise dull lessons for teachers and students. Technology acting as a vivid tool with graphics can also help address stumbling blocks in education that have not been
successfully addressed using traditional resources. Nowadays, computer technology is so powerful and useful that it cannot be unnecessary in our daily life. This means not only does computer technology help students learn various knowledge more easily, effectively and quickly, but also it helps the teacher to change at-risk students into good ones. Diggs (1997) was a math teacher in a middle-sized district in Missouri. He had a student, Joe, in his classroom with a behavior disorders and learning disabilities classification. At first he thought that the computer would be a wonderful way to keep Joe occupied and chose one program, Math Blasters, which requires a bit of reading. The other students took turns helping and working with Joe since they liked computers, too. After a few weeks, it became clear that Joe had gradually gained acceptance among his classmates. Rather than isolating him from the class, technology had helped Joe interact with his peers. Soon after he worked with computers, Joe learned to use a word processing program to send a conventional letter to Michael Jordan, his basketball hero. He started making his own decisions about what he wanted to learn and to do. He chose Math Blasters to improve his problem-solving skills. All of this was a good start for a student in need of success.

Technology helped this alienated student interact with his peers and begin to succeed in an academic setting. After working with Joe, Diggs (1997) felt the key to inclusion is
grabbing students' interest through issues that are in their lives--without that, they feel no ownership or drive to be involved.

On the other hand, the side effects of the computer technology like game playing are serious, too. The students may keep playing, be attached to the games, and forget anything else. It is a waste of time, energy, and money. Worst of all, they might be sometimes misled (Diggs, 1997). Another obstacle for computer technology to be widely adopted in classroom teaching is its high cost to build up a computer-assisted teaching and learning environment. The computer environment usually requires considerable time and effort (budget, you may say) to produce a limited, small, computer-based teaching program since the approach generally assumes a one-to-one interaction between student and computer, and hence, the need for many input-output devices.

However, with its powerful and irreplaceable advantages, the computer is believed to be one of humankind's most versatile tools, especially in education. By simply changing the set of instructions or computer program stored in the memory of the computer, we dramatically change its functions. With one program, it becomes an electronic typewriter or word processor; with another, it is turned into a powerful calculator. By inserting a diskette with other programs, we can turn the computer into an electronic filing cabinet, a drafting
table, or an artist's easel. It is true that these computer tools are often only new manifestations of other more common tools. However, the computer versions significantly expand their application, speed, accuracy, and power. It can extend our mental capabilities. Computer tools have potential application in virtually every aspect of the school curriculum. Helping students produce exciting and stimulating written documents and oral and visual presentations can teach them valuable skills for potential employment and motivate them to see new and unique options (Ryder & Hughes, 1997).

We have restricted our remarks mainly to the actual use of the computer in mathematics classes, and particularly to the use of the computer by teachers and students as a tool for investigating mathematical relationships and cultivate abstract thinking skills, as well as problem-solving skills. However, this type of use is not unique to mathematics and the results of such activity are encouraging and may well reflect a major school use in the future.

Most of the researches have produced evidence to the effect that students who study mathematics with computer applications are more apt to employ different problem-solving strategies effectively and perform significantly better on mathematical tasks (Anderson, 1997; Diggs, 1997; McClinlock, & Jiang, 1997). Among computer applications specially designed for math teaching and learning,
McClinlock and Jiang (1997) assumed that spreadsheets are a very powerful tool for simulating probabilistic situations with both high school students and mathematics teachers, not only for simple problems, but also for rather complex problem situations. This was supported through solving all the problems. For example, they use Microsoft Excel (1995) in their classroom to solve the "power-line problem," geometric probability: "Is it a triangle?" and the "Bubble-Gum-Card problem." The experience has shown that the problem-solving activities reflected in these examples are very beneficial for the students. The activities not only deepen the students' understanding of fundamental ideas of school mathematics, strengthen their problem-solving abilities, and develop their skills in using technology, but also help students and teachers develop innovative learning and teaching strategies. These experiences begin to open access to better mathematics education for all students (McClinlock & Jiang, 1997).

The introduction of technology to the classroom not only affects student learning, but it can have a profound impact on classroom social processes (Schofield, Eurich-Fulcer, & Britt, 1993). Schofield, Eurich-Fulcer, and Britt (1993) reported that using computers increased students' general enthusiasm. Podmore (1991) proved the idea that the use of computers in the classroom increases student motivation and interest and students exhibiting high levels
of task involvement and persistence. Studies also showed that the use of various forms of computer-assisted instruction have major implications for both teacher and student roles. Among them, one study suggested that when computers are used for instructional purposes, teachers become more comfortable with evidence of student expertise, teachers increasingly see themselves as facilitators of learning rather than authority figure, and students feel more in control and have more input into structuring classroom activities (Sandholtz, Ringstaff, & Dwyer, 1990).

Drawing a static picture representing one state of a functional relationship does not guarantee that students will "see" how changes in the independent variable produce corresponding changes in dependent variable. Emtse and Yoder (1998) found out that interactive geometry software, like TI-92 Geometry, resident of the TI-92 graphing calculator, makes this dynamic problem representation possible. They use TI-92 Geometry for "The Swimmer Problem" to simulate the dynamic process, transfer measurements to the data/matrix editor, and to get the graphical and algebraic solutions through technology. Interactive geometry software allows the user to create a micro-world where problems can be simulated and more important, can be manipulated to show the dynamic nature of their changing variables. Emtse and Yoder (1998) noticed that the lack of understanding of a problem could be a serious blockade to all types of solution strategies, even
for those using technology. The inter-connection among the various modes of the TI-92—Geometry, data graphing, function graphing, and algebraic—extends the power of the visualization to provide a rich environment for multiple approaches to complex problem situation. Many typical problems from the mathematics curriculum can be visualized and solved by the methods illustrated. We as teachers need only use our imaginations to apply these techniques to our favorite problems and bring them to life for our students (Emtse & Yoder, 1998).

Create Your Own Educational Materials with Authoring Tools

It is necessary to discuss creating educational materials for math classes (also applied to other subject matters) for those teachers who would like to design their own software for new teaching methods though we did not use teacher-created software for this project. If you give students a choice of researching environmental pollution using a textbook or using multimedia encyclopedia and information gleaned from a discussion with a scientist on the Internet, that student will not hesitate in choosing the computer (Schurman, 1994). This is true with mathematics teaching. Students can have fun while interacting with computers. They learn more when they research, organize, and report their content. Cross (1995) stated that technology gives students many ways to present their findings. When students do this in a classroom, they experience the power
of making technology work for them. Cross pointed out that computer technology motivates, promotes and gives the students familiarity with some powerful means for expressing themselves to others. Vaughan (1996) stated that multimedia authoring tools provide the important framework we need for organizing and are used for designing interactivity and the user interface, for presenting our project on screen, and for assembling multimedia elements into a single, cohesive project. Authoring systems typically include the ability to create, edit, and import specific types of data; assemble raw data into a playback sequence or cue sheet; and provide a structured method or language for responding to user input (Vaughan, 1996). With multimedia authoring software, Vaughan (1996) summarized in his paper that we can make:

- Video productions
- Animations
- Games
- Demo disks and interactive guided tours
- Presentations
- Interactive kiosk applications
- Interactive training
- Simulations, prototypes, and technical visualizations.

Multimedia authoring systems will provoke radical changes in the teaching process during the coming decades, particularly as smart students discover they can go beyond the limits of traditional teaching methods. Vaughan (1996)
stated that to some aspects teachers may become more like
guides and mentors along a learning path, not the primary
providers of information and understanding. The students,
not teachers, become the center of the teaching and learning
process. This is a sensitive and highly-politicized subject
among educators, so educational software is often regarded
as 'enriching' the learning process, not as a potential
substitute for traditional teacher-based methods (Vaughan,
1996).

According to Paul D. Houston, Executive Director,
American Association of School Administrators, "The demands
of the 21st Century require new thinking about education. We
must abandon those 're' ideas such as re-form, re-
engineering, or re-thinking, and create new systems for
learning which involve all of the environments that impact
children and life long learning, the home, the community,
and the workplace." He tested a solution aimed at
integrating technology into the unique education environment
called The Academy of Multimedia, a program designed to
provide the opportunity for both teachers and students to
learn about, practice, and then produce interactive
computer-based courses as part of their normal curricula
activities. Students use the Quest® Multimedia Authoring
System, which provides all of the tools and capabilities
needed to create the computer-based lessons.
"The Academy program gives students opportunities for real life training," said Allen Arko, an instructor at the Jordan District Technical Center. "It helps them show competency, not just a letter on a report card, by developing a portfolio and skills that they can use throughout life. It's definitely a win-win situation for everyone: students, teachers, parents, and society" (Houston, 1996).

The multimedia authoring tools can bring the creativity of teachers and students together in developing instructional software and in solving instructional problems, and accomplishes all of this at the basic level. They help schools create educational materials that could be used for distance learning purposes, and also help schools to integrate technology into the classroom, thus benefiting both teachers and students. Students and teachers can be actively involved in the creation of interactive computer-based instruction with authoring tools. We have seen courses completed that support and increase the effectiveness of their total curriculum. We have seen increased cooperation and excitement among the teachers and students. Authoring tools can firmly embed new instructional processes, create new skills, and open the doors to the world of multimedia technology that can bring important educational result if used appropriately. They can facilitate a sage arrival into the land of interactive multimedia instruction, and give our
students an opportunity that integrates all of their skills into a business-like setting and allows them to work with their peers across the globe (Vaughan, 1996).

Like the learning environment built by The Academy of Multimedia, both teachers and students should use the authoring tools to facilitate, enrich, and arouse the interest of their teaching and learning. Students can also use these tools to reinforce and develop their learning. We should build a new learning environment based on the combination of appropriate educational theories to integrate the authoring systems into curriculum and classroom in this computer age. The learning environment should be student centered. Teachers should give instructions on how to use these tools properly and regulate students' math learning direction in order to approach the general educational goal. In order to reach this educational goal, teachers who are not comfortable with computers need to be trained in computer literacy.

**Teacher Training and Educational Technology**

A typical example of proper use of computers in classrooms is described as: a group of students, linked together through software and computers, sharing ideas instantaneously as they work on a collaborative writing project; Internet access provides students engaged in research projects with a wealth of resources not accessible through traditional means and foreign language classes
become more purposeful when students communicate, via
electronic mail, with native speakers (The Role of
Technology, 1996). To have the computer-assisted teaching
and learning environment be successfully established,
acquiring technology for schools is the first step while
teachers integrating technology into practice is the next.
The reality is that technical equipment has been placed in
schools, but many teachers still rely on the traditional
methods of teaching (Hope, 1998). Hope pointed out that one
of the reasons many teachers are not integrating technology
in their classroom teaching is the lack of prior experiences
in using it as a productivity tool and for teaching.

Institutions responsible for preparing teachers in
pedagogy fail to sufficiently prepare them to use technology
to deliver academic services. The result is the perpetuation
of the marriage of teachers to traditional methods of
instruction (Hope, 1998). Therefore, as part of this review,
teacher training has emphasized the importance of the
teacher's knowledge of technology.

For teachers to integrate technology into their
teaching practice, they first of all need to believe that
using technology is more efficient and effective than their
usual methodologies. When computers and related technologies
are introduced in schools, a plan for why and how they are
to be used needs to be in place. Hope (1998) pointed out
that the problems in applying technology into schools and teachers are:

- The difficulty associated with obtaining hardware.
- Maintaining the hardware that has been purchased.
- Human realm influencing teachers' decisions about integrating technology into practice.

Secondly, teachers need to understand what technology is available in their teaching facilities. A list of technology includes computers, laser disc players, CD-ROM, overhead projector panels, digital cameras, and multimedia systems. Numerous applications yield computer-assisted instruction, computer-managed instruction, simulation, word processing, database, spreadsheet, distance learning, desktop publishing, communication, and networking (Hope, 1998).

Hope (1995) configured computer technology into eight parts. Those components are software, hardware, computer carts, training, computer disks, using the gradebook plus program, using the lesson planner program, and assistance.

Using this configuration, teachers were to accomplish two tasks. They were to record and maintain lesson plans and students grades. Configuring computer technology addressed problems that often prevent teachers from integrating technology into their practice, e.g., hardware and software. Simplifying computer technology allowed teachers to focus their attention on a manageable configuration. The more
complex an innovation is, the more time it takes to master it. Teachers may also abandon an innovation (computers and related technology) because they are unable to use it consistently and effectively (Hope, 1995).

Encouraging teachers to integrate technology into their practice is a formidable task. Teachers have personal and professional concerns about practically any innovation introduced to them. In addition, they are also concerned about technology’s impact on their students. Teachers in a particular stage need specific assistance to resolve the concerns they have about an innovation. Encouraging on a one-to-one basis, providing technical assistance, and modeling how to use technology are a few examples. Applying specific interventions to overcome teachers’ concerns encourages exploration of an innovation and builds confidence.

One of the challenges for educational reform is how to influence teachers to abandon old practices they have been trained to do and accept new practices they haven’t been trained to do. Teacher educators need to revisit their practices and teach with technology so that teachers emerge able to use computers and related technology. If those responsible for training teachers incorporate technology into their preparation repertoire, then schools which employ the graduates must nurture and extend the skills. Hope (1998) suggests that giving professional development credits
that can be used for recertification, and providing free software, computers, and related technology to teachers to use are all inducements. In addition, there are some small things that encourage teachers to use technology. One is to inform teachers that they do not have to become expert users of technology overnight. Two, let teachers see computers and related technologies making a difference in the teaching and learning process. Three, recognize and praise teachers when they use technology in their teaching.

Integrating technology in education, like any other significant change, requires systematic planning. Most educators have little background and fewer resources with which to conduct that kind of planning (Hope, 1998). There are quite a few methods and ways to achieve this goal, such as the utilization of related software packages, articles, and publications, and in-services and new teacher orientations. These approaches are introduced in the following paragraphs.

1. School Technology Planner (STP) software

The intent of the School Technology Planner (STP) software is to provide a degree of automated support for teachers and other educators who are proactive about realizing the promise of technology for schools.

STP is designed as an apt way to support school technology leaders as they plan the integration of technology into schools and curricula. It guides the user
through a needs assessment, prompts the user to answer questions about the readiness of the school, and generates interview/discussion questions for teachers, parents, administrators, and others (Lawler, Rossett, & Hoffman, 1998).

Various evaluations on STP employment by researchers showed that the STP is a valuable tool for technology leaders who hope to integrate technology into their classrooms and districts. Several individuals used the STP to move closer to their technology goals. Technology can indeed support teachers and administrators who are enthusiastic about integrating technology into classrooms and schools. All the respondents in the study were quick to voice their frustrations with respect to technology integration itself. A program like STP contributes to tempering individual passion with data, accessing relevant literature, casting a wide net for opinions, and generating a comprehensive and tailored Technology Use Plan with broad school and community support.

2. Articles and Publications

The information in the article Help them get IT: infusing technology in instruction (Murray, 1998) could be one approach a school or school district could use to educate its teachers in the need for computer technology, the available resources to teachers for continued training, the potential uses in the classroom, and the validity in
using modern technological methods to teach contemporary students.

3. In-service and New-Teacher Orientations

In-service and new-teacher orientations are great places to introduce technology to teachers. The ideal orientation should introduce teachers to the school system, show off some new software, and demonstrate a few model lessons. Teachers teaching teachers is concept that allows schools the opportunity to draw from its strengths and spread those to others within the school. Once teachers have at least a general knowledge of computer technology, they can gain access to many resources and tools on-line. Another tool that teachers could have in their quest for computer knowledge is a video curriculum produced by the ASCD called Teaching and Learning with the Internet. This series helps any type of teacher in any curriculum area to understand the power of this new technology and gives the veteran computer user new ways to use Internet applications. Teachers will learn to: create authentic learning situations, relate curriculum to life outside the classroom, engage students in constructivist learning activities, teach decision-making skills, promote problem-based learning, and prepare students for the information age.

If the teachers are properly trained and are given the support system in order to survive, they will become confident in their ability to use computers, effective
teaching, enraptured learning, and student success. Here there is a need to discuss the communication instruction with technology, another research on teacher training.

Expressed concerns about teacher qualifications, of course, are frequently heard in regard to any number of disciplines. What may make communication instruction perhaps somewhat unique, however, and what is the central concern of this research, is the tremendous impact that the new communication technology will have in this respect. Some argue that a communication revolution has taken place in recent years, a revolution that will have an enormous impact in terms of social consequences (Martinson, 1998).

Martinson (1998) stated that the communications teacher has an obligation to ensure that his/her students understand that the new communications technology has the potential for improving the life of individuals and serving the societal public good in an almost unlimited variety of ways. The communication teacher, however, also has a serious obligation to point out the negative consequences from both an individual and societal context that may evolve out of the introduction of these new media technologies.

Consequently, the communication teacher must have more than a cursory understanding of the mass communication process and the new media technology. A teacher is not adequately prepared. Teaching about the new media technology requires that the teacher know something more than the nuts
and bolts of the process. The effective communication teacher assists his or her students in acquiring evaluative knowledge. To have evaluative knowledge of the impact of the new media technology means the student has an understanding or way of knowing why it is important to him/herself and to society that one has this knowledge. As Rowe (1998) points out, evaluative knowledge is transmitted through a process of sharing—where the teacher shares his or her understanding of the importance of the material with students. Also the teacher should have an understanding of (and appreciation for) the subject matter that goes well beyond the previously cited nuts and bolts considerations. The teacher needs to understand him/herself, what researchers mean when they talk about agenda setting, uses and gratification, or modeling theory.

The revolution in communication technology presents social, political, economic, and philosophical considerations that are of critical importance to individuals and society as America moves rapidly toward the next century. The impact of that technology will occur for better or worse (Martinson, 1998).

In the case of teacher training, teachers are considered as learners as well. The only difference is that these learners (teachers) are theory and knowledge equipped but they are lacking computer technology (Pappaport, 1991). We need to equip them with technology.
Opportunities to apply learned theory and externalize knowledge are often lacking in the conventional classroom, even at the graduate level. Graduate students demand relevance and seek opportunities to apply their knowledge and test ideas against their own accumulated experience. With the advent of computing technology, specifically computer mediated communication (CMC), it is possible to enhance learning situations and create new opportunities that enable learners to experience authentic technological application and engage in the construction of individual and shared knowledge, instead of just reading about and discussing such phenomena (Rapaport, 1991).

According to Rapaport's classification (1991), CMC systems can be divided into four main categories: email, bulletin board systems (BBS), computer conferencing, and information retrieval. Through research, the author reached that interaction via computer conferencing systems provides new opportunities for managing and participating in the learning process that were unknown in traditional distance learning and conventional onsite courses. Computer conferencing, and CMC not only offer asynchronous many-to-many communication, they also make extensive use of interaction via the written word. The systems that handle this interaction are also known as "conferencing systems" and use asynchronous (or deferred) communication, sometimes with the addition of a chatting facility (real-time
interaction via writing) and file management (Papaport, 1991).

To convey the benefits of incorporating a computer-mediated learning environment into any graduate-level course whose content and objectives are conducive to such an activity, the researchers pointed out that other possible content areas suited to this type of learning activity include, but are not limited to, education, literature, sociology, philosophy, political science, communications, journalism, business and administration, environmental studies, and engineering. Basically, this type of computer-mediated learning activity could be implemented in any course where the mastery of content is facilitated via experiential learning and where the depth and richness of the learning experience depends on collaboration, diversity, and multiple perspective.

The interactive nature of CMC among its participants is often incongruent with the traditional lecture-based teaching methods, and this has forced a shift in thinking about curriculum and course design (Boyd, 1990). Through the application of CMC, instructors can provide learners with the opportunity to apply knowledge and test theories. By integrating CMC into the course curriculum, learners are presented with new challenges that extend beyond the passive learning of content. CMC introduces new opportunities for collaborative learning; facilitates individualized feedback
and contact with peers and faculty; promotes reflective and critical thinking due to its asynchronous nature; and permits learners to work at a time and pace that is convenient to them (Boyd, 1990).

Through the research, the authors found out that experiential learning via CMC helps students reach greater depths of understanding of the field of educational technology and encourages them to generate ideas and to think about the possibilities of improvement and innovation. Essentially, learners learn about educational technology by doing educational technology.

The researchers asked graduate students in two different universities (one in Canada, the other in Mexico) to execute the cross-cultural computer mediated activity (cross-cultural discussion) to promote purposeful and relevant experiential learning. The objectives were:

- to provide students with hands-on experience with CMC
- to provide students with an authentic cultural exchange so that they might explore how different cultures hold distinct views about the use of technology in education and its impact on society
- to help students gain a sense of the multidisciplinary aspect of educational technology and its applications.

With respect to this particular application of CMC, a number of adjustments had to be made to the course curriculum in order to implement a useful and relevant
learning activity. In order to make the computer-mediated learning activity successful, the researchers modified both Canadian and Mexican course curricula and the metaphor of the theater was selected for this activity. The actual debate was held in the Scenario conference with 5 Stages of different aspects of the topic. Five students (three Canadians and two Mexicans) were randomly selected to each Stage conference, and a key article was provided to each group. All participants had reading access to all the stages.

The result of the learning experience is that the discussion provided a good example of how technology can be used to share information and build important cross-cultural links. Some learners intended to keep in touch and continue to share information about common areas of interest/concern. This experience made learners realize that technology is used and valued differently by distinct groups of people. Also, the experience released the classes from the proverbial academic vacuum. Carrying on a graduate-level discussion in a foreign language is difficult. However, the Mexican students rose to the challenge and took full advantage of this unique learning opportunity.

Results showed positive outcomes at the learner, teacher, and classroom levels in terms of learning, attitude toward technology, and attitudes toward other cultures. From this research, we can conclude that thorough planning and
instructional design of the learning activity prior to implementation, the use of strategies, the selection of appropriate activities and technology to achieve learning objectives, and the use of clear criteria to evaluate participation are key to ensuring the success of the learning activities using CMC.

The use of technology in education has been a widely debated topic over the last several years. Computers have been hailed as a type of utopia that will save our students; yet, many teachers are intimidated by those scary monsters—technology frustration. A teacher may feel that computers are scary monsters because they have had no professional training on how to use them or how to incorporate them into the classroom. Schools across America, both public and private, are struggling with both purpose and function of technology. Many teachers or administrators have limited computer experience, and they are quite apprehensive of having to learn how to use one (Rowe, 1998).

Teachers must also feel that they have a choice in using technology if they are going to commit to using it. Programs would have to be established to allow time for the teachers to master skills and feel comfortable with technology instead of forcing them to use it before they are prepared. If a school is interested in using technology with its students, then that school must be interested in its teachers, providing them with all the training at the
school's expense and time. Even prior to this, the school should have a discussion with its teachers to present the need for computer usage in the classroom, the benefits of it, the realistic expectations of it, and the opportunity for free training to teachers interested in using it. Once the information is clearly communicated, the scary monster myth of computer technology should be eliminated. Then, the teachers who are ready to embark on a new journey can begin the process of adding this tool into their work of education.

Summary

The authors stated that everybody needs mathematics as the ideas of math affect us in many different perspectives of our lives. Learning math concepts is challenging because it deals with abstract relationships. The distinction of math teaching methods needs to be made between concepts, skills, and general teaching strategies. Constructivism educational theory offers new choices to teach math concepts. In a constructivist learning environment, the focus moves from the teacher to the student. Computer assisted learning provides activities which are part of a constructivist model. Computer learning provides flexibility and a means of communication that students will understand. One of the challenges for mathematical educational reform is to influence teachers to abandon old practices and accept technology assistance. For teachers to integrate technology
into their teaching practice, they first of all need to believe that using technology is more effective than their traditional practices. Integrating technology in education requires systematic planning. Technology can indeed support teachers of all subjects and administrators who are enthusiastic about integrating technology into classrooms and schools.
CHAPTER THREE
GOALS AND OBJECTIVES

Goals

The major goal of this project was to examine the effectiveness of how the computer-assisted teaching and learning environment will enhance high school students' math problem-solving skills, increase their learning interest and improve their classroom behavior.

The computer software application is the major part of the technology-oriented new class teaching and learning approach. Personal Trainer SAT was selected as the representative among thousands of other educational software packages. Appendix F contains software package selection and evaluation. The practical approach for this project is conducting an on-site study. Century High School was chosen as the site to conduct this project.

As a measurement of how the selected software package has changed the high school students' math problem-solving skills, students' scores on the SAT were considered to be a qualified assessment criteria due to the extensive use of the SAT in high schools throughout the United States. Other investigations, such as questionnaire, were made to examine how the software changed the tested students' math learning interest as well as their behavior in classroom.
Objectives

This project was a feasibility study of how effectively a computer-assisted teaching and learning environment would improve the math learning skills of high school students. It was expected that this project would demonstrate the realistic positive impacts of implementing computer technology into a traditional teaching and learning environment. A large amount of the studies regarding adopting instructional technology into day to day classroom teaching was discussed in the review of the literature from the theoretical level to the practical horizontal.
CHAPTER FOUR
ANALYSIS AND CONCLUSION

Description of the Research Design

The overall design of this project is presented on Figure 3 on the next page. As shown in the flowchart, the entire project has three major parts: 1) Theoretical Trace; 2) Project Determination; and 3) Conduction. The first two parts were discussed in the previous chapters. In this chapter, the Conduction part of the project will be fully illustrated.

As indicated in Figure 3, the Conduction part consisted of the following four stages: 1) Pre-project Stage; 2) On-site Stage; 3) Data Analysis Stage; and 4) Conclusion Stage. The following paragraphs of this chapter discuss each stage in detail.

Conduction of the Project

1. Pre-project Stage

As initially conceptualized, the research objective was to analyze the students' mathematical learning in a classroom setting in which the pedagogical practice supported learning mathematics with meaning. The original intention was specifically to extend the methodology of the constructivist teaching experiment (Wood, 1990) to the complexity of school classrooms by conducting a "classroom teaching with computer technology experiment." The plan was to focus the investigation on individual student's
Figure 3: Project Flowchart -- Overview

Trace Theoretical Basis

Determine Project Approach

Conduct the Project

Pre-project Activities

School Site Selection

Software Evaluation / Selection

Project Schedule Arrangement

On-site Investigation / Data Collection

Design & Conduct Onsite Investigation

Onsite Classroom Observation

Sort Collected Info. On a Timely Basis

Collect Pre-test Information & Questionnaire

Modify Info. In a Consistent & Comparable Manner

Conduct Horizontal & Vertical Comparison

Data Analysis

Findings from Students' Questionnaires

Findings from Classroom Observation

Findings from Pre and Post-test Score Comparison

Findings / Conclusion

CONCLUSION
construction of mathematical knowledge as they interacted with the teacher and computer in this setting.

Three major tasks were performed in the pre-project phase. The first task was the determination of the school site in which the project would be carried out (Figure 4). To determine the school site, an investigation was conducted on the current situations of five schools in both the San Bernardino School District and the Riverside School District, regarding their progress on employing educational programs in the day-to-day classroom teaching. To ensure the success of the project, the test school site was expected to be innovative in adopting new ideas and technologies into traditional teaching and learning style.

After the first selection, two schools remained on the potential experimental sites. The second step in the school site selection phase was to find out the willingness of each school in having a technology oriented teaching and learning environment from both the teachers and the students' point of view. Without the participants' interest in the project and cooperation in the conduction, it would be difficult to achieve a successful study.

The Century High School in Riverside was finally selected to be the test site of this project. For information regarding Century High School, please refer to Chapter 1.
School Site Selection

Determine current situation for the school sites in terms of the progress on adopting technology into classroom teaching.

Find Out both teachers' and students' willingness to have a technology-oriented teaching and learning environment.

Combine the fact of the schools' situation and the teachers' and students' attitudes, so as to determine the appropriate school site.

Obtain the permission of conducting the project from the administrations of the selected school.

Cooperate with the teachers and administrative personnel to prepare the project, such as select students, arrange time, classroom and necessary equipment.
Secondly, the test object of this project was to be identified (Figure 5). As instructional software packages are more commonly used technology in high school teaching than any other means (Schofield, Eurich-Fulcer, & Britt, 1993), the test object of this project was concentrated on one of the available instructional software packages. Two high school teaching and tutoring software packages were selected (Personal Trainer SAT and Personal Trainer ACT), and general information was collected on their features respectively, for example, the depth of difficulty, the interactive animation, and non-linear design, etc. At the same time, a set of instructional software evaluation criteria was developed (Appendix D), and the two packages were evaluated according to the pre-defined criteria. Meanwhile, Century High School's requirements and preferences on the software were obtained and analyzed. Combined with software features and evaluation results, Personal Trainer SAT was selected as the measurement objective. Further confirmation was obtained by the teachers in Century High School on using the software as the testing tool before entering the project conduction phase.

Finally, a detailed project schedule was determined (Figure 6). The sample was a stratified random group consisting of 15 students in the 9th, 10th, and 11th grades from Century High School in Riverside. These students were
Collect information on available instructional software packages.

Identify instructional software evaluation criteria.

Understand selected school site's requirement and preference.

Compare & Select proper software packages.

Obtain the comments of the teachers of the selected school, and make final decision.
Figure 6: Project Flowchart -- Schedule arrangements

Project Schedule Arrangements

Determine test group size

Select Students from different levels with the assistance of the teachers

Determine the time scale of the project

Arrange project schedule based on the class size and time scale

Notify the selected students with the schedule, ensure their full participation.

Confirm the project schedule.
also enrolled in AVID classes in which I was tutoring. Students taking the AVID program are mainly studying in a college preparatory curricular path. The demographics (characteristics of the sample) (Figures 7 and 8) are as follows:

a. Age range: 16--18 years old
b. Sex distribution: 60% female, 40% male
c. Ethnic breakdown: 26.67% white, 33.33% Hispanic, 20% black, 20% Asian.

Based on the scope of the project, and its requirements of the reliabilities of findings, the project was conducted in four weeks. During these four weeks, students had to complete a pre-test and a post-test, as well as ordinary class training (Appendix B).

Before entering the On-site Stage, two conditions were made to this project: one, the existing Computer Lab in Century High School in Riverside was used as a technology-assisted math classroom and two, technology was generalized to facilitate students solving math problems more skillfully and effectively. The final project schedule was confirmed
with both the teachers and selected students.

2. On-site Stage

To compare and assess the effectiveness of using the Personal Trainer SAT, certain evaluation criteria were set. The dependent quantitative variable was the ability of skills and efficiency to solve problems. The instrument was used to measure achievement, attitude, SAT tests, class activities, and questionnaires. The existing instruments used are SAT sample test, observation, and questionnaire.

The test class was one and one-half hours everyday, without breaks, in order to avoiding distractions of students. In the first class, all the 15 students were required to take a pre-test. The test is a practice SAT. The test results were entered into the Personal Trainer SAT, and the software analyzed each student's strength and weakness reflected in the pretest and provided suggestions on later training, including practice focus, review strategy, and time arrangement (within the one-and-half-hour session).

Classroom observations were also performed during the entire testing phase. Questionnaires (Appendix C) were handed out for students to track the changes and progress on their attitude and performance. All classroom observations were properly recorded, and questionnaires were collected at the end of the project's on-site conduction phase.

Threats to internal validity of the project were also noticed and properly controlled during the conduction. These
threats are summarized as the following:

a. Instrumentation--Data Collector Characteristic: Some teachers grade their students depending on the student's class performance, homework, tardiness, and final tests. Some teachers grade their students according to the students' homework and final tests. This was controlled by ensuring that all students took the same test (SAT sampling test) and scored by the Personal Trainer SAT software.

b. Testing: Some problems in the test instrument in the study could lack validity, or possibly show the effects of pre-testing. This was controlled by eliminating the same pre-testing and the test problems unrelated with subject matter. The time was counted for finishing the test for every individual person.

c. Implementation: The subjects may have a personal bias in favor of one method over the other. Their preference for the method, rather than the method itself, may account for the superior performance of students taught by this method. This was controlled by allowing them to choose the method they wished to implement or having all methods used by all implementers. Observations were conducted throughout the working of the sample group as well as regular classes. An attempt was made to note the students'
activities as objectively as possible to minimize the potential bias.

All known factors were successfully controlled so that any resulting relationships were unambiguous and not due to another factor. After the four weeks experiment, questionnaires and attitude surveys were administered and analyzed. Data from the tests was compared and used to prove the hypothesis.

3. Data Analysis

Classroom observations were conducted before, during, and after the Personal Trainer SAT was used. Proper records of the observation were sorted after each class in a timely manner. The records were used to analyze the effects of Personal Trainer SAT on the tested students in various aspects as comparing the performance and behavior of those students before it was utilized. A final questionnaire was also collected from the students by the end of the whole test SAT class as another data source for analysis. As data was collected, the information was also sorted in a consistent and comparable pattern, in order to make these source data to be ready for analysis.

The data analysis was conducted in both a horizontal and vertical manner. In the horizontal comparison, students' classroom behavior and attitude toward math learning in regular classes and the test class were observed and compared. In the vertical comparison, students (groups) were
analyzed focusing on his or her change in classroom behavior and learning attitude, as well as the improvement of their math problem-solving skills as the project went on. This analysis was merely based on my classroom observation, students' questionnaire reflection, and pre and post-test result comparison. Both horizontal and vertical comparison were combined and summarized in the later data analysis stage.

During the analysis, the differences in the reactions of different levels of students to the new learning environment were assessed. The environment is uncommon for students who were in 9th grade to end up in a higher track class simply because they liked it. It was difficult to know how to treat these students for purposes of analysis because their tested ability level is different from the 10th and 11th graders. However, their attitude and class activities could be analyzed and in this subject group there was only one student from 9th grade. So the belief is that this consideration did not affect the reliability of the test result.

4. Findings

Findings were summarized in three categories: 1) student questionnaires; 2) classroom observations; and 3) pretest and posttest score comparisons.
1) Findings from Student Questionnaires

In response to the Questionnaire, over 90% of the students indicated they would first go to the Personal Trainer SAT for help when they encountered difficulties in solving problems. If they still could not understand, then they went to the teacher, or me, the tutor for help. After they repeated work on problems with different level and subject area as well as seeking the strategy of solving problems, they came back to the normal short sample test.

Eighty-six and seven-tenths percent of the students stated that the Personal Trainer SAT improved their problem-solving skills. This was shown by their improved problem-solving speed, increased understanding of how to solve a problem, and higher SAT scores.

All of the tested students admitted that the online help menu of Personal Trainer SAT was very useful. However, none of them thought that getting help from the software was better than from the teachers.

When asked whether they prefer to enroll in a class using the computer software as the Personal Trainer SAT, 93.3% of the students said they would prefer to enroll in the class using the computer software in the classroom.

In answering how using the computers changed the way you behaved in class, Dianne, one of the students, wrote, "We didn't talk too much. On the computer you really concentrated on the problems. You didn't have time to talk
to the person next to you." This notion was reflected on most of the responses.

Students usually concentrated on using the computers to work the problems by themselves. In response to the question how often they used the trainer and help available on the system, 80% of them checked 'frequently using', 7% checked 'often', and 13% checked 'sometimes' (Figure 9). Furthermore, 73% of the students indicated that the strategy help windows were generally helpful, saved time and refreshed knowledge. "The students make much quicker progress in learning interest and problem-solving skills than a regular class," noted Mr. Robertson, the teacher who worked with me through the project.

Figure 9--Most students frequently go to computer for help

- frequently  ■ often  □ sometimes  □ seldom  ■ never
2) Findings from the Classroom Observation

In the classroom observation, which I conducted at Century High School, there were no student complaints about learning math. On the contrary, most students came to the computer lab 15 minutes earlier than class started. Once they came in, they first started the computer and worked on the strategies and problems with no chatting except for discussing the problems. They were so concentrated that at the end of every class, the teacher had to remind them that the class was over.

John* was in grade 11 and he was not good at math and slow in solving a problem. His sample math pretest score was 260 correct out of 800. When he started working with the computer he seemed pretty absorbed. He came to the class 20 minutes early every class and kept working with the computer until the very end of the class. He went to the computer for help when he encountered a problem and studied the strategies from time to time. If he still had problem, he would ask the teacher or me for help. Once I asked him why he liked working with computer, he answered, "I had learned these strategies from my teacher before, but I didn't pay attention at all. The computer is refreshing my memory and makes me feel confident in solving problems. It is another

* To keep the confidentiality of individuals participating in this research, all names used in this project are pseudonyms.
way of learning. It is interesting." When he solved a problem by using the strategies provided by the software, he would happily say, "Yeah, I made it. It's not like in (regular) class," he said, "I won't easily give up, 'cause I know I can work out the problem with the hints I got from the computer. Isn't it incredible?"

From my observation, a regular math class usually began with a review of homework from the previous class, which was solely conducted by the teacher. Sometimes the teacher would ask one or a few students to come to the front of the classroom to write out the solution on the board and let the class discuss it. The teacher normally stood in front of the class and illustrated the problems on the board. After homework review, the teacher would start introducing new material or reviewing previous material by lecturing. During lecturing, the teacher would ask students to answer questions related to the material being presented. After this, the teacher would assign a few problems related to what they had just learned for the students to work on. The teacher would circulate and inspect students' work and give necessary instruction. At last, the teacher would assign homework for students to work afterwards. During the whole period, students were asked to listen quietly and to take notes when the teacher was giving lecture or instruction. It is obviously a passive learning.
The apparent contrast is before and after the regular class. The students would never come early to the class (if so, they would chat or eat snacks other than study) and never be willing to stay late. The class is teacher-centered rather than student-centered. According to Goodlad (1984), the teacher was the "strategic pivotal figure in the learner group." It is the teacher who controlled relatively firmly what, when and how material was presented as well as the kind of learning activities in which students engaged. In contrast, during the computer-assisted learning experience, students had their own choice of when, what, and how to learn depending upon their own pace. They could find their weak area of the subject evaluated by the computer through their pretests and start working on whatever they thought should be first. It is totally an active learning process.

I had a discussion with a student when I was tutoring in a regular AVID class. He said to me, "I hate math. What's the use of math? Can you tell me what is the use of x and y?" After I told him using x or y as variable to solve some word problems happened in our daily life, such as interest earning, would make problems be easier to solve, he nodded his head but said, "that's pretty reasonable, but it is still hard."

In the process of working with Personal Trainer SAT, I noticed that the classroom had simultaneously and unintentionally become a learning environment for the
teacher as well. When encountering a difficult problem, the teacher worked together with students, asking for help from the Personal Trainer SAT. As the project teacher used the instructional activities, he encountered situations that were in sharp contrast to his previous experiences in teaching mathematics. In this class, the teacher's role, the students' role, and the nature of mathematics changed dramatically.

It was observed that in working with computers, students seldom talked about unrelated topics with each other during the class. Occasionally they came together to discuss what the trainers instructions meant. They spent much more time concentrating on working with their problems. Studies suggested that time and concentration on task is an important predictor of learning (Caldwell, Huiit, and Graeber, 1982; Egbert and Kluender, 1984). Wertheimer (1990) reported that students using the software as the tutor, appeared to show more gains in skill in solving problems than did peers in the control class taught by the same teacher. These statements were directly reflected in tested student's pretest and posttest SAT scores, as discussed below.

3) Findings from Pretest and Posttest SAT Scores

The mean pretest score was 390 with a standard deviation of 132 because the students were from different levels. The highest possible score on the sample test was
The mean posttest score was 494. The standard deviation for the posttest mean score was 127. The average increase in four weeks of working with Personal Trainer SAT was 104 with a standard deviation of 45. Mr. Robertson was very pleased and exclaimed, "This is amazing."

Generally speaking, students who received high or low scores on the pretest received low achievement scores on the posttest (Figure 10). For example, Pat was the only one in 9th grade with pretest score 260 and posttest score 310. Mr. Robertson said this is reasonable because he had not got enough math knowledge for SAT. This happened to Tina, too. Tina was in 11th grade and her pretest score was 710 and her posttest score was 750. Compared to the average achievement in the group, hers was only 40. It seemed that the Personal Trainer SAT worked better for the students performing at average levels. However, it helped all the students in the
class improve their problem-solving skills because not one of the participants dropped his or her score.

4) Summary of Other Findings

Based on the data and the responses to the questionnaire as well as my observation, the advantages of working with instructional software packages are summarized as the following:

• Confidentiality. Scores are kept confidentially, so students do not feel pressured. One student mentioned to me that it was easier for her to accept help from the computer than from the instructor since it was much less embarrassing.

• Efficiency. Forty percent of the students stated that the computer gave quick score once they finished the test or a problem. It is very convenient and practical. Also, first hand feedback strategies are available when students were stuck.

• Creates efficient thinking skill in problem solving.

• More descriptive on abstract concepts, so students feel they could have a better understanding of knowledge.

• Plenty of practical problems of different levels for students to work with.

• Comprehensive coverage of knowledge.

• Increase students' knowledge of computer literacy.

• Animation design such as timing available on solving each problem helps in time control.
• Fun. It motivates students and releases them from boring feelings of solving math problems. During my project, some of the disadvantages exist in working with instructional software packages were noted:
  • Insufficient explanation. Further explanation is needed to enable students to trace back to the basic knowledge instead of going to teacher or getting lost.
  • Lack of diversified difficulty levels. More difficult levels of instructions and problems should be available for students with different skills and ability.
  • Require more variety in both explanations and problems.
  • Need more comprehensive questions so as to link each identical knowledge together, so as to increase student's extensive problem-solving skills.

Project Constraints

The constraints of this project is summarized as the following:

• Limitation on Project Conduction:

In this project, there was no comparison group. This is due to the fact that the purpose of the project is solely to identify the positive effects of proper computer-assisted learning and teaching environment on high school students' math problem-solving skills and their classroom behavior. At this point, the scores have been obtained on the students' pretests and posttests. By comparing these scores, the effects on students' math problem-solving skills would be
fairly reflected. Also, close classroom observation and frequent questionnaires were performed, which could reasonably mirror the chance on students' classroom behavior and learning attitudes. Other comparisons such as the comparison between students who worked in pairs and those works alone were not performed due to restraints on timing and scope of this project.

- Limitation on Project Scope

There are many ways to realize a computer-assisted teaching and learning environment. However, this project only focused on the how the instructional software packages improved students' math problem-solving skills, and as well as how it changed students learning attitude and classroom behavior. Moreover, due to the time constraints, only one such software package was tested.

The project was conducted only in one high school, and the tested group was limited to 15 students. However, the carefully selection of school site, tested software package and test student group (as described in previous parts in this chapter) would somewhat effectively compensate for these constraints.

- Limitation on Project Time Scale

The project lasted five months from the preparation phase. Yet only four weeks were spent on on-site project conduction (due to the tested school's requirement). The time limitation reduced many of the chances for further
investigation and analysis. It is expected that these further studies would be carried over on a continuous basis, which would provide more promising findings.

Conclusion

Certain computer-assisted teaching and learning environments may offer unique opportunities for the enhancement of high school students' math problem-solving skills as well as their creativity (Clements, 1991). It is recommended that high schools should integrate certain methods of computer-assisted teaching and learning environment into their traditional teaching methodology.

Students in this study demonstrated an autonomous and active role in the computer tutor classrooms than they had previously. The computer-assisted teaching changed the kind of help students received from the teacher and the context in which this help was received. Specifically, it changed the students' control over whether or not they received help from the teacher and whether the help was received in a potentially embarrassing way. In general, these changes seemed to promote student motivation and learning.

Students may have also been motivated to work harder when using the computer tutor simply because they enjoyed their experiences. The large majority of students indicated in interviews that using the software was more fun than learning without them.
In conclusion, the impact of technological innovations on the educational process will go beyond a narrow focus on the intended subject matter to a broader examination of how utilizing the software changed the content, process, and the context of student learning.

It should also be pointed out that different kinds of computer applications may have quite different effects depending on differences in the applications themselves or the social context of their use. However, most notably the students' increased enthusiasm for and interest in their work, appear very similar to changes reported in the review of the literature on the impact of more traditional computer-assisted education on students' attitudes. What is needed is theoretical work delineating how subject-matter learning and classroom social processes are likely to be influenced by specific features of the software itself and of the social context of technology use. Until we gain a better understanding of these issues, computer technology may be inhibited from achieving its full potential for a positive impact on our learning process. In the future, it is important for teachers of mathematics to work cooperatively with instructional technologists to enhance computer-assisted environment in the mathematical learning process.
APPENDIX A

Data Overview of the Questionnaire

The data collected from the students' responses to the questions are as follows.

1. Gender: 9/15 Female 6/15 Male
   Grade level: 1/15 9th 2/15 10th 11/15 11th 1/15 12th

2. The average Pretest score is 390. The average Posttest score is 494 (Figure 10 on page 70)

3. How much do you think that the Personal Trainer SAT has improve your problem-solving skills?
   13/15 A lot 2/15 Not much 0/15 Not at all

4. How do you get help from the software when you encounter difficulties in solving a problem?
   12/15 (Click Strategy icon);
   3/15 (Ask the Trainer for help).

5. How do you get help from the teacher?
   Answer varies. Mostly answered: when I didn't understand the computer.

   12/15 answered both and the explanation is the teacher can explain thoroughly and you need a teacher to explain the computer.
   3/15 answered teachers' help because they explain it in the simplest way and more explanatory.
7. Would you advise a friend who has a choice to enroll in a class using the computer software Personal Trainer SAT or in a class taught by the same teacher without the Personal Trainer SAT software? Please check: 
13/15 Using the computer software Personal Trainer SAT  
2/15 Without any computer software (these two got the highest scores).

8. Do you like working with computer software Personal Trainer SAT? 13/15 answered Yes of Sure. 2/15 answered it is OK.

9. How did using the computer change the way you behave in class? 
Answer varies. 8/15: more concentrated on task; 3/15: I am more careful, it keeps me calm and relaxed during class; 3/15: no change or in no way.

10. The Personal Trainer SAT had a number of windows designed to help you on solving problems. How often do you use trainer and help available on the system? Please check: 
0/15 Never 0/15 Seldom 2/15 Sometimes 1/15 Often  
12/15 Frequently (Figure 9 on page 66).

Why? Because: for practice, save time, no stress, helps to understand the problems, good for practice, and so on.

11. What do you think are the major advantage(s) of using a computer to help you prepare for SAT?
Always there when you need help, it is confidential, it has a lot of tips, make you have partial skills to operate computer, quick score, and so on.

12. In what aspect(s) do you think we should improve the design of Personal Trainer SAT?

Needs more comprehensive practices and more questions, some strategies need to be further explained, needs several different questions, more different sample tests, none, I like it already and this is my first time on the system, and so on.
APPENDIX B

SAT Class Arrangement

This is a tentative schedule for computer-assisted learning environment. The software to be used is Personal Trainer SAT (Davidson, 1993). The class will be from 3:00pm–4:30pm on Tuesdays and Wednesdays and lasting for four weeks. Students will work on math problems with computers based on their own needs.

Week 1

Day 1--introduction to computer, math pre-test
Day 2--math practice and self-decision-making

Week 2

Day 1--math practice
Day 2--math practice

Week 3

Day 1--math practice
Day 2--math practice

Week 4

Day 1--math practice
Day 2--complete SAT post-test
APPENDIX C  
Student Questionnaire

Your Responses Are Important.
Please respond to the following questions. Your responses are completely anonymous.

1. Gender: ___ Female ___ Male  
   Grade level: ___ 9th ___10th ___11th ___12th

2. My Pretest scores are: Math: ___ Verbal: ___  
   My Posttest scores are: Math: ___ Verbal: ___

3. How much do you think that the Personal Trainer SAT has improved your problem-solving skills?  
   ___ A lot ___ Not much ___ Not at all

4. How do you get help from the software when you encounter difficulties in solving a problem?

5. How do you get help from the teacher?

6. Do you prefer teacher’s help or Personal Trainer SAT’s help? Why? Please explain.

7. Would you advise a friend who has a choice to enroll in a class using the computer software Personal Trainer SAT or in a class taught by the same teacher without the Personal Trainer SAT software? Please check:  
   ___ Using the computer software Personal Trainer SAT  
   ___ Without any computer software
8. Do you like working with computer software Personal Trainer SAT?

9. How did using the computer change the way you behave in class?

10. The Personal Trainer SAT had a number of windows designed to help you on solving problems. How often do you use trainer and help available on the system? Please check:

   ___ Never ___ Seldom ___ Sometimes ___ Often ___ Frequently

   Why? Because_________________________________________________

11. What do you think are the major advantage(s) of using a computer to help you prepare for SAT?

12. In what aspect(s) do you think we should improve the design of Personal Trainer SAT?
APPENDIX D

Software Evaluation Criteria

The evaluation of an instructional software shall be processed from both students and teachers stand of view. The following aspects are important to multimedia software evaluation based on the relative curriculum.

1. Name of the product:

2. Content align with relative curriculum to what extent:
   _A little __OK __Wholly

3. Compatible to: ___Macintosh ___PC ___Both

4. The visual attractiveness of graphical and icon design:
   _Low __Medium __High

5. The accessible and navigable extent: __Difficult __Fair __Easy

6. The outcome to meet the designing goal: __Unsatisfied __Medium __Very Satisfied

7. The nonlinear design: __Poor __OK __Good __Excellent

8. The interactive design: __Poor __OK __Good __Excellent

9. Learner control and feedback design: __Poor __OK __Good __Excellent

10. Distracting to learners: __Yes __Not much __No

11. Cost of the product: __________

12. Service of the product: __________

The overall rating scale based on the above criteria is:

Poor __ OK __ Good __ Excellent

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