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An Analysis of Mathematics Interventions: Increased Time-on-Task Compared with Computer-Assisted Mathematics Instruction

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AN ANALYSIS OF MATHEMATICS INTERVENTIONS: INCREASED TIME-ON-TASK COMPARED WITH COMPUTER-ASSISTED MATHEMATICS INSTRUCTION

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by

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Abstract

Student achievement is not progressing on mathematics as measured by state, national, and international assessments. Much of the research points to mathematics curriculum and instruction as the root cause of student failure to achieve at levels comparable to other nations. Since mathematics is regarded as a gate keeper to many educational opportunities as well as, eventually, potential job prospects, critics are asking schools to fix the problem.

This research project is a comparison of two different interventions used to improve student performance as tested on the Colorado State Assessment Program (CSAP). The first intervention, increased time-on-task, was used at Freedom High School for the school years 2004-2005 until 2008-2009. In those years, mathematics achievement did not improve and CSAP scores showed a negative trend. In the school year 2009-2010, Freedom High School used a computer-assisted instruction program as an intervention for low performing students. A matched-pair design was used to compare these two interventions to determine if the new intervention would improve student achievement.

Eighth grade CSAP scale scores for both groups were used as a pre-test and ninth grade CSAP scale scores were used as a post-test. Pre-test mean scale scores were compared to determine variance between the groups. An analysis of covariance was used as a control for the mean differences. The statistical analysis showed that the computer-assisted instructional program was ineffectual in improving student achievement in the sample group selected. Chapter Five offers discussion focused on the reasons why the computer-assisted instruction program did not work and possible solutions to correct the problems in the future. References are made to the fact that pedagogy must change if real achievement gains are going to be made by students.

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Table of Contents

List of Tables

Chapter 1: Introduction

"Houston, we have a problem." This statement, made by Jim Lovell during the Apollo 13 space mission, is a fitting introduction to an analysis of mathematics interventions in public education. It is an apt association because the United States is once again mired in a controversy regarding deficiencies in mathematics achievement; much like the parallel concern in the 1960s that fueled the Apollo space mission. The Soviet's Sputnik flight and the resultant "Race to the Moon" were a response to the Soviet Union's successful first manned mission into outer space. In addition, leaders in the United States spoke of the need to protect our nation with the development of more engineers and scientists so we could meet the challenges of a world focused on the containment of communism. Fast forward several years and a similar call for reform in our schools was made in 1983 by the National Commission on Excellence in Education (NCEE) their report, *A Nation at Risk – The Imperative for Educational Reform*. Embedded in this report was an exclamation that, "If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war" (NCEE, 1983, p.5). Educational malfeasance, as identified by the poor results on national and international comparative assessments, was being linked to the future success and safety of our nation.   Today the concern for education is still a priority on the national landscape. The phrase uttered by Apollo Astronaut Lovell in 1970 might be restated in 2010 as, "United States educators, we have a problem," in response to the poor performance of American students on a variety of international mathematics assessments.

There is some irony regarding the lack of student achievement in the United States. The U.S. is generally regarded as the wealthiest nation on the planet and is on the cutting edge of the technological age. Most citizens would agree that the U.S. is a leader in defending democracy across the globe. In addition, there would be some consensus that American universities continue to educate some of the top minds from almost every nation. So it seems paradoxical that a country experiencing so much success in these other areas can have a K-12 public education system that is touted as ineffectual when compared to many other industrialized nations. America’s success as a nation is glorified as a crew of astronauts travel to space and back, and yet, the nation’s educational system is failing to teach all of its children to read, write, and compute at levels comparable to other nations across the world.

Similar to the poor results on international tests by U.S. students, state-level assessments also reveal an overall negative performance. This is true in the state of Colorado where most high school students are not proficient on the mathematics portion of the Colorado State Assessment Program (CSAP). CSAP scores reflect the national trend showing deescalating results from elementary school to middle school and from middle school to high school. Approximately 70% of the state’s third-grade students are proficient or advanced each year in mathematics. However, that ratio is reversed by the time they reach high school, with the majority of secondary students scoring unsatisfactory or partially proficient (see Appendix A). These negative trends across the state have been mirrored at a high school in southern Colorado, Freedom High School

(FHS), where test results have consistently failed to show acceptable progress. Concern over these disappointing trends at FHS prompted the staff there to develop strategies which addressed poor student performance.

In response to its consistently low scores in mathematics, FHS developed an intervention to address the needs of those students performing poorly. This intervention was developed based on the research that reported students needed more time with mathematics instruction to "catch up" with their peers. Students scoring below a certain level on CSAP were placed in an intervention class designed to cover the same curriculum but with double the class time to do so. Using the additional "time-on-task" (TOT) intervention to address student needs, teachers worked in a deliberate manner to cover the curriculum needed to help students move forward on the mathematics achievement tests (CSAP). After four years using this program, student scores still did not improve. As a result, FHS administrators and teachers investigated and implemented another type of intervention as a possible solution to their perplexing problem.

In addition to being a traditional high school, FHS is also pioneering a one-to-one technology initiative. As administrators investigated possible interventions, the research surrounding computer-assisted instruction was examined. It was decided to pilot one such mathematics computer-assisted instruction program during the 2009 summer school session. With the issues regarding the management and efficacy of the program seemingly worked out during the summer session, FHS implemented the ASCEND mathematics computer-assisted instructional program for the 2009-2010 school year. The ASCEND program was used as an intervention for students scoring poorly in mathematics, and its effectiveness was compared to that of the time-on-task intervention.

Now that the study is completed, FHS administrators can use the data to map a course of action to improve mathematics achievement.

Summary of the Problem

In the book, *Ed Thoughts: What We Know About Mathematics Teaching and Learning*, Sutton and Krueger (2002) claim, “Despite significant changes throughout society over the last half century, teaching methods in most mathematics classes have remained virtually unchanged” (p. 26). The resistance to pedagogical change in the mathematics classroom presents a significant challenge for educational leaders in that test results from multiple international, national, and state assessments indicate students in the U.S. are not learning mathematics at acceptable rates. At the international level, McEwan (2000) summarized the results of the TIMSS test:

> It’s hard to ignore the results of the Third International Mathematics and Science Study (TIMSS), however. Even though U.S. students scored above the international mean at the fourth-grade level, their scores were considerably lower at the eighth-grade level, and our showing at the 12th-grade level was downright dismal. On general math knowledge at the 12th-grade level, the United States placed 18th out of 21 countries whose students took the test (p. 2).

A national test in mathematics gives the same gloomy appraisal. The 2008 NAEP (National Assessment of Educational Progress) Trends in Academic Progress report shows that, “The average score for 17-year-olds did not change significantly” (Rampey, Diaon, & Donahue, 2009, p. 2) between the years 1973 and 2008. At the state level, the Colorado Department of Education (CDE) online data repository shows that mathematics achievement at the ninth-grade level has improved four points in seven years. At the tenth-grade level, mathematics scores have improved five points in eight years. This rate of improvement is unacceptable, as it means the state will fall far short of the No Child

Left Behind (NCLB) requirements for all students to become proficient by the year 2014. As stated earlier, almost 70% of all high school students are performing below proficiency levels established by the state of Colorado. The significance of poor performance in mathematics is illustrated in Sutton and Krueger (2002), “As the demand for a more mathematically literate society continues, schools need to respond to this challenge and provide meaningful mathematics to all of our students, all of the time” (p. 4). Since mathematics is regarded as a gate keeper to many educational and job opportunities, it is imperative that FHS concentrate intently on correcting the problems associated with the lack of progress and comprehension mastery.

Root Cause

Poor national test results have understandably led to much criticism of the methodologies currently being used in mathematics education in the United States. Unfortunately, there have been no failsafe or proven solutions offered to remedy the problems that exist in an education system mandated to educate every student. Public educators are faced with many challenging variables and obstacles in their mission to ensure that all students reach a predetermined level of proficiency. Some of the variables include poverty, parental involvement, disparate ability levels and variance in the quality of instruction. Of these variables, the one which educators have the greatest amount of control over is the quality of instruction provided for students. The importance of having a quality teacher and the sound instruction that is provided by that teacher is underscored by research. A highly acclaimed book, *Classroom Instruction That Works,* revealed that:

> The conclusion that individual teachers can have a profound influence on student learning even in schools that are relatively ineffective, was first noticed in the 1970’s when we began to examine effective teaching practices. In fact, after

> reviewing hundreds of studies conducted in the 1970's, researchers Jere Brophy and Thomas Good (1986) commented: 'The myth that teachers do not make a difference in student learning has been refuted (Marzano, Pickering, & Pollock, 2001, p. 3).

There are many factors that impact student achievement, but quality instruction given by a quality teacher can improve student learning. The crucial issue in the United States, and certainly at FHS, is that teachers are not making a difference. One issue at play here is that teachers are mired in the poor foundational mechanics of traditional mathematics education. Jo-Anne L. Manswell Butty helped illustrate this point in her examination of teacher instruction as it related to Black and Hispanic student achievement. She stated, "Researchers also found that, at the high school level, much mathematics instruction remains teacher-centered, with teachers placing greater emphasis on lectures and textbooks than on a desire to help their students think critically across subject areas and apply their knowledge to real-world situations (Cohen, McLaughlin, & Talbert, 1993; U. S. Department of Education, 2000)" (Butty, 2001, p. 20). The teaching strategies used by mathematics instructors who are steeped in traditional pedagogy are not addressing the diverse needs of the leaners. As a consequence, ineffective instruction has disengaged many students as evidenced by the poor mathematics achievement of students across America. Butty further argues, "Traditional mathematics instruction consists almost entirely of teachers directing students to memorize presented facts or apply formulas, algorithms, or procedures without attention to why or when is makes sense to do so" (p.21). Methods of teaching mathematics are not preparing students to achieve at high levels nor to be successful in career or post-secondary options.

Improving mathematics instruction is important for more than just improved test scores. There is a real world demand for competent mathematicians not being met by public education. Current pedagogical practices that follow a traditional model do not prepare students for real world mathematics. Writing for *Phi Delta Kappan*, Michael Battista (1999) stated, “The focus on computation is so myopic that few students develop any understanding of why the computations work or when they should be applied” (p.3). Mathematics curricula must change from the emphasis on computational memorization to curricula which address abstract reasoning, problem solving, application of problems to real world issues, justifying mathematical ideas, and critical analysis. As a result of having such a pedagogical focus, “Students are offered opportunities to develop intellectual autonomy and become mathematical authorities themselves” (Butty, 2001, p.21).

However, one cannot throw the baby out with the bathwater. There are studies revealing that basic skills cannot be ignored in the process of moving to a more reformed pedagogy.

> The debates over mathematics education in the United States often pit two views against each other. One group believes that U.S. classrooms do not focus enough on concepts and understanding. The other group believes that U.S. classrooms overemphasize concepts at the expense of basic skills, thus holding back students achievement (Loveless, 2003, as cited in Stigler & Hiebert, 2004, p. 15).

Unfortunately, “There is no single best method for mathematics instruction. However, we do know that any mathematics topic should be presented involving multiple instructional techniques, allowing all students to develop a mathematical understanding through at least one method” (Sutton & Krueger, 2002, p.91).

The dichotomy between a traditional approach to learning mathematics and a process based on conceptual processes to develop understanding was not addressed by the leaders at FHS when searching for answers to helping students achieve at higher levels. Instead, teachers and administrators focused on the ways technology could have helped deliver targeted and appropriate instruction for struggling learners.

The leadership at FHS, therefore, selected computer-assisted instruction as its primary strategy to address the issues surrounding poor mathematical achievement. The ASCEND program, selected by FHS, is a computer-assisted program that addresses varied student needs. Strategic Education Solutions (SES) (2009), in support of the ASCEND program states:

> The program develops consistent, individualized course plans for students based on state and NCTM standards. These course plans target student skill gaps and aim to teach exactly what a student needs based on identified strengths and weaknesses. Instructional options are rich and varied, including video tutorials presented by award winning mathematics instructors, multimedia explorations including technology-based manipulative and ample practice (p. 2).

Providing more instructional options targeted to meet the needs of the students effectively is the aim of the intervention. A year-long study of this intervention methodology at FHS will help determine the effectiveness of the program in improving the performance of students who have traditionally struggled with mathematics. The belief is that targeted instruction related to specific individual student needs will help teachers deliver meaningful instruction via the computer on a daily basis. In addition, the hands-on activities embedded in the ASCEND program will give students chances to think in different ways about their learning.

Definition of Terms

ASCEND mathematics solution. ASCEND is a computer-assisted program that employs instructional and administrative strategies proven by scientifically-based research to improve mathematics outcomes for students. ASCEND's focused, individualized instruction—closely and constantly developed and adapted activities using diagnostic and ongoing assessments—attempts to ensure that students quickly gain proficiency in basic mathematical concepts. ASCEND is highly engaging and motivational; providing high quality video instruction; and student-relevant mathematical explorations that empower students to direct, assess, and internalize their mathematics proficiency. Teachers and administrators, in turn, have immediate access to achievement data, enabling them to make sound instructional decisions quickly and easily (SES, 2009, p. 7).

Colorado Student Assessment Program. CSAP is a state-level assessment that is designed to provide a picture of how students in the state of Colorado are progressing toward meeting academic standards, and how schools are doing to ensure learning success of students (CDE, 2009).

Computer-assisted instruction. The deliberate use of technology to increase student motivation, engagement, and address specific individual skill deficiencies.

National Assessment of Educational Progress. NAEP is a national assessment of student educational achievement in a variety of subjects in schools across the country.

No Child Left Behind. NCLB is federal legislation that was signed into law in January, 2002. The legislation reauthorizes the Elementary and Secondary Education Act (ESEA) of 1965. It provides grants to states for education programs to assist in closing the achievement gap through accountability, flexibility, parental choices, and research-based reforms. School districts must demonstrate by 2013-2014 that all students meet their state's definition of academically "proficient." The requirements of NCLB also include publishing school district report cards, testing 95% of students in reading and mathematics, having "highly qualified" teachers in core academic subjects, allowing parents of students in chronically low performing schools to transfer their child to a higher performing school in the district, and establishing timelines for moving students to English proficiency (CDE, 2007)

Third International Mathematics and Science Study. TIMSS is a test designed to measure the achievement level of students across the globe. This international test has been used to determine the effectiveness of mathematics instruction in the participating countries.

Time-on-task intervention. Time-on-task is an approach used to give low achieving mathematics students more time to learn and understand the concepts they are being taught. The intervention parallels the practice of literacy interventions that require students to spend more time on learning skills in order to "catch up" with their peers.

Research Question

The ASCEND Mathematics Solution was picked by FHS as an intervention based on the recommendations of several schools, including one school in the area, and the successful implementation of the program during the summer school session. The following research question was developed to focus this study and help determine if the program can benefit students: Will a mathematics program that includes computer-assisted instruction result in higher student mathematics scores than a program that emphasizes increased time-on-task? The research question gives a general scope of the study and provides structure for the hypothesis below.

Hypotheses

The two hypotheses, given below, help guide the research methodology. A matched-pair study will be used to examine the achievement of students in the time-on-task treatment during the 2008-2009 school year versus students who were in the computer-assisted instruction (CAI) treatment during the 2009-2010 school year.

Null Hypothesis: there will be no difference in standardized mathematics scores (CSAP, SCANTRON) between ASCEND students and students in the previous time-on-task intervention.

Alternate Hypothesis: ASCEND students will score significantly higher on standardized mathematics tests than students in the previous time-on-task intervention. Based on the alternative hypothesis, it is expected that the students in the CAI treatment will achieve at higher levels than the students in the time-on-task treatment.

Organization of the Study

This study is an examination of two different interventions used to improve student performance as tested on the CSAP. A traditional five chapter format is used and a summary of each chapter is provided below.

Chapter One provides an introduction to the study. It relates that there are significant issues with the mathematics achievement of students in the United States. According to some, this problem is impacting the United States' ability to be competitive in the global market place. The root cause of the problem can be traced to mathematics instruction. Freedom High School is used to examine the efficacy of these two different mathematics interventions.

Chapter Two provides a review of the literature tracing the mathematical reform efforts over the past century. It also examines the efforts of practitioners and researchers in trying to resolve the problems associated with poor mathematics instruction. Part of the solution may be contained in the use of technology and computer-assisted instruction; the review explains how technology has impacted mathematics achievement. Finally, the two interventions examined in this study are outlined. Increasing a student's time-on-task was an intervention used at FHS for several years. Student achievement did not improve, so another intervention, computer-assisted instruction, was studied and implemented in the 2009-2010 school year. Several studies are shared using the match-pair design as well as studies using the computer-assisted instructional model.

Chapter Three delineates the methodology used in this study. It begins with a review of the setting, followed by a description of the demographics at FHS, and the participants are discussed. A matched pair research design is outlined and the data collection procedures are discussed. SPSS will be used to analyze the data. The ASCEND program will be described.

Chapter Four examines the findings from the data collected. An analysis of the mean scale scores will help determine the variance between the matched-pairs through the use of a paired samples t-test. The same t-test will be run to determine the change in mean scores between the two groups and to determine if the new intervention had any impact on student achievement. In addition to the summary of findings, charts and graphs will be used to illustrate the information.

Chapter Five concludes the study with an examination of the research question and how the computer-assisted instructional program impacted student achievement. The results of the data analysis are discussed, as are the ways in which the study could have been improved.

Chapter 2: Review of the Literature

The need for reform in mathematics education has been documented in Chapter One. Popular sentiment would indicate that reform stops short of what is needed, and instead, a complete educational overhaul may be necessary. Today, even an ardent supporter of the current educational system would admit there is room for improvement in our methods of teaching mathematics in this country. Evaluating ways to increase mathematics achievement requires an understanding of what has been tried in the past, what research is telling us now, and how technology may be able to impact instruction and, thus, improve student learning in the future.

Review of Mathematical Instructional Reform Efforts of the Last Century

General education at the turn of the 20th century was designed to prepare students for a future involving mathematics, and yet most individuals that attended school did not finish school so they could use that preparation. "In 1890, fewer than 7% of the 14-year-olds in the United States were enrolled in high school, with roughly half of those going on to graduate" (Stanic, 1987, as cited in Schoenfeld, 2004, p. 256). As our country grew, more young people completed high school. "By the beginning of World War II, almost three-fourths of the children aged 14 to 17 attended high school, and 49% of the 17-year-olds graduated" (Stanic, 1987, as cited in Schoenfeld, 2004, p. 256). National attention on mathematics education was not a hotly debated issue because most students did not even graduate from high school.

The attention to effective mathematics education would take a drastic turn during the time period of the 1950s and 1960s. This period, commonly known as the Cold War, was marked by increasing tension between the United States and the Soviet Union. Suddenly, there was a need for more American infrastructure to deal with the spread of communism. The United States adopted a foreign policy to deal with the Soviet Union that was characterized as "massive retaliation." Nuclear capabilities were used as a deterrent to stop Soviet influence in weak areas around the world. When it was discovered that the Soviet Union had entered outer space with the Sputnik flight, there was widespread concern that U.S. foreign policy would not be adequate in the face of superior technology and resources. In a brief overview of the history of mathematics education, the editors of Mathnasium state that, "The launch of Sputnik in October, 1957, forever changed mathematics education in the United States. The cry went out across the land: 'Our children are behind in math and science'" (Mathnasium, 2009). Federal resources were gathered to usher in a new emphasis on improving mathematics and science education to help ensure that the nation would have the human resources capable of developing the new technologies needed to maintain a peaceful world.

The "New Math" was the result of the push to increase mathematics achievement and the number of students earning mathematical related degrees. The National Science Foundation contributed to the movement to modernize and make more appealing methods of teaching basic skills to a new generation of mathematicians. The skill and drill method of teaching the basics was replaced by application problems that were supposed to help students learn the complicated mathematics concepts. Students did a lot of independent work as part of the process to develop an understanding of algorithms.

Unfortunately, the “New Math” curriculum did not work. John Woodward, a professor at the University of Puget Sound, summarized the basis for the failure of the “New Math” of the 1960s by saying:

> The new math of the 1960s foundered for a number of reasons, not the least of which was the abstract nature of the reform mathematics at the elementary school level. The lack of broad-based professional development for K–12 teachers also played a role in its demise. Teachers faced a situation where they needed to reconceptualize their own understanding of mathematics. This resulted in many instances where the implementation of the new curricula failed (Moon, 1986). Another instrumental factor was the back-to-basics movement of the 1970s, which drove schools to place greater emphasis on reading, writing, and arithmetic (Woodward, 2004, p. 18).

As criticism of the “New Math” began to mount, a back-to-basics movement saw educators redirect efforts to return to the traditional methodologies in place prior to the Cold War. It was a renewed attempt to ensure that students learned the skills and concepts needed to be successful mathematicians. The result of this knee-jerk reaction was that students were in the same position as they were before the Cold War. Drill, practice, and memorization were used to get students to learn basic concepts. Educators soon rediscovered that students were not learning or understanding what they were being taught. Critics demanded another change. This outcry marked the beginning of the development of reform mathematics.

The decade of the 1980s created an atmosphere that might be described as the “Perfect Storm.” Poor achievement in mathematics by students across the country was a big part of the problem, but there were other factors as well. Standardized testing became the way most schools measured their performance. Of course, results on these assessments indicated students were not learning mathematics. Social issues spilled into the educational arena. There was a call for equity in education for the poor, minorities, and students with disabilities. The United States found itself in an economic crisis as countries like Japan began to experience huge economic growth. In 1983, the National Commission on Excellence in Education published a report called “A Nation at Risk.” John Woodward (2009) called this report, “One of the most important documents of the last quarter of the 20th century in the United States” (p. 20). In these turbulent times, reform mathematics got its start.

Reform mathematics was a throwback to the “New Math” of the 1960s. Students worked at-their-own-pace and created their own learning experiences, a concept referred to as constructivism by educational theorists. Assessments were authentic and included projects, presentations, portfolios, and reflections. In many ways, the teacher became a facilitator and was no longer standing in front of the class giving instructions or demonstrating what students should know and be able to do. Students were asked to learn through discovery. One hallmark of reform mathematics was the integration of the traditional mathematics sequence of subjects: Algebra I, Geometry, Algebra II, and Trigonometry into courses that covered those subjects in a non-linear way. The integrated mathematics also covered subjects like probability and statistics. Again, the shortcomings included a lack of support for teachers as they struggled to teach mathematics in a nontraditional way.

The National Council for the Teachers of Mathematics (NCTM) created another focus for the reform mathematics movement. The NCTM standards provide a set of performance criteria for what should be taught, assessed, and learned in schools. By giving mathematics educators a clear focus on what should be taught, the standards theoretically provide the infrastructure for reform mathematics. With the target clearly defined and instructional practices that help students discover the essential underpinnings of mathematical concepts in place, educational leaders would then provide the right opportunities for students to improve achievement.

Much time and money has been spent on reform mathematics curricula. Every Day Math, Math Connections, Integrated Mathematics Program, CORE Plus, and Connections Mathematics Project are a few examples of the curricula developed to address concerns about mathematics achievement. Professor Jeffery Frykholm at the University of Colorado addresses the determining factors by which these curricula were developed.

> The picture became clear. On average, U.S. mathematics teachers spent far less time engaging students in problem solving and reasoning activities. In addition, they "cover" many more topics than in other countries and seem to only skim the surface in both their modeling of, and expectations for, the kind of problem solving and reasoning that leads to an understanding of mathematics that goes beyond simple steps in procedures and algorithms (Frykholm, 2004, p. 126).

Likewise, Stigler and Hiebert (1999) point out the differences in instructional pedagogy in other countries like Japan and China compared to standard practice in the United States. Their study reinforces the TIMMS research by noting that teachers in U.S. classrooms spend only 11% of allotted time on high level mathematics content. In addition, major themes are developed only 21% of time. They conclude that the corresponding time totals of the Japanese teachers for these methodologies were 89% and 73%, respectively. This type of information helped fuel the development of reform mathematics programs and curricula.

The problem is that reform mathematics has been slow to win over traditionalists. In fact, the debate between reform mathematics supporters and those who favor traditional instruction has developed into what some refer to as the “Math Wars.” Schoenfeld (2004) describes the difficulty experienced by teachers working with reform mathematics curricula:

> This too seems alien to people who have experienced mathematics instruction only in traditional ways. Teaching in the ways envisioned by the authors of the reform documents is hard. It calls for both knowledge and flexibility on the part of the teacher, who must provide support for students as they engage in mathematical sense making. This means knowing the mathematics well, having a sense of when to let students explore and when to tell them what they need to know, and knowing how to nudge them in productive directions (p. 272).

The road to increased student achievement is paved with good intentions. The problem revolves around finding the method best suited to enhance student learning.

A review of the efforts to improve mathematics instruction over the last century reveals that there is a theoretical framework which describes how students learn and construct meaning that is the foundation of the reform movement. Constructivism is a belief that learning is derived from the world surrounding the learner, and has its roots in Piagetian cognitive development theory. There is a relationship between how the learners generate their own ways of thinking and their development of an understanding of the learning experience. In the classroom, the teacher supports the learning experience for the student in nontraditional ways. “Observing and listening to the mathematical activities of students is a powerful source and guide for teaching, for curriculum, and for ways in which growth in student understanding could be evaluated” (Steffe & Kierner, 1994, p. 723).

Constructivist philosophy relates to reform mathematics because of the efforts from supporters to get the mathematics community to see the inherent value of students learning mathematics in the manner described above. Steffe and Kieren (1994) reported, "It is perhaps not surprising that influences of constructivist approaches to mathematical learning and teaching are apparent in both the curriculum, evaluation and the teaching standards of the National Council of Teachers of Mathematics" (p. 729). The National Council of Teachers of Mathematics has been a key player by supporting the improvement of mathematics education. The mathematics standards developed by NCTM are now the cornerstone of most state standards, and the Council has supported reform curricula to enable the achievement of those standards. Since traditional instructional methodologies have not worked, constructivists seek to use their framework to approach new methodologies.

As the efforts of reform mathematicians and curricularists to change instruction in mathematics classrooms across the United States builds momentum, traditionalist continue to hold fast to their arguments that reform math does not work. Battista (1999) writes about the research regarding mathematics reform by saying, "As they cite isolated examples of alleged failures of mathematics reform, they ignore the countless failures of traditional curricula. Their arguments lack understanding both of the essence of mathematics and of scientific research on how students learn mathematics" (p. 1).

Although there are strong arguments against traditional mathematics instruction, critics of reform mathematics like Sandra Stotsky, former Senior Associate Commissioner of Education in Massachusetts, continue to defend the traditional pedagogy. By pointing to the success of students in Massachusetts on the recent National Assessment of Academic Progress (NAEP) she backed up her claim. Students were first in the nation in fourth and eighth grade mathematics assessment. In her article, *The Massachusetts math wars,* she denigrates the efforts of reform mathematicians and relates that, “Strong academic standards are the foundation of any systemic approach to upgrading public education” (p.490). The point to remember here is that educators have to make a decision defining the direction they will take to improve student achievement amidst the varied messages from both traditionalists and reformers.

Adding fuel to the fire, the No Child Left Behind legislation changed the way educators address student achievement and thus ushered in a new era, an age of accountability. High stakes testing now ruled every state across the nation, and requirements were put in place to ensure that all students were proficient in reading and mathematics. The goal of NCLB is to create educational equity for students across the country. NCLB has accountability benchmarks that increase every year until 2014 when all students are required to be proficient in reading and mathematics. Although this requirement has drawn criticism from many, it has caused many schools to reexamine the way they are teaching mathematics. NCLB has added to the pressure schools are under to improve mathematics achievement and it has also intensified the debate over mathematics pedagogy.

The Impact of Technology and Computer-Assisted Instruction

While the “Math Wars” continue to rage over mathematics curricula and instructional strategies, some educators maintain that the emergence of technology as a tool to support student learning is the wave of the future. The use of educational technology by schools across the nation offers a multitude of teaching and learning opportunities through increased student engagement with the mathematical concepts being taught. Technology offers students new ways to perform the algorithmic functions associated with mathematics. In ways not possible without technology, teachers are able to provide a variety of strategies to help students learn the concepts being taught and can do this on a student by student basis. Through the use of digital manipulatives, technology is used to help students understand the concepts associated with the algorithms being taught.

The research in this field generally supports the use of technology to improve student learning (Hannafin & Foshay, 2004; Kulik & Kulik, 1991; Stacey, 2002; Hsu, Wu, & Hwang, 2007; Toumasis, 2006). Kulik and Kulik (1991) found that, “A meta-analysis of findings from 254 controlled evaluation studies showed that computer-based instruction (CBI) usually produces positive effects on students" (p. 75). A study written by Hannafin and Foshay (2004) outlines the areas in which technology directly impacts student learning. They surmise, "Early advocates believed that computers would make learning more efficient and increase student motivation to learn, and ultimately change how teachers teach, how students learn, and the ways schools are organized. This belief was based on, “The computer's ability to provide individualized instruction, facilitate drill activities, and provide immediate and non-judgmental feedback" (p. 148). Technology can also impact mathematics instruction by offering new ways of communicating mathematics concepts to the students and this can, “Foster conjecturing, justification and generalization by enabling fast, accurate computation, collection and analysis of data and exploration of multiple representational forms (e.g., numerical, symbolic, graphical)” (Skouros, 2006, p. 951).

Technology in the classroom can impact the instructional process in a variety of ways. The role of the teacher changes from the proverbial “Sage on the Stage” to the “Guide on the Side.”   Activities used to support instruction are much more hands on and exploratory. There is abundant current research reinforcing the premise that student engagement increases with the use of technology (Hannifan & Foshay, 2006; Hsu et al, 2007; Toumasis, 2006; Skouras, 2006; Cobb, 2009; Suh, Johnston, & Douds, 2008). Part of the reason for this increased engagement is that technology can quickly connect students to the real world. With the help of technology, students can actually experience the mathematical concepts they are being taught. Technology also provides students with immediate feedback, which has a positive impact on the retention of learning. The teacher can tap into technological resources to help analyze assessment data which clearly define student strengths and weaknesses. It is apparent from the evidence given above that technology is a tool that can increase student learning.

Role of the teacher.

The teachers who use technology in the classroom to support student learning will find that their role changes. The pedantic lecture, never really effective, is replaced by computer-assisted instructional programs which elicit greater levels of participation and engagement by the student. The traditional mathematics lesson that most often included a diagram of an algorithm on the board for students to copy and repeat is now being replaced by individualized, computer-supported lessons. CAI gives students opportunities to experience what they are learning through digital manipulatives. The teacher then becomes a facilitator and coach who supports student learning by offering assistance and guidance. The activities provided by CAI are more student centered and constructivist in their approach. Students are encouraged to explore, create, and initiate their own learning, and the teacher becomes a support system.

Another aspect that is critical to the role of the teacher is attitude. Teachers who have a strong background in technology and a strong belief in the positive impact of technology on student learning create learning environments that produce increased student achievement. Hsu et al. (2007) analyzed the factors that influence instructional practice by teachers in the classroom. The author's stated that, "We learned that 'belief' in the effectiveness of computer-based instruction is the single biggest predictor of a teacher's successful practice of it in the classroom" (Hsu et al., 2007, p. 118). Positive teacher attitudes toward the use of technology in the classroom are strongly influenced by effective training. Teachers must have a strong knowledge of computers and the vision to see how technology can impact student learning to be able to use technology effectively. In some cases, teachers bring that knowledge to the table. In other cases, that knowledge must be cultivated through staff development. Hsu et al. (2007) summarized, "Computers or/and Internet technology have positive impacts on students' learning only when teachers know how to use computers or/and Internet technology to promote students' knowledge construction and thinking" (p.118).

Student engagement.

The computer is used to increase student engagement. Students are continually using technology in some form during their daily interactions. Cell phones, I-pods, social networking, digital imaging, and other technology-based interactions are examples of opportunities in which students consistently use technology before they even step foot in a classroom. Students live in a world in which technology is embedded in every aspect of their lives. It makes sense to use technology to support what teachers do in the classroom because students have so much experience using technology on a regular basis.

The computer can improve student motivation and attitudes toward learning. It also allows teachers to access information and activities that are relevant and of high interests to students.

Real-world connections.

Learning in the mathematics classroom can improve when teachers connect the concepts they are teaching to real-world situations. Students solving problems that they realize have an impact on their daily lives learn concepts more quickly and efficiently. Although the computer can be used for skill and drill type activities, it is the application of mathematical concepts through the use of technology that helps students developed a stronger understanding.

> Driscoll (2002) believed technology could facilitate learning by providing real world contexts that engage learners in solving complex problems. Reksten (2000) shared that Wenglinsky's research from the 1996 National Assessment of Educational Progress concluded that teachers who used computers for mathematical applications rather than for drill and practice produced higher student scores and achievement. He also believed, "Integrating technology skills with a concept-based curriculum results in a powerful combination to improve student thinking as well as student achievement" (as cited in Cobb, 2006, p. 17).

Connecting mathematics problems and concepts to real world contexts is a key component of computer-assisted instruction.

Technology as a mathematical tool.

Technology in a classroom can be a tool to assist teachers in a variety of ways. When technology is used, assessment is more effective and efficient. Teachers can get instantaneous feedback on student progress that is much more detailed than that which can be achieved by hand. This allows teachers to make decisions about their instructional methods that heretofore were made through intuition or luck. One of the strengths of computer-assisted instruction is the feedback given students as well. Whenever students are given immediate feedback, they are aware of their progress and do not have to wait for teachers to evaluate their work.

Students in classrooms where technology is used have opportunities to learn through hands-on manipulations. Through programs or online resources, the teacher can access activities that have manipulatives built in for the students. These types of opportunities allow students who might have different learning styles to understand the concept because of the different ways they can see the concept illustrated.

As teachers begin to use technology more effectively, they will offer students the opportunity to see mathematics in varied ways. Teachers can give students different scenarios, different ways to solve problems, and/or different levels of difficulty for problems. The computer offers differentiation of lessons and activities at multiple levels. Because of this, students' needs are met in ways that teachers could not provide before the use of technology. This is because every student could possibly have a different learning need. Students can also experiment and be creative when trying to solve problems. Programs have been constructed which allow students to manipulate mathematical concepts for greater understanding. For example, equations that can be graphed are easily manipulated via a computer to show students the impact of negative numbers or inverse relationships. In fact, "One of the important features of the computational media in the learning of mathematics is their ability to help students see the relationship between different representations of the same mathematical situation" (Skouras, 2006, p. 951). Suh et al. (2008) provided a list of the benefits of using virtual manipulatives which summarize the richness of using technology as a tool for teachers.

1. Linked representations provide connections and visualizations between numeric and visual representations.
2. Immediate feedback allows students to check their understanding throughout the learning process, which prevents misconceptions
3. Interactive and dynamic objects move a noun (mathematics) to a verb (mathematize)
4. Virtual manipulatives and applets offer opportunities to teach and represent mathematical ideas in nontraditional ways
5. Meeting diverse learners' needs is easier than with traditional methods (p. 236).

The reward for using the tool is that teachers can meet the needs of more learners and increase their opportunities for learning.

Computer-Assisted Instructional Programs

Computer-assisted instruction has features attractive to educators looking for ways to improve the achievement of struggling learners. For one, CAI provides for more individualized instruction. Many of the programs are loaded with what the industry calls “Intelligent Design.” This means that the computer program adjusts to students’ needs based on their positive or negative responses. A student who misses several problems in a row will receive additional problems, which are easier. The same holds true for students who continue to answer questions correctly. The computer can give more difficult and challenging questions. The key component of this feature is that students can work at-their-own-pace. This is true individualized instruction.

The computer engages students at a higher level than traditional lecture based instruction. The program sits idle when a student is absent so that student can pick up right where he left off when he returns. Teachers do not have to develop a plan to help that student make up work. Immediate feedback is a positive feature of CAI that helps motivate students as well as assist teachers as they diagnose student problems. Finally, a teacher who needs to spend time with an individual student can count on the program to continue working with students. In one respect, there are multiple teachers in the classroom.

There are many CAI programs to from which to choose. FHS researched several programs before making a decision to use ASCEND. These programs included: ALEKS, Cognitive Tutor, and PLATO. The following information describes the research behind the programs.

ALEKS.

ALEKS is a program that was being used by another area high school. FHS visited this school and talked to students and teachers. Also, ALEKS provided the following program description:

> ALEKS is a Web-based, artificially intelligent assessment and learning system. ALEKS uses adaptive questioning to quickly and accurately determine exactly what a student knows and doesn't know in a course. ALEKS then instructs the student on the topics she is most ready to learn. As a student works through a course, ALEKS periodically reassesses the student to ensure that topics learned are also retained. ALEKS courses are very complete in their topic coverage and ALEKS avoids multiple-choice questions. A student who shows a high level of mastery of an ALEKS course will be successful in the actual course she is taking. ALEKS also provides the advantages of one-on-one instruction, 24/7, from virtually any Web-based computer for a fraction of the cost of a human tutor (ALEKS, 2010).

The program also offered features that intrigued the teachers at FHS. Information presented by the ALEKS Corporation noted the following components that make the program unique.

- All problems require that the student produce authentic mathematical input.
- Assessment questions are generated from items based on curriculum standards.
- The assessment is adaptive; the choice of each new question is based on responses to all previous questions. As a result, the student's knowledge state can be found by asking only a relatively small subset of the possible questions in the curriculum.
- Assessment results are always framed relative to specified educational standards.
- A color-keyed pie chart report that provides a detailed, graphic representation of the student's knowledge state.
- The entire student system and all of the course contents are available in English and Spanish in assessment and learning mode; students can toggle easily between English and Spanish at any time (ALEKS, 2010).

Schnoebelen (2008) analyzed a high school’s use of ALEKS as an intervention. The school was located in the Midwest and was described as having, “A diverse student population (N=1600)” (p. 5). The school was recognized as a top-ranked high school by *Newsweek* magazine six times and was a three-time winner of the *National Blue Ribbon Schools* program. In spite of these recognitions, the school was in danger of not meeting the specifications of NCLB and becoming, “A School in Need of Assistance” (p. 8).

Students were selected to be in the intervention based on previous test score data. From that group of students, 32 were selected to be interviewed regarding their experience using the ALEKS program. The goal was to determine if the program improved student achievement. Statistically, over 50% of the students improved their ITED scores over two years. It was reported that, "The majority of students interviewed claimed that the program played a role in improving their math proficiency" (Schnoebelen, 2008, p.67). However, it was also reported that student motivation, teachers, and psycho-social issues played a role in student performance (p.76).

Cognitive Tutor.

Cognitive Tutor developed by Carnegie Learning Inc. was another program examined by FHS. Because no one in the area was using the program, little attention was paid to what this program had to offer. Later research revealed that, "The other computer-based algebra program that produced positive results, Cognitive Tutor, is used in 1500 schools nationally" (Viadero, 2004, p. 3). The *Guide to Mathematics Intervention Solutions: A Roadmap for Student Success* by Carnegie Learning (2010) provides the following program description:.

> Carnegie Learning is a leading developer of core, full-year mathematics programs as well as supplemental intervention applications for middle school and high school students. The company's Cognitive Tutor® is helping more than 375,000 students in more than 1000 school districts across the United States succeed in math by integrating interactive software sessions, text, and student-centered classroom lessons into a unique learning platform for Bridge to Algebra, Algebra I, Geometry, Algebra II and Integrated Math programs. The U.S. Department of
>
> Education recognizes Carnegie Learning's Cognitive Tutor Algebra I program as one of the only math curricula scientifically proven to have significant, positive effects on student learning. Based in Pittsburgh, PA, Carnegie Learning was founded by cognitive science researchers from Carnegie Mellon University in conjunction with veteran mathematics teachers.

The computer-assisted instructional program, Cognitive Tutor, claims to offer two effective techniques that can improve student achievement. Formative assessment provides targeted instruction for each student. In addition, the program provides differentiated instruction that focuses on student background and ability.

Arbuckle (2005) studied the impact of Cognitive Tutor in his dissertation. He used concept mapping as a way to determine the depth of understanding between six students who had a traditional direct instruction math intervention and six students who used Cognitive tutor. Arbuckle (2005) concluded that, “The complete Cognitive Tutor program as prescribed from Carnegie Learning not only helped the students of this study achieve higher scores but also allowed for deeper conceptual understanding to develop when compared with traditional direct instruction” (p. 71).

PLATO.

Research was also gathered on another CAI program called PLATO. “The first computer-assisted instructional program, ‘PLATO (Programmed Logic for Automatic Teaching Operations)’ (Hayes, 1999, p.4) was designed in the 1960s” (as cited in Dockery, 2006, p. 3). The innovation of using the computer to assist instruction has become ubiquitous across the United States. The computer is being used to meet the individual needs of students, raise student engagement, and assess student learning in ways that were not possible even 20 years ago. PLATO (2010) describes instructional philosophy and structure as follows:

> PLATO Learning products cover a broad range of teaching and learning needs—from intervention and credit recovery and innovative and teacher-facilitated solutions for traditional classroom instruction to trend-forward distance learning options. PLATO Learning’s elementary, secondary, and post-secondary customers have come to expect that each of our product lines will be developed with our signature passion for education and the unparalleled expertise and precision achieved after more than 40 years of experience in the educational technology market.

> Our tradition of innovation dates back to 1963 and continues today as we deliver just-in-time online assessments that are tied directly to standards; bring learning standards to the classroom, fully integrating them with your instructional resources; and provide meaningful professional development, customized to meet your needs. Most importantly, we make a difference in the lives of learners—as they upgrade their skills, increase their self-esteem, discover successful employment, and become better, more self-sufficient students and employees.

Plato Inc. publishes its own evaluation series. In one such document, Thomas Brush (2002) examined a high school in Rosenberg, Texas. This large and diverse school had major achievement issues including an achievement gap between Caucasian and minority students. In 1996, Terry High School adopted the PLATO learning systems to address students' needs in mathematics, reading, and writing. The results were extremely positive in all three areas. Germaine to this study is the success the school had in mathematics. Brush (2002) reported, "Over the same six year period, the percentage of students passing the mathematics portion of the TAAS improved from 61% to 85.9%, an increase of nearly 25 percentage points" (p. 13). In addition, the report indicated that minority test score gap was significantly narrowed after implementing PLATO (Brush, p.14). PLATO has over 200 evaluation studies testifying to their product design and success.

In the end, ASCEND mathematics solution was chosen to serve the needs of students at FHS. The central reason for picking this program hinged on administrators' and teachers' ability to see the program in action. A local high school was using the program at all grade levels and having great success. Students were enrolled in the ASCEND support class and were using the program every day. Some students were even using the program at home. Although the research on ASCEND was limited compared with other programs, it was selected because teachers could see the program in action at a nearby local high school.

Theories that Support the Chosen Interventions in this Study

It is assumed that improving student achievement is the goal of all teachers. Success rates in the United States are low, as has been documented previously. At FHS, teachers and administrators worked several years on a mathematics intervention for low achieving students. The basic framework behind this intervention was to increase the time available for students to learn the concepts being taught through double dosing. Students attended a mathematics class all year long that offered twice the amount of time allotted for students who had higher achievement scores. The curriculum covered in 90 minutes was essentially the same as the regular class would cover in 45 minute segments. Teachers were able to spend more time teaching and re-teaching concepts students did not understand. Research used to support the increased time-on-task intervention is outlined in the paragraphs below.

Increased time-on-task.

In a policy brief written for the state of North Carolina, a review of the literature from the 1960s through the 1980s supports the concept that increased time improves student achievement.

> As early as 1963, Carroll hypothesized that actual time spent learning and the time a student needs to learn are important determinants in achievement. Many well-known studies conducted in the 1970's and 1980's indicated that more instructional time enhances learning (Bloom, 1974, Berlinger 1978, Denham & Lieberman, 1980). John Goodlad, in A Place Called School, stated that, "It is apparent that simply the amount of time spent on a given subject is a factor in learning" (Goodlad, 1984 as cited in Suarez et al., 1991, p. 2).

If time is a critical component when looking at interventions for struggling learners, then increasing time should be a necessary factor to improve these students' accomplishments. However, there are other key factors that also must be present for students to learn. Classroom instruction must be of high quality, students must be engaged, activities must be relevant, and the curriculum must be focused. Without these components, students will continue to struggle regardless of how much time is allocated.

When there is more time to teach, teachers are more successful and students benefit in a variety of ways. First, there is more time for learning experiences. This is critical, especially for students who may experience developmental delays or have cognitive issues that keep them from moving at a faster pace. Teachers have more time to meet individually with students. Students have more time to work collaboratively. Other strategies can also be used when there is more time. Vocabulary exercises, writing assignments that extend student thinking, multimedia activities, and projects that emphasize problem solving are activities teachers can use when given extra time.

Finally, research that compares United States instructional time with other countries indicates that U.S. schools have less instructional time. It is true that, "American children spend less time in academic activities than Chinese and Japanese children do measured in terms of hours spent at school each day and days spent in school each year" (Stevenson & Stigler, 1992, p. 52-53). Increasing time-on-task with students who struggle at FHS made sense for the multitude of reasons listed above. Despite the outlined benefits of increasing time-on-task, the assessments results at FHS from 2006 through 2009 did not show improvement. Leaders at FHS decided that something needed to change and alternative intervention programs were studied. The ASCEND

Mathematics Program was chosen to meet the needs of low achieving mathematics students. ASCEND is a computer-assisted instructional program that gives a diagnosis of student mathematical levels and then prescribes a program of study based on those identified weaknesses.

Computer-assisted instruction.

Computer-assisted instruction (CAI) programs create daily individualized lesson plans. The individualized plans that CAI offers gives the program the power to meet the needs of individual students in ways the teacher alone cannot replicate. This changes the role of the teacher. Teachers facilitate and coach. They navigate the classroom helping each student progress through the lessons given them by the computer. Student progress is measured by the computer, and the teacher analyzes this data continually. With the support of the computer program, it is expected that students will develop deeper understandings of the basic mathematics concepts that they failed to master in previous years (Hannafin & Foshay, 2006, Kulik & Kulik, 1991). This new knowledge that has been mastered can then be applied in the regular mathematics class.

Similar Methodologies

Other matched-pair studies have been completed to compare educational programs. In his 2004 dissertation for Florida Atlantic University, Francis O’Boyle compared scale improvements for two Florida school districts. One district, Palm Beach County, used the Accelerated Academic Achievement Plan for High Needs Schools (AAA Plan). The Miami Dade School District used its own internal design called the Performance Excellence Plan (PEP). The plans differed in that the Palm Beach District mandated district use while Miami Dade County employed a site-based decision making model. O'Boyle related that, "The purpose of this research is to compare the relative effectiveness of the approaches that were taken to raise student achievement at comparable low performing schools in Palm Beach and Miami-Dade County School Districts" (O'Boyle, 2004, p. 12).   The Florida school comparison used state level testing and the resulting scale scores to determine if one plan worked better than the other and ultimately shed light on the effectiveness of districted mandated plans vs. a more site-based approach.

The study used a process to determine which schools would be compared. Variables such as the percentage of minority students, the percentage of students receiving free and reduced lunch (socioeconomic status), teacher experience, and the number of new teachers were used to determine the matches. 39 schools were matched based on these variables used. "A two-tailed, matched-pair t-test (t) was conducted to examine statistical differences in the changes in MDSS *(mean-development scale scores)* in both reading and math subtests of the FCAT subtests of the 39 matched-pairs" (O'Boyle, 2004, p. 60). The result of the comparison was that the null hypothesis could not be rejected. There was no statistical significance in the achievement gains between the Palm Beach and Miami-Dade County School Districts.

In a more recent dissertation study completed by Linda Rorie, AVID (Achievement Via Individual Determination) students were compared to a group of matched students who did not have the support of the AVID program. Demographic characteristics were used to match students including gender, ethnicity, past CSAP scores, and grade point average. A group of students were also selected to have their data analyzed.   The result of the matched-pair study was that AVID strategies were shown to impact positively student performance on state level testing (Rorie, 2007).

The advantage associated with the matched-paired study is that it controls for individual differences. For example, it is difficult in public education to assign students to a controlled condition in a random manner. The matched-pairs design allows educators to make comparisons between groups receiving different treatments without assigning students to treatments they do not need nor desire.

Chapter 3: Methodology

The methodology chapter describes the details of the study which include the purpose of the study, the setting of the school in which the study takes place, the demographics of the participants, a description of the treatments used in both interventions, the measures used to determine the student matches, the design of the study, the limitations of the study, and how the data will be analyzed.

Purpose and Background

As has been established in the previous chapters, Freedom High School has worked to determine the best way to address the needs of students who have not been successful in mathematics. According to the state testing results emanating from the 2009 school year, 72% of the FHS ninth grade student population was not proficient in the state level mathematics assessment (CSAP). This high percentage of low achieving students, coupled with an overall negative trend in mathematics scores, was the impetus which led school officials to change math interventions from increased time-on-task to a computer-assisted instructional program. Teachers and administrators researched different interventions and it was decided that a new approach to helping struggling students would be a computer-assisted instructional model. The ASCEND mathematics program was selected and used for the school year 2009-2010.

This study examined the CSAP results of the ninth grade students in the school year 2008-2009 against the ninth grade students who were in the school year 2009-2010. Gauging the effectiveness of the new program over the previous one was the goal.

Setting

The research for this study was conducted at a large suburban high school in southern Colorado with a student population of 1640. The school is in a rapidly growing district with just one high school. The high school serves two communities; a small suburban community and an army post. Sixty-five percent of the students have at least one parent in the military. The military influence is responsible for the high transiency rate which is 42%.

At FHS, CSAP assessment scores have reflected a downward trend for the last four years. In the school year 2009, FHS was above the state average in only one tested area after being above the state average in all but one tested area in 2007. Table 1 shows all the CSAP scores for the last four years. It should be noted that the scores listed for the school year 2010 were not available when decisions were made to adopt a new mathematics intervention. These scores are included to show the reader the overall struggle FHS is having improving student achievement. In addition, the table shows that the ninth grade mathematics score is the only tested area that did improve in 2010. Ironically, this group of students includes the sample of students receiving the CAI intervention used to compare against the previous intervention used in the 2006-2009 school years. The scores also reflect that as of the 2010 school year, FHS is no longer above the state average in any of the tested areas.

Table 1. *CSAP 4-year Trend Data*

Year	9th Reading	9th Writing	9th Math	10th Reading	10th Writing	10th Math	10th Science
2007	79	57	35	80	63	28	51
2008	72	47	32	69	47	29	44
2009	69	51	28	77	47	26	48
2010	68	46	33	67	46	20	41

Note. Highlighted scores at or above the state average

The ACT score over the last few years has hovered in the mid 18's. In 2007, the school average was 18.8. In 2008 it fell to 18.5, and in 2009 the score was 18.6. A significant improvement in the spring of 2010 was recorded (19.2). Each year the school has been below the state average.

The ethnic minority percentage reflects a diverse student population. There are 53% Caucasian students, 27% African American students, 19% Hispanic, 3% Asian, and less than 1% Native Americans. The free and reduced lunch percentage is 32%. It is important to note that less than 1% of the student population speaks English as a second language (ELL).

The graduation rate is 88% and the dropout rate is less than 2%. At FHS, these two rates are difficult to track because of the high transiency. The school has a senior-to-sophomore program that allows students to take college credit courses and potentially skip their freshmen-year in college. In 2009, 61% of the graduating seniors took at least one college class offered by the school. The average number of college credits earned was 13.2. Many of the high achieving students earn more than 30 credits from both University of Colorado at Denver and Colorado State University at Pueblo.

As mentioned earlier, FHS is in its third year of a one-to-one technology initiative. This means that every student has a laptop computer that they keep for 24 hours a day, 7 days a week. This is one of the main reasons the staff selected a mathematics program that was computer-based. Technology gives the instructors several advantages which include; instant feedback on assessment; the ability to differentiate lessons; and the capability to help students with a deeper understanding of concepts through digital manipulatives, video instruction, and multiple practice opportunities. All these advantages are provided at the click of a button. Because the school has issued a laptop to all students, they are able to navigate the ASCEND website easily because they are familiar with the operation of a computer. Access to the computer 24 hours a day and 7 days a week is beneficial as well. Students do not have to wait for computer lab time and they can access the program at home. Although eight percent of the students are at a disadvantage because they do not have internet connectivity at home, this was not seen as a problem because there was no expectation that students would work on the program from home. The staff felt that the 43 minutes a day in the intervention class was sufficient. However, there are many places in the community available for students to get internet service such as the library, fast food establishments, coffee shops, and several establishments on the army post (commissary) and even the school parking lot.

The school building is in its 11th year of use. Classrooms are arranged into pods of six. It has an open concept in which four of the classrooms have no doors, and each of these classrooms opens into a shared study area. The mathematics department occupies three of the pod areas. Fourteen of the 15 mathematics teachers have their own room. This lone teacher was hired in late September and he taught in three different classrooms. The classrooms are fairly traditional in size. The recommended capacity for these rooms is 30 students. There are two different types of classroom furniture in use. Some teachers prefer individual student desks; other teachers prefer tables and chairs. In the rooms with tables, two students sit at each table. The classrooms are equipped with a teacher's desk, filing cabinet, storage closet and cabinets, two white boards located on one wall, a video screen, and an LCD projector.

FHS has a complicated schedule. For seniors and juniors, the schedule is a traditional block. Students take four classes first semester and four different classes second semester. The block classes are 90 minutes long. For freshmen and sophomores, core classes are 43 minutes long, and they attend these classes all year long. In the 2008-2009 school year, the students in the intervention (increased time-on-task) attended their class for 90 minutes a day all year long. This modular schedule for freshman and sophomores has their core classes fitting inside the four-by-four block schedule. For students in the 2009-2010 mathematics intervention, ASCEND, the time spent on mathematics is the same (90 minutes) but the students attend a 43-minute algebra class and then attend a 43-minute intervention class where they use ASCEND to address their individual mathematics needs.

The algebra course has a standards based curriculum aligned to the Colorado state assessment frameworks. Teachers plan lessons each day to cover the material outlined in the curriculum. The classes are traditional in the sense that topics are covered sequentially, concepts are introduced in a lecture style format, students are asked to perform practice problems, and then assigned homework to complete. Teachers develop activities which encourage students to think more critically. Consequently, there are projects assigned, technology is used, and students work in collaborative groups. Projects are linked to relevant topics to help motivate students, such as, finding the line of best fit that will reveal the most economical cell phone payment plan. Technology programs like Geometry Sketch Pad and online mathematics applications are used to give students opportunities to experience what they are learning.

Participants

There are two groups of students in this study. The first group is a set of students who were in the freshman mathematics intervention during the school year 2008-2009 (Group one). The intervention they received is termed increased time-on-task. These students received the same curriculum as the other students but were scheduled in 90-minute classes instead of 43-minute classes that met for the entire year. The extra time allowed the teachers to concentrate more fully on helping students learn the concepts.

The second group is a set of students who were in the freshman mathematics intervention during the 2009-2010 school year (Group two). These students are taking the traditional mathematics class (Algebra I) that meets 43 minutes a day. In addition, they are scheduled in the ACSEND computer-assisted instruction class for an additional 45 minutes of training.

There are 120 students in Group 1 (this is about 30% of the ninth grade class). Group 2 has 440 students in the intervention (two notes on this population: this is over 83% of the ninth grade class and 25 of the 440 are 10th graders). Some of the students came to the high school from the middle schools and some are new to the district. There are two middle schools and the students were instructed by a variety of teachers. Approximately 40% of the students come from the middle school on the army post. Of those 200 students, almost 100 move over the summer and never enroll at FHS. These students are replaced by over 100 students who move in over the summer. This a typical event in an area highly impacted by the military. The other middle school is much more stable in the number of students who enroll at the high school.

Printed below is a table that gives demographic trend data for the last five years at FHS. The information in the table shows that the district mobility rate increased slightly over the last five years. This is due, in part, to the troop movement from Fort Hood, Texas. This movement of students also slightly impacted the free and reduced lunch status of students as well as the percent of minority students at FHS.

Table 2. *Demographic Trend Data*

Year	Mobility Rate	% F/RL	% Minority
2006	46%	21%	43%
2007	42%	25%	44%
2008	38%	27%	43%
2009	36%	30%	45%
2010	38%	33%	47%

Table 3 shows the CSAP mathematics testing trend data for each group. The negative trend each year is the same negative trend represented at the state level. However, the data also show that the scores from these two groups were above the state average in before the groups come to the high school. Group Two was not above the state average beginning in the 7th grade.

Table 3 *Mathematics CSAP Trend Data for Each Group*

Year	Group One		Group Two	
2005	5th Grade	70	4th Grade	74
2006	6th Grade	66	5th Grade	70
2007	7th Grade	52	6th Grade	63
2008	8th Grade	50	7th Grade	42
2009	9th Grade	25	8th Grade	45
2010	10th Grade	19	9th Grade	31

Treatments

Year 2008-2009 treatment (Group 1).

The Group 1 treatment is referred to as increased time-on-task. The 120 students assigned to the treatment participated in a 90-minute mathematics class. This was different from the students who were scheduled in the regular mathematics class, because the regular class met for only 43 minutes. The teachers working in the increased time-on-task intervention worked hard to cover the same curriculum that was covered in the regular mathematics class. The extra time allowed teachers to work with students on basic skills they may have missed or did not learn at previous grade levels.

There is a process in place for evaluating students to determine who will be placed in the intervention class. Seventh grade CSAP scores were examined in the spring of the potential student’s eight grade year. This was done because eighth grade scores are not released until July prior to the start of ninth grade. This information gives the high school math teachers a look at the skills and abilities of the incoming ninth graders. From there, middle school counselors then, provide the course taken and grade earned of the current eighth graders. Students generally come from three levels of math classes. There is a regular pre-algebra class, an advanced class where students take Algebra I, and a low level math class where basic math concepts are taught (addition, subtraction, multiplication, division, fractions, percent, etc.). Students can move up or down in levels but generally move to the next level class in high school. The next step in the process is to get input from the middle school teacher. Armed with these recommendations and the other data points, high school counselors schedule students into their ninth grade mathematics class. During the week of registration (before the first day of school), mathematics teachers then look at the recently released eight grade CSAP data. This information is used to confirm student placement. Changes can be made before school starts. Finally, during the first few weeks of school, all ninth grade mathematics teachers keep a close eye on their students to ensure they have been placed appropriately. This step is crucial because there are generally over 100 students who did not attend the district middle school the year before. The end result is that there were 120 students assigned to be in the intervention class for the 2008-2009 school year.

An important initial aspect of the class was for teachers to establish a positive and productive learning environment. Many of the students in the intervention classes had been failing mathematics for a number of years. Their attitude toward mathematics was generally poor. In some cases, students had negative attitudes toward school as a whole.

Teachers worked hard to change these attitudes by providing structure, support, and creating ways for students to experience success.

There was a constant focus on organization and organizational development. Students had to keep notebooks where they tracked their assignments and their progress. Homework was limited because most students would not complete the assignments (even easy assignments). Teachers found that, in general, there was a lack of support at home. This also hurt the homework completion rate. It also necessitated extra effort on the part of teachers to stay in contact with parents.

Structure was important in these classes. Lesson plans reflected a routine by which students could count on certain things happening at specific times or on specific days. Direct instruction was given every day and there was time to work on the objective. Students received immediate reinforcement and feedback regarding their assignments and test grades. Teachers developed routines that helped students stay focused and engaged. This structure also helped teachers reinforce with students the importance of getting their work done. Students were exposed to the importance of taking responsibility for their own learning.

Teachers in these classes tried various strategies to help motivate students to develop a better understanding of algebra concepts. In addition to the student notebook, teachers worked to encourage students to keep track of their assignments on a highly visible poster hung on the wall. This was in response to the low achieving student's propensity not to turn in class work or homework.

Different methods were derived to overcome the reluctance of many students to give input during class. Poker chips were used to reward student participation. These chips could be redeemed later for extra points or prizes. Teachers would draw names from a jar when calling on students to ensure that all students got a chance to work problems on the board or answer questions. Knowing that success breeds success, teachers recognized good work and increased participation from students with positive reinforcement and praise.

Goal setting was another strategy implemented in the time-on-task intervention. Teachers worked with students to enable them to articulate and write effective goals. After writing the goals, students would then follow up on a regular basis to check their own progress. Teachers would check the students' progress by monitoring the goals recorded in each notebook.

Teachers would begin every unit with some sort of skill training related to basic mathematics. Low achieving mathematics students often had difficulty doing simple addition, subtraction, multiplication and division. Most students in these classes could not work with fractions as well. Lacking basic skills, students struggled with even the most basic algebra concepts. Teachers would use games and activities to teach these skills and help reinforce positive images of mathematics.

Since low achieving mathematics learners were not successful in mathematics classes taught in the traditional style, teachers worked to address this issue by presenting a concept in multiple ways and, thus, appeal to the visual, auditory, and kinesthetic/tactile learner. Concepts were also taught using mathematics manipulatives that required students to use their hands. Teachers developed algorithms for solving problems that were simplified and easier to remember. The rooms were arranged in learning quads (tables or chairs pushed together to form a square so students are sitting two-by-two and the pairs face each other). Students often worked in cooperative learning groups so they could help each other throughout the period.

Embedded in each unit there would be an activity that would have real life applications. Teachers working on the concept of slope would introduce the idea by showing a skateboard park and the impact of slope. Students would do projects related to line of best fit. Finding the best cell phone plan or predicting when a female sprinter will actually run as fast as a male runner based on data from the last 16 Olympics were problems given to students which they used to help learn specific objectives. These strategies would help gain student interest and improve the engagement.

A final challenge facing these classes is that these students often had other learning issues. Many students could not read or write at grade level. Some students were slow processors of information. Some had behavioral issues related to ADHD. Intervention teachers adopted strategies that helped students with these weaknesses. One such strategy was to work on vocabulary. Many terms in mathematics have multiple meanings that are not related to mathematics. Product, for example, is something you buy at a store. It is also the sum of two numbers multiplied together. This led to student confusion. Teachers used a strategy where students had to write the definitions of the mathematics terms used in a unit, draw a picture to support that term, and then write the definition in their own words. Students were asked to describe the process by which they solved a problem. Graphic organizers were also used to help students see concepts on paper in a different manner than the way the concept would be shown on the board or in the book.

Year 2009-2010 treatment (Group 2).

The second treatment is a computer-assisted instruction class that uses a mathematics program called ASCEND. The teacher does not plan these classes in the traditional way. The computer develops an individual lesson plan for each student and the teacher then coaches students through the issues that the computer may not be able to address. Teachers are on their feet all period as they move from student to student. During each period students log on to the web-based site provided by ASCEND. Students worked through several components of the program identifying what they need to help them understand the concept. Students can use written explanations of the concept, visual explanations on the video provided, or use the mathematics manipulatives that help illustrate the concept. Once the student feels they have mastered the concept, they take a quiz. When they can show 80% mastery or better, the computer will direct them to the next concept. If mastery is not reached, the student will repeat the process. Students are instructed after the third attempt to consult the teacher.

A typical day in the classroom would have several key elements. First was getting students settled and logged-on to the internet-based ASCEND program. Most days this happened within the first minute or two of the 43 minute period. The highly motivated students would then have at least a 40 minute lesson in mathematics that was built around their individual weaknesses. The next key element was for students to work through the elements of the program which included explanations (via a video showing an award winning mathematics teacher) of the concept or skill, practice (using manipulatives if needed), and taking a quiz. Some students could work through a module (all of these components) in a day and some students would take several days. Another important factor was assistance given to the students by the teacher. This varied depending upon the teacher. Some teachers could only help four to six students a day and some teachers reported that they helped a few students but touched base with every student every day. One teacher felt he spent most of his time with struggling students and this became a cycle of dependence from one module to the next. Another teacher stated that he could not spend as much time with the students who needed help each day as he wanted. Thus, he felt that some struggling students would sit and wait instead of using the video or manipulatives to help them gain the knowledge they needed to finish the module (Personal Communication, February, 5, 2010). Basically, the computer built an individual lesson for each student and the teacher helped facilitate students efforts on the program as they moved through that lesson. This procedure was repeated each and every day.

There are over 440 students enrolled in the ASCEND class. These students are scheduled in 21 sections. Class sizes are around 27 with the exception of a few classes that have 15 or 16 due to master schedule issues. These sections are offered all day long. There are 15 teachers in the mathematics department and eleven of them teach the ASCEND intervention class.

Often, student motivation was a major issue. All students in the ASCEND class have scored poorly on state testing, and many of the students have done poorly in previous mathematics classes. The computer does not provide strong motivational incentives except for instant feedback. That means the teacher in the ASCEND classroom must continually encourage students to stay engaged with the computer program. The teacher does this by walking around the room to answer questions and checking on student progress. They also monitor student progress through the data provided by the ASCEND program. Teachers can get data on how long students spend on specific objectives. There is also a data field that reports the number of times a student attempts to take a quiz on a certain concept. This information helped separate students who struggled but were working hard from students who did not attempt to learn the objectives.

One motivational tool that teachers have used is the posting attractive data posters throughout the room. Students, then, recorded their assignments on the wall charts as they completed each task. Students could then determine their progress on a specific assignment and their current level of their achievement.

At the beginning of the year, all students started the ASCEND program at the fifth-grade level.   This was because the grade level identifying pretest developed by ASCEND did not prove to be consistent in identifying where students should be placed. In fact, the test did not accurately place the 50 students who took the class during the summer. Knowing that most of these students had many mathematics deficiencies, the fifth-grade level was determined to offer a good review for those that needed it and great information for those students who had not learned the concepts. Students could also test out of material they had already mastered and quickly move to the next level.

Teachers had to be trained to navigate the ASCEND program. FHS used the train-the-trainer model. A lead teacher was selected, and with another teacher received the initial training. They taught a pilot program over the summer. During the pilot program, the two teachers were able to learn the program thoroughly and address key issues. One of these issues was developing an efficient way to grade student progress in the program.

The teachers selected to teach the ASCEND program have varied experience levels, but all are perceived as having the skills to deal with low achieving students. Four teachers are in their first year of teaching. Two teachers are in their second year of teaching but have shown a proclivity for the use of technology. Three teachers have four years of experience and have taught intervention classes in the past. Of these three teachers, one is working on his master's degree. One teacher has 14 years of experience. He was identified as the best teacher for the ACSEND program because of his success in working with low achieving students. He also recently earned his Master's in administration. The last teacher has taught for 27 years and is the department chair. The lead ASCEND teacher has taught for four years but also has two master's degrees and is a leader in the mathematics department. All the teachers are highly qualified. One of the first year teachers is working in the alternative licensure program but has passed the teacher Place exam. This teacher worked as a computer engineer in private industry. He is also the teacher hired in late September.

The ASCEND Math Solution was selected as an intervention at FHS for two reasons. First, as a school in its third year of a one-to-one laptop initiative, it was important to find an intervention that made use of technology. So a web-based mathematics program was sought for students with basic skills deficiencies. Several programs were examined and the ASCEND program was selected. Secondly, a mathematics intervention had to address the individual needs of students. ASCEND met this requirement because the program could personalize instruction for each individual student.

ASCEND begins by assessing the mathematical abilities of each student. It does this through a pre-test. The computer identifies students' strengths and weaknesses and then designs a program by which students work at their own speed. Students are able to access teaching aides such as content overviews, video guides, practice problems, and computerized mathematics manipulatives. When a student completes a module, a post-test is given. Students scoring 80% or higher proceed to the next module. When the modules are completed at a particular level, the students then takes a pre-test for the next level and the process begins again. Teachers support students as they work through the program.

Measure

Colorado Student Assessment Program (CSAP).

The eighth grade CSAP scores were used to help determine the matched pairs in the study. Students with like scores (along with the other demographic factors: SES, Gender, and ethnicity) were matched. The ninth-grade CSAP scores were used to determine if and how much each student improved over the course of the year. The CSAP assessment in grades three through ten was approved by the United States Department of Education and meets all the requirements stipulated in the No Child Left Behind Legislation. The assessments started in the year 2000 for students in ninth and tenth grades. The mathematics assessment was given to the ninth graders for the first time in 2001. "The assessments were developed by CTB/McGraw-Hill, LLC in collaboration with the Colorado Department of Education and were scored and scaled by CTB/McGraw-Hill" (CDE Technical Manual, p 1, 2009).

Research Design

Matched-pair control group design.

he process described above was used to compare Group 1 (time-on-task intervention) with Group 2 (computer-assisted instruction). The purpose of the comparison is to determine if the new intervention used at FHS is more effective than the intervention used the previous year.

A matched-pair control group design was used to compare two different groups of students. Group 1 was given the time-on-task intervention and Group 2 was given the computer-assisted instruction intervention. Each student in Group 1 was matched with a similar student in group two. The matches were made using the following criteria: gender, ethnicity, socio economic status, and achievement (eight-grade Math CSAP score). The matched pairs were made and a t-test was used to determine the variability between the two groups. The data used for this analysis was the eighth-grade CSAP scale scores for each matched pair. Once the pairs were established, then a comparison of ninth grade scores was made to determine the effectiveness of the two interventions.

A University of New England web-publication on research methodology explored the theories defined as the matched control group design. This study explains how the matched samples used in the study are related in some way. The publication clarifies this concept thusly, "The idea behind the matched samples design is that the advantage of greater power and economy found with repeated measures can be applied to the situation in which separate individuals are employed" (Price, 2009) Isolating similar individuals for comparison in this study minimizes the statistical impact of variables not being measured.

The University of New England web-site explains the basis by which subjects are to be compared, “The matching variable must have a significant relationship with dependent variable” (Price, 2009). In this case, achievement data from the eighth grade is being used as one of the matching criteria, while ninth-grade achievement data is being used to determine student growth over this one-year time period.

Mortality data.

Only 44 matches were made from the original intervention groups. The following information is related to the students who were eliminated from the study. Comparisons can be made among the overall school demographic data, the large group demographic data, and the smaller matched pair groups.

Table 4. *Mortality Data*

Group	Gender		Ethnicity					Free & reduced Lunch %
	Male	Female	Native American	Asian	Black	Hispanic	White	
School	51	49	< 1%	3	27	19	53	33
Large Group One	62	38	< 1%	.5	21	29	45	43
Small group One	59	41	0	2	18	24	57	34
Large Group Two	60	40	< 1%	3	25	16	55	40
Small Group Two	59	41	0	2	18	23	57	34

There are some small discrepancies in each area that need to be noted. The male population in the large and small groups is overrepresented. The over-all ethnicity is close to the same in each group except large Group One. The 55% minority population is overrepresented. There is also a small discrepancy in both large groups in the free and reduced lunch category.

Delimitations and limitations.

In the book, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, Creswell states that, “Two more parameters for a research study establish the boundaries, exceptions, reservations, and qualifications in every study: delimitations and limitations” (p. 147).

The delimitations of this study are that the focus is on only two mathematics interventions and student data is compared based on matching similar students instead of comparing the achievement of the groups as a whole. The two groups also have a varied subject size from which the matched pairs can be selected (Group 1 n=120 and Group 2 n=440). Incomplete data sets from many of the students in these groups further limited the number of matched-pairs (because of the high transiency rate, some students were not present for either the per-test or the post-test)

There is a basic limitation in this study, as the selection criteria used cannot eliminate every variable. A study by The School of Psychology at the University of New England states that the best possible matched pair study would be with the use of twins. “Each twin serves as a control for the other; they are therefore matched on an innumerable physical and mental characteristics” (Price, 2009). This study cannot make use of twins but is using four matching variables to help increase the power of the comparison. As mentioned before, these variables include achievement scores as well as demographic data (SES, ethnicity, and gender). The mathematical experiences of the two groups will be different in some ways. In addition to the differences described above, there is more variability in the instructional practices of the eleven teachers. Some of these differences are discussed in Chapter 5.

The researcher.

Another important aspect for the reader to consider is that the researcher works in the school. Although this could present some bias issues when discussing the reasons why the program did not work, working in the building offered many additional advantages. The researcher was able to gain access to data, observe instruction in each of the treatment classes, and discuss issues related to the interventions used with the teachers. The intimate nature of being in the school helped the researcher better understand the nature of implementing a computer-assisted instructional model and continually collect information regarding the program from the varied parties involved in the study.

Data Analysis

The data for this study was collected from several sources. Original CSAP data is obtained from the Colorado Department of Education and then downloaded into a district data warehouse called Alpine Achievement Systems (AAS). The AAS communicates with the district student management system called Infinite Campus (IC). This allows AAS to collect important information like student state identification numbers, gender, ethnicity, SES, class schedules, instructors, and other important information that a teacher or administrator might need. The information for this study was collected from these sources and put into an Excel spreadsheet. A feature called “v-look up” was used to match student data by state identification number. This process ensures that mistakes are not made and it saves the researcher hours of tedious work.

With the data collected and organized, it was downloaded into a program called PASW Statistics Base (also called SPSS). Analyses of the data were performed using this program including frequencies, t-tests, ANCOVA, and charts.

The data collected was analyzed in the following manner. First, a t-test was completed on the pre-test data (eighth-grade CSAP) to compare the differences between the two groups. Because the two groups were found to have a significant difference in their CSAP eighth grade mathematics scores (discussed in more detail in chapter 4), an Analysis of Covariance was run to determine if the means score difference should be adjusted.

Chapter 4: Results

This chapter will provide the results from the analyses done on the 44 matched pairs selected for this study. A descriptive analysis was done which provided frequency data in the areas of ethnicity, gender, socioeconomic class, and 8th grade CSAP scale score. The chapter discusses the comparative analyses that were run to determine how the ASCEND computer-assisted instructional program impacted student achievement.

Review of the Research Question

The ASCEND Mathematics Solution was used by struggling students at Freedom High School. The following research question was developed as a way to determine if the ASCEND program would benefit these students: Will a mathematics program that includes computer-assisted instruction result in higher student mathematics scores than a program that emphasized increased time-on-task? A matched-pair study was used to examine the achievement of students in the time-on-task treatment during the 2008-2009 school-year vs. students who were in the computer-assisted instruction (CAI) treatment during the 2009-2010 school year.

Hypotheses Restated

Null Hypothesis: there will be no difference in standardized mathematics scores (CSAP, SCANTRON) between ASCEND students and students in the previous time-on-task intervention.

Alternate Hypothesis: ASCEND students will score significantly higher on standardized mathematics tests than students in the previous time-on-task intervention.

Based on the alternative hypothesis, it is expected that the students in the CAI treatment will achieve at higher levels than the students in the time-on-task treatment.

Descriptive Data

Organizing the descriptive data into frequency distributions helps to define the major characteristics of the matched pair group and then relate this information to the general population. The tables show all matched pairs are equal in three of the four demographic areas. All students were matched based on ethnicity, gender, socioeconomic class, and eighth grade CSAP scale scores.

In the following paragraph and tables, school ethnic minority percentages are examined. The FHS student population has the following make-up: 53% Caucasian, 27% African American, 19% Hispanic, 3% Asian, and less than 1% Native Americans.

Table 5 *Group 1 Ethnicity*

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid				
Asian	1	2.3	2.3	2.3
African American	8	18.2	18.2	20.5
Hispanic	10	22.7	22.7	43.2
Caucasian	25	56.8	56.8	100.0
Total	44	100.0	100.0	

Table 6. *Group 2 Ethnicity*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Asian	1	2.3	2.3	2.3
	African American	8	18.2	18.2	20.5
	Hispanic	10	22.7	22.7	43.2
	Caucasian	25	56.8	56.8	100.0
	Total	44	100.0	100.0	

The distribution of ethnic students did closely match the distribution of ethnicities in the school. There is some discrepancy between the Hispanic percentage and African American percentage of students. At FHS, the Hispanic population is 19%. The sample population of Hispanic students is almost 23%. The African American school population is 27% and the sample population is 18%. The Asian population only differs by one percentage point and no Native Americans were selected for the study.

The gender characteristics do not match the general population. The sample students have a 60% male representation. The general school population is 51%.

Table 7. *Group 1 Gender*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	26	59.1	59.1	59.1
	Female	18	40.9	40.9	100.0
	Total	44	100.0	100.0	

Table 8. *Group 2 Gender*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	26	59.1	59.1	59.1
	Female	18	40.9	40.9	100.0
	Total	44	100.0	100.0	

There are differences in the number of males and females in the study as compared to the regular school population. However, there is no discrepancy between the percentage of males in the intervention program and the percentage of males in the sample size.

The SES representation for the sample population (34%) is almost the same as the general population (33%).

Table 9. *Group 1 Socioeconomic Class*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Free Lunch	12	27.3	27.3	27.3
	Reduced Lunch	3	6.8	6.8	34.1
	No Support	29	65.9	65.9	100.0
	Total	44	100.0	100.0	

Table 10. *Group 2 Socioeconomic Class*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Free Lunch	12	27.3	27.3	27.3
	Reduced Lunch	3	6.8	6.8	34.1
	No Support	29	65.9	65.9	100.0
	Total	44	100.0	100.0	

Data was also collected regarding students with an Individualized Education Plan (IEP). These students are receiving special education services from the school in addition to being in the intervention. It should be clarified that only moderate needs special education students are put into the intervention. Students with more severe needs are placed in a separate class.

Table 11. *Group 1 Special Education*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No Services	35	79.5	79.5	79.5
	Special Education	9	20.5	20.5	100.0
	Total	44	100.0	100.0	

Table 12. *Group 2 Special Education*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No Services	32	72.7	72.7	72.7
	Special Education	12	27.3	27.3	100.0
	Total	44	100.0	100.0	

Students are not matched perfectly in the area of special education. Special Education students are overrepresented in intervention classes as the actual population of special education students is 14%. This variable is included for informational purposes only. It was not one of the matching criteria

Students were also matched based on their achievement levels using eighth grade CSAP scale scores. The distribution of scores and the small sample size necessitated some leeway in matching students. Table 13 shows the matches on a case by case basis.

Table 13. *Individual Scale Score Case Summaries*

Matches	Group 1 8th Grade CSAP	Group 2 8th Grade CSAP
1	426	426
2	520	521
3	569	572
4	442	447
5	565	567
6	466	478
7	504	511
8	506	529
9	546	542
10	547	552
11	575	570
12	459	470
13	460	474
14	507	495
15	540	544
16	600	605
17	526	527
18	487	484
19	497	501
20	504	505
21	528	527
22	540	539
23	549	544
24	550	552
25	555	555
26	559	561
27	563	566
28	555	537
29	466	488
30	572	571
31	524	550
32	447	469
33	458	483
34	606	626
35	467	448
36	495	493
37	473	469
38	487	491
39	503	510
40	504	514
41	528	531
42	529	532
43	540	536
44	554	554
Total N	44	44

a. Limited to first 100 cases

The range of differences can be seen in Table 14. It shows the number of exact matches (3) and the number of matches within 15 scale score points (33). There are 8 matches that are outside of 15 with the highest discrepancy being 26.

The Colorado Department of Education in conjunction with CTB-McGraw-Hill (the assessment developer for the state) has set cut scores for each grade and subject level. These cut scores divide a student's proficiency into four categories: unsatisfactory, partially proficient, proficient, and advanced. The upper boundary of unsatisfactory is 521, the upper boundary of partially proficient is 577, and the upper boundary of proficient is 628. The range in the partially proficient and proficient performance levels is over 50 scale score points. In trying to get as many matched-pair samples as possible, it was decided that student scores exceeding 26 would not be used in the study. Their differences would increase the variability of the original scores and thereby further reduce power.

Table 14. *Differences in 8th Grade CSAP Scale Scores*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-26.00	1	2.3	2.3	2.3
	-25.00	1	2.3	2.3	4.5
	-23.00	1	2.3	2.3	6.8
	-22.00	2	4.5	4.5	11.4
	-20.00	1	2.3	2.3	13.6
	-14.00	1	2.3	2.3	15.9
	-12.00	1	2.3	2.3	18.2
	-11.00	1	2.3	2.3	20.5
	-10.00	1	2.3	2.3	22.7
	-7.00	2	4.5	4.5	27.3
	-5.00	3	6.8	6.8	34.1
	-4.00	3	6.8	6.8	40.9
	-3.00	4	9.1	9.1	50.0
	-2.00	3	6.8	6.8	56.8
	-1.00	3	6.8	6.8	63.6
	.00	3	6.8	6.8	70.5
	1.00	3	6.8	6.8	77.3
	2.00	1	2.3	2.3	79.5
	3.00	1	2.3	2.3	81.8
	4.00	3	6.8	6.8	88.6
	5.00	2	4.5	4.5	93.2
	12.00	1	2.3	2.3	95.5
	18.00	1	2.3	2.3	97.7
	19.00	1	2.3	2.3	100.0
	Total	44	100.0	100.0	

One final piece of comparison data is included here. All students are listed in the table below. Their eighth grade CSAP scores are shown beside their ninth grade CSAP scores and the difference (growth or regression) is shown in the final column. This comparison is made to show how each individual student improved from one year to the next (or failed to improve). The first 44 students are from Group One and students numbered 45-88 are from Group Two.

Table 15. *8th Grade/9th Grade Comparison*

	8th Grade CSAP	9th Grade CSAP	Growth + or -
1	426	447	21
2	520	558	38
3	569	535	-34
4	442	447	5
5	565	547	-18
6	466	462	-4
7	504	473	-31
8	506	535	29
9	546	506	-40
10	547	512	-35
11	575	550	-25
12	459	340	-119
13	460	525	65
14	507	544	37
15	540	531	-9
16	600	584	-16
17	526	474	-52
18	487	530	43
19	497	518	21
20	504	482	-22
21	528	539	11
22	540	543	3
23	549	550	1
24	550	591	41

	8th Grade CSAP	9th Grade CSAP	Growth + or -
25	555	556	1
26	559	568	9
27	563	539	-24
28	555	486	-69
29	466	499	33
30	572	543	-29
31	524	502	-22
32	447	472	25
33	458	449	-9
34	606	607	1
35	467	435	-32
36	495	520	25
37	473	472	-1
38	487	475	--12
39	503	580	77
40	504	498	-6
41	528	485	-43
42	529	516	-13
43	540	520	-20
44	554	574	20
45	426	429	3
46	521	518	-3
47	572	552	-20
48	447	340	-107
49	567	563	-4
50	478	526	48
51	511	514	3
52	529	533	4
53	542	584	42
54	552	605	53
55	570	572	2
56	470	452	-18
57	474	417	-57
58	495	406	-89
59	544	580	36
60	605	611	6

	8th Grade CSAP	9th Grade CSAP	Growth + or -
61	527	494	-33
62	484	485	1
63	501	446	-55
64	505	534	29
65	527	548	21
66	539	555	16
67	544	546	2
68	552	572	20
69	555	558	3
70	561	568	7
71	566	475	-91
72	537	469	-68
73	488	484	-4
74	571	500	-71
75	550	452	-98
76	469	430	-39
77	483	513	30
78	626	645	19
79	448	374	-74
80	493	446	-47
81	469	512	43
82	491	397	-94
83	510	506	-4
84	514	417	-97
85	531	557	26
86	532	534	2
87	536	567	31
88	554	584	30
Total N	88	88	88

Paired Samples T-tests

Having completed the matching, a t-test was needed to determine the mean scale score difference between Group 1 and Group 2. SPSS was used to run a paired samples t-test. Tables 4.11, 4.12, and 4.13 show data needed to draw conclusions regarding the differences between the two groups.

Table 16. *Paired Samples Correlations 8th Grade CSAP (Pre-test)*

		N	Correlation	Sig.
Pair 1	Group 1 8th Grade CSAP & Group 2 8th Grade CSAP	44	.973	.000

Table 17. *Paired Samples Statistics 8th Grade CSAP (Pre-test)*

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Group 1 8th Grade CSAP	518.14	44	43.775	6.599
	Group 2 8th Grade CSAP	521.95	44	42.601	6.422

Table 18. *Paired Samples Test 8th Grade CSAP (Pre-test)*

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	T	Df	Sig. (2-tailed)
Pair 1	Group 1 8th Grade CSAP - Group 2 8th Grade CSAP	-3.818	10.038	1.513	-6.870	-.766	-2.523	43	.015

The data in Table 15 shows a strong correlation in CSAP scores between the two groups (.973 and a p-value < .01). However, the t-test also reveals that the difference in means (-3.818) is significant (.015alpha level < .05). Group 2 (CAI group) had an advantage over the Group 1 (TOT) of 3.818. Essentially, the CAI group had a mean scale score head start over Group 1 (TOT). This difference in mean scale scores occurred despite the fact that the students were matched as closely as possible.

Because of the difference in mean scale scores, an Analysis of Covariance (ANCOVA) was run on the ninth grade CSAP (post-test) to adjust the mean score differences. Tables 4.14 and 4.15 show the results of the ANCOVA.

Table 19. *Tests of Between-Subjects EffectsDependent Variable:9th Grade CSAP*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	167406.273[a]	2	83703.136	49.166	.000
Intercept	209.660	1	209.660	.123	.727
Pretest	166701.716	1	166701.716	97.918	.000
Group	2002.915	1	2002.915	1.176	.281
Error	144709.716	85	1702.467		
Total	2.331E7	88			
Corrected Total	312115.989	87			

a. R Squared = .536 (Adjusted R Squared = .525)

Table 20. *Group ID*

Dependent Variable: 9th Grade CSAP				
Group ID	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Time-on-task	516.014[a]	6.223	503.640	528.388
Computer-assisted Instruction	506.463[a]	6.223	494.089	518.837

a. Covariates appearing in the model are evaluated at the following values: 8th Grade CSAP = 520.05.

The corrected model shows the f-value to be 49.166 significant at .000 (alpha <.01). The adjusted mean scale scores are shown in Table 19. The almost 10 point difference in scale score points shows that the performance of Group 2 (CAI) was actually worse than the performance of Group 1 (TOT).

Conclusion

The mean scale score differences between Group 1 and Group 2 were significant although not in the direction that supports the alternate hypothesis. Therefore, the alternative hypothesis: ASCEND students will score significantly higher on standardized mathematics tests than students in the previous time-on-task intervention, is rejected.

Chapter 5: Discussion

Educators spend much of their time seeking ways they can provide instructional opportunities, leading to the goal of increased student performance. In the case of Freedom High School, mathematics achievement as measured by the Colorado Assessment of Student Progress was in a four year decline and the efforts of the teachers and administrators did not seem to be effective. The negative trend in student achievement scores led to increased pressure from the superintendent and central office administrators. Also, the demands for meeting the requirements of “No Child Left Behind” (NCLB) legislation created tension among the staff members at FHS. Responding to the need to do things differently, an effort was made to come up with a different approach to increasing student achievement. The ASCEND mathematics program was selected to achieve this purpose. The ultimate reason for this study was to determine the utility of the ASCEND program. Since the results of the study appear to disprove the original hypothesis, a thorough analysis of the reasons for this must be considered in order for FHS to find methods that will enable students to be successful in their study of mathematics.

Results: Why did the program fail to improve student achievement?

The reasons for the program falling short of obtaining the expected results can be explained by addressing three issues. First, there were problems associated with execution of the quasi-experimental matched-pair design. Second, there was a failure to maintain fidelity to the ASCEND program. There were some unintended issues that developed because of how the ASCEND program was structured. Finally, the ASCEND program did not address the issues regarding students understanding of the basic skills and concepts being taught.

Problems associated with the matched-pairs design.

The strength of a matched-pair design is that it allows educators to compare treatments without having to use randomized groups. It is difficult to assign students in advance to one treatment or another. In the study, the time-on-task treatment was no longer in use for anyone in Group 2. It would also be unethical to assign students to a treatment that was not getting the intended results. Therefore, random assignment to both treatments was not plausible.

The matched-pair design also helps the researcher control for variables that could skew the data. When matching students based on several key variables, individual differences of the subjects are negated. However, even though the matched-pair design is a practical solution for educators, it does not eliminate all the issues. Although this study controlled for ethnicity, gender, socioeconomic class, and pre-test score, there are other confounds that could have influenced the results. Decisions made on which variables to include may be invalid or have flaws. For instance, scale score differences between students had to be decided upon. Based a study of scale score cut points related in the CDE technical report (p. 69), students were matched if their scale score was within 26 points. If this decision led to matching two students who were not close in mathematical ability, the results of the study could be impacted.

It was not possible to control for all confounds as well. There were 11 teachers assigned to facilitate the ASCEND program. Several of these teachers were within the first few years of teaching. Teacher inexperience could have impacted students' success in the program. Another confound is the high transiency rate at FHS. A high percentage of students transferring to the school came from a military post having a poor academic reputation. Students leaving the school benefited from a focused effort on improving achievement for the three to five years while attending schools in the district.

More subjects were needed in the study. Although matching subjects increases the power of the study, the process of matching does eliminate potential subjects. In this case, Group 1 had 120 students who took the TOT treatment. From that group, one third of the students had to be eliminated as possible matches because they did not have a pre-test score or a post-test score. Group 2 started with over 400 students but because of the same problem, only 235 were left to go through the matching process. Only 44 matches could be produced from the number of students who took both the pre-test and the post-test. The fact that there were unequal groups and many students had incomplete data sets made it difficult to find a sufficient number of matches to give the study more power.

The quasi-experimental matched-pair design was selected because it allowed for a comparison of two groups. Because random assignment could not be used, the matched-pair study presented a way to effectively make comparisons between two interventions. It should be noted that the results of the study could have been impacted by the fact that not all variables could be controlled for and there were not enough subjects.

Lack of fidelity.

The inability to maintain fidelity to the treatment was the key factor in Group 2 failing to improve in relation to Group 1. The lack of fidelity has a multitude of components and must be discussed at length. Included in the discussion are the following issues: problems associated with the first year of implementation (mostly issues dealing with technology) and lack of teacher training.

First year problems with technology.

There are always issues when a new program is implemented. This was the case for FHS. Despite piloting the ASCEND program in the summer of 2009, all the technology issues were not worked out. For the first few months, the video tutor segment of the program would not function properly. In retrospect, this problem was critical for the teachers. With average class sizes at around 27, the teachers worked extremely hard to touch base with each student. In the 43 minute class period, many teachers complained that they did not have enough time to get to every student. The video was meant to help the teacher. A student who may not understand a concept could access the video and an award winning mathematics teacher would demonstrate for the student how to solve the problem. Students who showed the ability and motivation could work through most concepts with the help of the video (and the other resources provided, such as practice problems and math manipulatives). This, then, freed the teacher to work with students who struggled more than others.

The lead teacher for the ASCEND program dealt with these video issues. He worked with the FHS technology department and the parent company of ASCEND. At one point he wrote, “The original ASCEND fix doesn’t seem to be proving reliable in all cases. We have students with freezing video and the inability to stream video at home. Ted's idea to fix ASCEND is turning out to be a successful solution so far. SOOOO, starting Monday we are going to begin implementing our solution to all ASCEND students class by class" (Personal Communication, August, 8, 2009). Unfortunately this second attempt at a fix did not provide a permanent solution. The video issues plagued the students and staff for over two months.

In this the third year of being a one-to-one laptop computer school, many computers were experiencing problems. The end result was that students sometimes had to go days without a computer. From time to time, the wireless environment at the school would not work. When this happened, the ASCEND program, which was Internet based, would slow to a mind-numbing pace or not be available. Teachers would have to do something else with their students during these slow days. At one point, all teachers joked that they were spending more time with "Plan B" over a period of time than on the ASCEND program. Problems with technology led to student and teacher frustration and this impacted the ability of the teachers to implement the program.

Teacher training.

There were a number of teachers who had to be trained to implement the program and this hurt the ability to maintain fidelity to the ASCEND program. Eleven teachers were used to teach 17 sections of the ASCEND program. Two of those teachers taught summer school and piloted the program. They had the responsibility of training the other nine teachers to navigate the program on the computer. The training took place on a day before school began. One teacher was not present for the training. He was hired after the school year started. It did not take long to determine that more training was necessary to help teachers deal with the implementation of the ASCEND program. Working to keep the fidelity of the program was a constant battle. Some teachers had great success because of their demeanor and abilities. A few teachers struggled because they did not know the program well enough from the beginning. Other teachers struggled because they lacked classroom management skills. Better training and teacher preparation would have helped solve some of these issues.

Lack of Cohesiveness in the ASCEND Program

The ASCEND math program was selected for use at FHS because many students coming to the ninth grade were lacking in many foundational mathematics skills. In previous years, mathematics teachers were spending an inordinate amount of time re-teaching basic concepts such as multiplication and division of whole numbers and fractions. It was felt that the CAI program could help students achieve mastery in the basics and this would leave more time for algebra teachers to teach algebra. However, not all teachers believed in the approach or were able to motivate students to follow the program. It was not long before some teachers were trying to figure out how to manipulate the program to fit their needs or beliefs. A memo from the lead teacher to all the ASCEND teachers outlines some of the issues and concerns that were shared by the teachers. It is reprinted here to help illustrate the teacher perspective.

> After talking with a lot of you, it sounds like lunch Monday is the best time for us to meet. So plan on eating lunch in my room Monday while we brainstorm a few Ascend ideas. You don’t need to bring anything to the meeting but an open mind, some ideas, and positivity. I recommend answering these questions, writing them down, and emailing them to me. I will post them on my board and we can talk about them to make the meeting more efficient. This may take more than one lunch to get through, so plan on Tuesday as well if we can’t meet after school.
>
> The topics that will be discussed include the following in order of importance:

> 1. How can we effectively track growth for Ascend? Currently we can't. One idea is a set pre and post-test for a set amount of objectives that will be assigned to students individually by the teacher. I will create the tests using Ascends test bank and Ascend will grade them, but you will have to track progress, find deficiencies, and assign the quizzes as the students reach specific points in the program. Other ideas are very welcome, this is just what we've come up with so far?
>
> 2. Is the 5th grade level appropriate for all of our students to start in? Justification and comments are wanted here. What do you think about this and should we think about changing it?
>
> 3. What kind of motivational techniques should we begin to implement in Ascend? Challenges, contests, pizza parties, group motivation with all classes and individual classes are wanted here.
>
> 4. Should we take Wednesday each week to implement a gold seal lesson or a math lesson/project each week to help students in their Algebra or Geometry classes? If so, what will this look like and what kind of lessons should we implement?
>
> 5. Expectations for the teacher and the students…If teachers start pulling student groups out for group instruction what could that look like, what data could we use to identify the students and how will it look when implemented? Student expectations… If we require work and notebooks how can we grade, monitor, and check for understanding and retention of material? What kind of grade, if any, do we give for notebooks?
>
> These are some of the things we are going to look at changing pretty quick. If there is any other concern you can see with Ascend, please be prepared to discuss this with the group. Videos and technical issues are not going to be discussed at this particular meeting because they are still being figured out by T. and L. right now. Please write a few things down to answer these questions and we'll get to it on Monday. Our goal is to brainstorm right now, not make final decisions. (Personal Communication, September, 18, 2009)

The email (personal communication) suggests that some teachers were struggling with certain aspects of the ASCEND program and there was a need to work out these issues. The lunch meeting was called to help resolve some of the issues surrounding their frustration. The main areas of concern were tracking student progress, dealing with students who were bored with the skill and drill nature of the program (thus the talk of

“Gold Seal Lessons” or activities that were more problem-based), and motivating students to stay focused. These issues caused some teachers to divert from the program and try different strategies with their students.

Another concern coming from the teachers as they tried to implement the program was the traditional nature of the mathematics instruction in the videos provided by the program. Many teachers felt that the video was just another teacher standing at the board teaching mathematics the same way students were being taught in previous years. The general opinion was that these students did not learn the concepts with a traditional approach the first time and the program was only giving them more traditional instruction. Meanwhile, another concern was raised. Students had no way to relate what they were learning in the ASCEND program directly to their algebra class. Algebra teachers complained students needed more help with issues that connected to the objectives being covered in their classes. In essence, the ASCEND math program did not align with the algebra curriculum being taught.

As a result of teacher concerns, an email was sent from the principal’s office requesting that teachers submit what they felt were the strengths and weaknesses of the program to date. The email sent on November 15, 2009, solicited teacher feedback at a point when the technical aspects of the program seemed to be working. There had not been many issues related to technology the previous month and few complaints were registered. However, the data indicated that many students were still at their original level and not making progress. Table 21 summarizes the strengths and weaknesses submitted by most of the eleven teachers and it gives some insight into how the program was working at the mid-point of the school year.

Table 21. *Strengths and Weaknesses of the ACSEND Program*

Strengths

1. Most students have settled in and come to class prepared to work
2. The course is the embodiment of differentiated instruction
3. The course does address fundamental skills necessary for success in math
4. The repetition is a strength for the weaker students
5. The program correctly identifies areas where the students have gaps in their knowledge and need additional help
6. The questions are appropriate for the material being covered and requires the students to have a basic level of understanding in order to pass the post-assessments and quizzes
7. For those who are motivated by grades/points/accomplishing tasks, the program works well
8. Students are working on the program at home despite having a grade over 100% so it does motivate certain students.
9. Allows students to work at a pace suitable to their needs
10. The program does a great job of spiraling the content.
11. The immediate reinforcement of successfully passing objectives is important for students.
12. The program provides an additional means by which the student can learn math.

Weaknesses

1. Many of my students log time but do not pass objectives
2. There is no rigor and no relevance. Students will move from one objective to the next eventually but they still do not retain much from previous objectives
3. Some students don’t watch the video, don’t take notes, don’t do practice problems, and then ask for my help
4. There is no accountability other than grades

5. Students work for the grade, not for increased knowledge/understanding
6. Repetition is a weakness for the stronger students
7. The video is boring for many students
8. The program is not well suited for students who are easily distracted and need more variety in the classroom. It is difficult for the teacher to engage the students based on the day or the period since it is the same thing every day.
9. Several students have figured out how to "game" the system by jumping to the post-assessment without necessarily doing all of the intermediate tasks.
10. One or two disrupters in the class can throw the whole class off and make it difficult to keep everyone focused.
11. The weakness of the program occurs when teachers believe the program will run the classroom. The teacher needs to be the focal point of the classroom while the program supports and reinforces the beliefs of teacher. I have been disappointed in the efforts of some of my colleagues as too many of them simply sit back and expect ASCEND to do their job (Personal Communication, November, 15, 2009)

The chart reveals the varied thoughts and opinions of the teachers as well as the philosophical differences teachers had with the ASCEND program. The lack of cohesiveness among the 11 ASCEND teachers led to a failure to consistently execute the ASCEND program across all 17 sections. Students did not get a consistent educational experience. This inconsistency played a role in students not performing as expected on the ninth grade CSAP.

Unforeseen and Unintended Consequences of Computer-assisted Instruction

FHS administrators and the lead teachers built the structure of the program with the intent of helping students improve their mathematics achievement. However, some issues developed that were not foreseen when the plan was rolled out. The two main issues were class size and student motivation.

From the beginning of the researching phase for a new intervention in the spring of 2009, an understanding among the staff members was that a CAI program would be able to assist more students than current practice was allowing. Over 70% of the ninth grade class had some sort of mathematics deficiency. The problem was how to meet all their needs. It was felt the computer could provide individualize lessons for each student and the teacher could facilitate student learning based on what the computer dictated. It was felt that if several teachers took one or two sections of the ASCEND class, it would not impact their ability to plan for other classes. Consequently, the decision was made to include every student not proficient or advanced in CSAP. Consequently, the number of students placed in the intervention was over 400. This meant that class sizes went from 15-20 in previous years to 25 – 30.

The computer could handle this number of students but the individual teachers struggled. When broken down, a 43 minute class period allowed for about 2 minutes per student if the teacher worked with everyone. Of course some students needed more help than others but the end result was that some students would go days without any direct interaction from the teacher. Some students were fine working on their own. Other students would sit idle waiting for the teacher to help them. Many students lacked the initiative to pursue the different parts of the program that could help them. Instead, they would wait for the teacher. Large class sizes made it difficult for students to get the help they needed.

Low achieving students exhibit characteristics that make a teacher’s job difficult. Many students lack the motivation and work ethic to close their own achievement gap. Most low achieving students at the high school level have had a history of low achievement in mathematics throughout their history in school. The reasons for the lack of success are varied. Poor math instruction in previous grades, lack of interest, poor support at home, and lack of readiness for more complex math concepts, are reasons that students come to high school lacking the preparation to do well in math. Motivating the struggling student is difficult and the ASCEND program did not provide the type of environment that was hoped for when the program was implemented. An additional factor was that all the successful students who could be positive role models for the struggling students were not available. Every teacher had to deal with a classroom full of unmotivated students.

Some teachers developed motivational strategies to help keep students focused. They posted wall charts where students could show their progress (and see the progress of others). Teachers shared data garnered from the ASCEND program with students. This data could show students more details of what they had accomplished. Teachers also worked on changing the way they graded. It was very difficult to find a way to motivate the student who worked hard but did not show enough progress to get a great grade. These students became highly frustrated when they saw a low grade, yet, were working as hard as they could. Some other motivational techniques included setting goals, pizza parties, contests, class competitions, and group strategies. However, most teachers found that the best method was working with students one-on-one. These personal conversations helped students the most. One teacher communicated his frustration to the principal by stating, “The problem that I have is not really with ASCEND. ASCEND still does not reach that kid who is unmotivated to learn. That kid will tell you that the lady in the video is boring (or that the video won’t play at all).

Another kid will tell you that his computer needs to go to E.R (the technology repair shop). Still another kid will find any excuse not to get better" (Personal Communication, November, 11, 2009). Motivating students to use the ASCEND program as it was designed was at the forefront of teacher frustration in implementation of this CAI program.

Recommendations for Future Programs

This study compared two mathematics interventions used at FHS. The reason for the study was to determine if the CAI intervention, ASCEND, would improve student achievement. Having shown that the ASCEND program did not have a significant impact on the sample students, it is important to reflect on possible recommendations for any future implementations of computer-assisted instructional programs.

Give struggling students more time.

One of the biggest complaints from teachers was the lack of time that could be spent with students. Often teachers would be monopolized by one or two students during a period. This meant other students would not get their needs meet. At times, struggling students would sit and wait for the teacher. This idle time sometimes digressed into misbehavior which then impacted the attitude of the other students. The strength of the ASCEND program was that it could differentiate for each student. However, the teachers could not divide their time in a way that ensures that students received the help they needed.

This issue was manifested because of the large class size alluded to earlier in Chapter Three and in the previous section. Having over 400 students in the intervention meant that teachers had to address the needs of many students instead of a few. The students needing the most help missed opportunities for that help on occasions in class.

Research-based pedagogy is the key.

Using computers in the mathematics classroom must include more than just recreating the methodologies that already exist there. The studies suggesting that computers can increase student engagement, individualize instruction, and give immediate feedback (Hannafin & Foshay, 2004; Kulik & Kulik, 1991; Stacey, 2002; Hsu, Wu, & Hwang, 2007; Toumasis, 2006) are meaningless if students do not develop an understanding of the concepts they are being taught. One FHS teacher stated that the computer program effectively modeled what we had already been doing in the classroom (Personal Communication, February, 5, 2010). In other words, the computer effectively gave the students exactly what they had been getting for years. This was not the answer the staff at FHS was looking for when investigating a change that would make a difference for struggling mathematics students. The computer needs to create opportunities for students to apply what they learn instead of reinforcing the memorization of formulas and algorithms.

Technology used by the ACSEND program excited students for a short period of time. It engaged students at higher levels at the beginning of the year. However, as the year progressed, more and more students became disenchanted with the program. Management of the classroom became more difficult for the teachers with less experience teaching. Butty stated that, “According to Fennema, Carpenter, and Peterson (1989), students who experience this reform tradition are encouraged to explore, develop conjectures, prove, and problem solve. The assumption is that students learn best by resolving problematic situations that challenge their conceptual understanding (p. 20-21). The technology solution picked by FHS addressed the weak fundamentals issues shown by students but did not help students with their fundamental lack of understanding of those key concepts.

The fundamental needs of struggling math students calls for more attention than an instructional program based on improving basic skill through memorization of skills and concepts. “The National Research Council has dubbed the ‘learning’ produced by such instruction as ‘mindless mimicry mathematics.’ Instead of understanding what they are doing, students parrot what they have seen and heard” (Battista, 1999, p.2). At the core of the student misunderstanding is a lack of ability to relate the concepts to something that makes sense. Batista outlines what is needed in mathematics classrooms that will improve student learning.

> Sound curricula must include clear long–range goals for ensuring that students become fluent in employing those abstract concepts and mathematical perspectives that our culture has found most useful. Students should be able to apply, readily and correctly, important mathematical strategies and lines of reasoning in numerous situations. They should possess knowledge that supports mathematical reasoning. For instance, students should know the ‘basic number facts’ because such knowledge is essential for mental computation, estimation, performance of computational procedures, and problem solving. (Battista, 1999, p. 3)

Skouros (2006) wrote that technology could build student capabilities to use conjecture, help students accurately compute allowing more time to analyze the data, and explore mathematics multiple representational forms. Technology can add value to a classroom if applied in appropriate ways.

Final Remarks

The ASCEND program was used in an attempt by school administrators and teachers to meet the fundamental deficiencies students had in mathematics. The computer-assisted instructional program supported teacher efforts to address individual needs and have students work at their own pace prescribed by their ability, work ethic, and interest level. Most students took advantage of the time they were given to work on the program and made progress toward improving their skills. However, the matched pair study revealed that Group 2 (CAI) performed worse on the CSAP Ninth grade assessment than did Group 1 (TOT). The disappointing results left teachers and administrators asking, “What did the students really learn?”

Knowing that student achievement in mathematics in the United States is low and that mathematics instruction appears to not have effectively changed in the last century has put additional pressure on mathematics educators. It has become a moral imperative for today’s educational leaders to design strategies that will improve mathematics achievement for students. The idea that traditional mathematics instruction is about learning skills and procedures misses the point that understanding the fundamentals is only as good as a student’s ability to apply what they have learned. The research that challenges the antiquated approach to mathematics instruction underscores the fact that mathematical concepts must also be understood in order for students to learn mathematics effectively (Stigler & Hiebert, 2004).

During the spring of 2009, pedagogical approaches were not debated as the staff at FHS decided on the type of intervention to be used to improve mathematics achievement in the school. Instead, school leaders focused on technology that could provide the support students needed. The research mathematics achievement indicates students can benefit from the targeted instructional strategies. Computer-assisted instructional programs, some of them mentioned in the literature review, have the ability to develop individualized lesson for each student. The leaders at FHS felt this was a huge advantage over what a teacher could develop. Research surrounding student engagement and confidence indicates student achievement improves when using computer-assisted programs (Kulik & Kulik, 1991). This in part due to the fact that computer-assisted instructional programs have technology-based manipulatives that give students opportunities to see the mathematics take form in front of them. Because of the positive indications in the research, administrators at FHS believed that using a computer-based program would help increase the basic skill level of students and thus improve student achievement and thus, the decision was made to use CAI.

This study revealed that the CAI intervention did not work as hoped. Although technology addressed many of the identified needs of struggling mathematics students, the ASCEND program did not address the pedagogical changes necessary to help students gain a better understanding of what they were learning. In the end, The CAI program was able to identify individual deficiencies among the students but used many of the same traditional pedagogical methods that had been used in the past with these students. The result was achievement did not improve.

This researcher believes that working to improve student achievement should begin with what is the best way to get students to understand what they are being taught and, unfortunately, FHS school leaders did not begin their discussion with this in mind. It is hoped that the lessons learned in this high school’s attempts to improve mathematics achievement will assist others in their similar efforts by encouraging consideration of pedagogical changes in the classroom.

Jo-Anne Butty (1991) and this researcher believe that effective mathematics instruction must engage students in a variety of ways. Students must be able to construct their own meaning and they can do this by exploring, reasoning, and thinking critically. To assist students, teachers need to use a variety of resources like math manipulatives, technology and relevant activities which help deepen student understanding. The new pedagogy must give students opportunities to develop their own thinking, make conjectures, be creative, and promote their explanations. In the end, teachers must abandon tradition, contrived acts of memorization and regurgitation, and employ pedagogical practices that inspire student learning and understanding.

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Appendix A

State CSAP math scores for each year and grade

Grade	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3						68	71	68	70	69	71
4						66	69	71	68	70	70
5		53	55	56	59	63	65	65	65	63	66
6			51	50	53	56	57	60	61	63	61
7			39	41	41	46	45	50	46	54	49
8	35	39	39	38	41	44	45	46	47	50	51
9			31	31	32	33	38	35	38	35	39
10		25	27	27	27	30	31	30	30	30	30