THE RELATIONSHIP BETWEEN COMPUTER-ASSISTED INSTRUCTION AND ALTERNATIVE PROGRAMS TO ENHANCE FIFTH-GRADE MATHEMATICS SUCCESS ON THE ANNUAL TEXAS ASSESSMENT OF KNOWLEDGE AND SKILLS

Tommy Howard Tucker, B.S., M.Ed.

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APPROVED:

Jimmy K. Byrd, Major Professor
John Brooks, Committee Member
Richard Fossey, Committee Member
Simon Andrew, Minor Professor
Nancy Nelson, Chair of the Department of Teacher Education and Administration
Jerry Thomas, Dean of the College of Education
Michael Monticino, Dean of the Robert B. Toulouse School of Graduate Studies

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The purpose of this study was to determine the relationship between using computer-assisted instruction (CAI) and success on the Texas Assessment of Knowledge and Skills (TAKS) mathematics exam with fifth-grade students in Texas compared to the effect of alternative improvement approaches used by a control group. Research explored the use of SuccessMaker® CAI educational software (Pearson Education, Upper Saddle River, NJ, www.pearsoned.com) in public elementary schools in Texas.

Successmaker® CAI was not a good predictor of passing percentage on the mathematics TAKS. Multiple regression analysis utilized in this quasi-experimental design study predicted a negative and not statistically significant change in the percentage of students passing the mathematics TAKS exam (B = -.448, p > .05). SuccessMaker® use exhibited a very small effect size (r = -.04) and accounted for less than 1% of the change in passing percentage (r^2 = .0016). Multiple regression model predicted a negative and statistically significant effect upon mathematics passing percentage by economic disadvantage percentage (B = -.211, p < .01). The 95% confidence interval for B ranged from -.365 to -.057. The large effect size correlation coefficient (r = -.51) accounted for 26% of the variance in the mathematics TAKS passing percentage (r^2 = .26).

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Finally, the project possibly would not have been completed with my sanity intact during the last nine months of full-time dissertation writing if it had not been for periodic interruptions by my granddaughter, Olivia (1½ years old) who kept me grounded by reminding me with her presence why I was engaged in this project. The periodic monitoring of my condition by the in-residence granddog, Kandace, provided amusement. Finally, the vocal and insistent grandcat, Munchkin, had to have her 2:30 afternoon petting session thereby preventing me from becoming too self-absorbed.

My appreciation is extended to each person and companion that contributed in his or her own special way to the successful completion of this project.

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CHAPTER I

INTRODUCTION

More than 11% of Texas school districts are currently employing SuccessMaker® computer-assisted instruction software (CAI) (Pearson Education, Upper Saddle River, NJ, www.pearsoned.com), but there is no statewide scientific research assessment of its effectiveness (K. Kleine, personal communication, February 27, 2008; Texas Education Agency, 2009). Several empirical studies conducted on instructional software use indicated that technology-based drill and practice can improve student performance in specific areas of mathematics, for example, at specific grade levels, in specific subjects, and on specific instructional outcomes (Christmann, Lucking, & Badgett, 1997; Kulik, 2003; Mintz, 2000; Underwood, Cavendish, Dowling, Fogelman, & Lawson, 1996). Underwood et al. (1996) reported a “substantial” effect size of 0.4 for mathematics with the use of computer-assisted instruction (CAI) after their six-month study. In addition, Mintz (2000) found positive nominal but not statistically significant gains in critical-thinking skills by students in mathematics classes after using CAI.

CAI was designed to improve mathematics scores through individualized instruction among students who arrive at school with varying levels of knowledge, understanding, and misunderstandings. This heterogeneity of students presents the need for individualized instruction (Suppes, 1967). While teachers provide individual assistance to the extent possible (which is limited since there are 20-30 students in each classroom) (Cuban, 1986), CAI provides targeted, individualized instruction and guided practice to students in their specific areas of deficiency. In the traditional classroom setting, students would have to wait their turn for assistance from the teacher. While waiting, students at times practiced new mathematics skills incorrectly or continued to practice misunderstood concepts from previous instruction without correction. It was purported by the developers that CAI could eliminate this detrimental wait time and provide tutoring where needed to improve mathematics learning (Suppes, 1967).

The developmental path of CAI began simply as an electronic form of programmed learning but later incorporated developments in artificial intelligence as they emerged so that CAI became an instructional system to assist teachers. Skinner's work in programmed instruction based upon behaviorism provided an initial model.

Theoretical Framework

Behaviorism

According to Suppes (1978) and Atkinson (1968), CAI can increase student learning through the process of interactions with a computer program on an individual basis. While CAI appears to be a novel concept, CAI fits nicely with Skinner's work in programmed instruction (Reiser, 2001b). Skinner (1954) proposed that programmed instruction materials provide instruction in small steps, require direct responses to frequent questions, provide immediate feedback, and allow self-paced learning. Skinner's work was based upon Thorndike's learning theory of behaviorism (Niemiec & Walberg, 1989; Saettler, 1990). Mastery learning theory is also associated with behaviorism.

Mastery Learning

Mastery learning theory and constructivism were fundamental in the development of CAI. These were also the guiding theories of this study. Mastery learning from Block and Bloom along with cognitive psychology from Simon, Newell, and Zhu and constructivism from Piaget, Kant and Dewey, and Vygotsky contributed to the development of CAI. Benjamin Bloom and James H. Block in the late 1970s developed the modern version of mastery learning originally developed by Henry C. Morrison in the 1930s. Mastery learning is associated with behaviorism and emphasizes cognitive, affective, and psychomotor objectives. The major premise of mastery learning is that academic skills can be mastered by almost all students when they are provided quality instruction and sufficient time to learn. Mastery learning is best suited for hierarchical or sequential subject matter (Block, 1971; Saettler, 1990).

Mastery learning theory along with programmed instruction is alluded to as the basis of Suppes's (1967) computer tutoring program plans. There are six main components of CAI: (a) content coverage and dynamic ordering of concepts, (b) distributed presentation of instruction based on strands, (c) initial adaptive placement, (d) learning models for judging mastery, (e) retention models for assigning review, and (f) decisions on tutorial intervention (Block, 1971; Dalgarno, 2001; Saettler, 1990). Increase of acceptance of constructivism at the expense of behaviorism lead to significant changes in teaching and learning practices.

Constructivism

Constructivist theories of teaching and learning have had consequences for computer-assisted learning (Dalgarno, 2001). In the field of psychology, the cognitive view of learning has overshadowed the behaviorist view. Dalgarno notes that the behaviorist view of learning places emphasis upon repetitive conditioning of learner responses while the cognitive view emphasizes the learner's cognitive activity and the mental models formed during the process.

Preconstructivist computer-assisted instruction tutorial systems were essentially computer based forms of programmed instruction modeled heavily upon Skinnerian behaviorism including drill and practice materials. Intelligent tutoring systems, developed with input from cognitive psychology studies, now use artificial intelligence techniques that model expert knowledge and utilize models of the learner's current knowledge to develop a course of instruction tailored to the individual learner (Dalgarno, 2001).

Cognitive Psychology

Newell and Simon's (1972) work at Carnegie-Mellon University using computers to simulate human behavior contributed to intelligent tutoring. Intelligent tutoring was developed by combining artificial intelligence with a comprehensive database of domain knowledge from the Stanford tutoring program. Newell and Simon also reported on the nature of expertise. It was determined by Newell and Simon that experts had specific and more efficient strategies for solving problems than those of novices. Expertise, then, is comprised of both domain knowledge and a set of strategies for exploring and using that domain.

Newell and Simon (1972) were involved in human organizational behavior during the 1940s and 1950s and were influenced by control theory, information theory, operational mathematics including game theory and decision theory, computers, and programming. The development of the science of information processing or computer science led to the study of thinking and problem solving. The study implied "that thinking can be explained by means of an information processing theory” (p. 5). Subjects were asked to solve problems and to think out loud while doing so. Responses were used as data to analyze the human problem solving theory and to develop a problem solving simulation program.

Zhu and Simon (1987) related that students can learn from studying examples alone without lectures or direct instruction. It was conjectured that the computer could choose the examples, present them to the student, monitor the student’s performance, and sequence the instruction. Over a 4-year period, experiments were conducted with Chinese middle-school students. Students in fifth, seventh, and eighth grade classrooms comprised the experimental and control groups. The tasks to be learned involved simplifying fractions, factoring quadratic expressions, manipulating terms with exponents, and solving geometry problems. In the factoring experiment, School A experimental group average posttest score of 93.13% correct, when compared with the control group score of 75.50% correct, produced a statistically significant *t*-test difference $p < .00l$. Total sample size was 64 with 32 students in each group. On the other hand, School B experimental and control group posttest scores were 97.23% and 95.08% correct respectively. Difference was not statistically significant. Total sample size was 77 with 39 students in the experimental group and 38 students in the control group. The experiments involving the other tasks produced results that were not statistically significant. Experimental groups while learning from examples required less time to learn the tasks and performed as well as or slightly better than control groups being taught in the conventional manner.

Simon's (2002) research in human problem solving revealed that experts are able to recognize "even hundreds of thousands" of familiar patterns in daily experience compared with many fewer by novices. Example of the experiment with the master and novice chess players is presented to support his position. Both players are shown a chessboard from an unknown game from which the pieces are removed after about five seconds viewing. The master can replace the pieces in their correct spaces with only two or three mistakes while the novice can only replace six or seven correctly. When the pieces are placed on the board randomly, the novice can still replace six or seven pieces while the master can replace only seven or eight pieces. It was contended that the mental images of familiar chunks of information held by the master made the difference in performance.

Additionally, Simon (2002) restated experimentation findings that learning from examples is an extremely powerful and efficient way to learn. Simon cautioned, "The new technology will improve education only to the extent that it induces continuous mental activity in the student by presenting tasks that require thoughtful responses" (p. 69).

Intelligent tutoring systems (ITS) combined Suppes's work on understanding the patterns of student error with Simon's work on using computers to simulate human behavior. Computer development had attained the ability to learn to understand the student's problems and level of knowledge in order to begin to bring the student's mental model into line with that of an expert. The computer became a "smart" tutor (Brady, 2007). By the end of the developmental period, SuccessMaker® had become one of these "smart" tutor computer programs.

Purpose of the Study

The purpose of this study was to determine the impact of SuccessMaker® CAI on improving student achievement on the Texas Assessment of Knowledge and Skills (TAKS) mathematics exam among fifth-grade students in Texas.

Importance of the Study

Examining the use of SuccessMaker® CAI in Texas is important because more than 11% of Texas school districts (140 of 1,222) are currently employing the software while there is no statewide scientific research assessment of its effectiveness (K. Kleine, personal communication, February 27, 2008; Texas Education Agency, 2009). Furthermore, the National Mathematics Advisory Panel (2008) recommended that more rigorous studies on topics of mathematics education be conducted, such as randomized controlled designs or methodologically rigorous quasi-experimental designs which involve adequate statistical power.

Additionally, the National Mathematics Advisory Panel (2008) recommended more research on issues related to software use in the areas of implementation according to developer's guidelines, integration into the curriculum, and the use of software to replace or supplement other instruction. Generally, it is expected that research would be conducted before the outlay of large amounts of funds. Interestingly, the recommendation came 11 years after the President's Committee of Advisors on Science and Technology urged dramatic increases in the percentage of expenditures for computer and information technologies for classroom use. These technologies were to provide academic content and not merely teaching about technology (Hickey, Moore, & Pellegrino, 2001).

Despite the recommendations and dramatic increase in public expenditure for computer and information technologies in classrooms, a crisis in K-12 public education in the United States still persists. Children in the United States are not as fluent in mathematical computation as children in other countries. The National Mathematics Advisory Panel reviewed more than 16,000 research publications and policy reports in keeping with the President's commission to use the best scientific evidence available to develop the panel's recommendations for improvement in mathematics education in the United States.

Compared to other developed countries, "few curricula in the United States provide sufficient practice to ensure fast and efficient solving of basic facts combinations and execution of the standard algorithms" (National Mathematics Advisory Panel, 2008, p. 26). In fact, there are significant differences in fluency of mathematical computations between children in the United States and in countries with higher mathematics achievement, which can be traced to differences in the quantity and quality of practice, emphases of the curricula, and parental involvement in mathematics learning (Miller, Smith, Zhu, & Zhang, 1995; Miura, Okamoto, Kim, Steere, & Fayol, 1993; Steel & Funnell, 2001; Stevenson et al., 1990).

Developers of SuccessMaker® CAI contend that their program provides individualized instruction that meets the need of students to improve mathematics skill development. This contention led to the development of the following question that provided guidance for the study.

Research Question

Does SuccessMaker® CAI impact mathematics performance among fifth-grade levels?

Effort in Mathematics Education

A successful mathematics education program provides students with college and career options and increases students' likelihood to gain future income (Horn & Nuñez, 2000)**.** However, the United States has a serious problem with mathematics literacy. The mathematics crisis is further underscored by Phillips (2007), where he found that 78% of adults cannot explain how to compute the interest paid on a loan, 71% cannot calculate miles per gallon on a trip, and 58% cannot calculate a 10% tip for a lunch bill. Additionally, it is clear from the research that a broad range of students and adults also has difficulties with fractions, a foundational skill essential to success in algebra, according to Hecht, Vagi, and Torgeson (2007) as well as Mazzocco and Devlin (2008).

The current mathematics program in the United States does not seem to be successful. National Assessment of Educational Progress (NAEP) tests students in Grades 4, 8, and 12 in mathematics and reading. Review of the mathematics results supports the contention that a crisis in mathematics literacy exists. Fewer than half of the students tested at Grades 4 and 8 scored at or above the proficient levels. Even though there is an improving trend for both grade levels, eighth-grade students continue to lag behind fourth-grade students. These are different tests based upon the mathematics concepts that are expected to be learned at the respective grade levels by the time of the test. Assuming that the tests are valid and reliable, the concern is generated that students are not maintaining a positive learning rate between testing cycles. Additionally, overall mathematics performance is low. Only 39% of eighth-grade students scored at or above the proficient level in mathematics learning on the 2007 mathematics NAEP, compared to 45% of fourth-grade students (U.S. Department of Education, 2003, 2005, 2007).

Although the general public seems to hold the idea that success in mathematics learning is largely a matter of inherent talent and not effort, research has shown that most children's beliefs about the relative importance of effort and ability or inherent talent can be changed. Studies have also shown that increased emphasis on the importance of effort is related to greater engagement in mathematics learning and with this engagement followed improved mathematics grades and achievement (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 1999).

Roschelle, Pea, Hoadley, Gordin, and Means's (2000) cognitive research examining the mental processes of thinking, perceiving, and remembering revealed that the four basic characteristics of the most effective learning are: (a) active engagement, (b) participation in groups, (c) frequent interaction and feedback, and (d) connections to real-world contexts. Lessons that are conducted including none or only some of the effective learning characteristics were likely to lead to a lack of understanding of the mathematics concepts presented.

Piaget (1973b), an early constructivist, recommended that teachers use active learning approaches that allow the student to acquire new truth through spontaneous research in order to rediscover or at least to reconstruct new information by the student. In this approach, the school teacher needs to become a mentor who can stimulate initiative and research instead of a lecturer providing canned solutions.

CAI in mathematics was built upon the theoretical foundation of behaviorism. It might be questioned whether CAI would be compatible with the current constructivist style of instruction. The theoretical framework for the development and use of CAI to meet the need for improved academic success in mathematics moved beyond behaviorism to embrace mastery learning and constructivism.

Duschl, Schweingruber, and Shouse, (2007) stated, “What is developmentally appropriate is not a simple function of age or grade, but rather is largely contingent on prior opportunities to learn” (p. 2). Piaget (1973b) came to the same conclusion previously. After conducting more than 120 investigations involving children ages 4 to 5 and 12 to 15 with mathematics concepts, Piaget reported that all of the students, both boys and girls with few exceptions, made the same effort and had the same understanding of mathematics. It was Piaget’s opinion that the difficulty in understanding mathematics by students was a result of not understanding the “lessons” instead of not understanding the subject of mathematics. Piaget’s point suggests that the quality of teacher effort is important along with student effort in the learning process.

Contributions of the Study

Contributions to the Literature

This study makes contributions to the literature in two ways. First, the study adds to the knowledge concerning the value of computer-assisted instruction in general and the impact of the SuccessMaker® software in particular. There are numerous studies that have reported upon CAI at all education levels including kindergarten through university (Christmann, Lucking, and Badgett, 1997). However, there are only a limited number of studies that address the results of the use of SuccessMaker® software

(Mintz, 2000; Pearson Digital Learning, 2002; Phillips, 2001; Underwood, Cavendish, Dowling, Fogelman, & Lawson, 1996).

Second, this study shows that there were no statistically significant gains made in student achievement of mathematics with the use of SuccessMaker® CAI. Multiple regression analysis results yielded no statistically significant difference in passing percentage on the mathematics TAKS by fifth-grade levels using SuccessMaker® and fifth-grade levels using alternative improvement approaches ($B = -.448$, $p > .05$).

Contributions to Practice

Three contributions are made to educational practice. First, administrators can be informed about the ineffectual impact of CAI for students in their academic development of mathematics skills. Second, administrators and elected officials are provided with data concerning the relative effectiveness of CAI and alternative improvement approaches being used in schools to increase the mathematics success rate of students. This information can be made available to assist administrators in making informed policy recommendations regarding curriculum and instruction.

Third, this study contributes to the program evaluation process. The results of this study extend the knowledge base concerning the effectiveness of specific education practices, thereby providing additional information upon which practicing administrators and elected officials can rely when making education reform policy decisions. This process of evaluation is consistent with the “No Child Left Behind” policy which requires decisions to use programs and materials in schools to be based upon results of scientific research.

Delimitations

Delimitations of this study include the use of 3 years of data (2005-2007) after the implementation of the intervention of using computer-assisted instruction in mathematics. Only elementary schools in Texas were included in the study group. Specifically, the level of analysis involved only fifth-grade levels. Thus, generalization of the findings of this study beyond the use of the SuccessMaker® program in an elementary fifth-grade setting is not warranted. Results cannot be attributed to computer programs other than SuccessMaker®.

Summary

Numerous studies have indicated that computer-assisted instruction programs have been successful in improving student performance in specific areas of mathematics (Christmann, Lucking, & Badgett, 1997; Kulik, 2003; Mintz, 2000; Underwood et al., 1996). Students in other countries performing better on mathematics assessments than U.S. students, along with poor mathematics literacy of U.S. adults, suggests a crisis in mathematics education (Phillips, 2007). CAI is one approach utilized to address this perceived crisis. SuccessMaker® CAI program is used in 140 Texas school districts while there is no statewide scientifically researched assessment of its effectiveness.

The development of CAI was influenced by several theories. Behaviorism, mastery learning, constructivism, and cognitive psychology theories made contributions to CAI. Mastery learning and constructivism provided the theoretical framework for the study.

Fifth-grade levels using SuccessMaker® formed the treatment group while fifth-grade levels using alternative improvement approaches comprised the control group in this study. No statistically significant difference in passing percentage on the mathematics TAKS between the groups was revealed by this study.

CHAPTER II

REVIEW OF THE LITERATURE

The review of scholarly literature related to the use of computer-assisted instruction (CAI) in mathematics classrooms in public education that follows presents arguments that either support or refute the claim that CAI provides a superior avenue for student academic success. In order to place the arguments in context, education theories of behaviorism, mastery learning, constructivist learning, and human problem solving related to the development and use of CAI are presented along with a discussion of scholarly reports concerning the results of CAI applications utilized by schools to improve mathematics success. A very brief history of CAI quickly provides the foundation for the literature review.

History of Computer-Assisted Instruction

Computer-assisted instruction in public education is a very new concept although the idea of individualizing instruction has been around for a long time (Reiser, 2001b; Suppes, 1978). Using machines to improve efficiency in education harks back to the influence of Frederick Taylor's *Principles of Scientific Management* (1911). School administrators were influenced by the concepts of scientific management along with business and public administrators. Urban schools experienced rapid student population growth during the industrialization of America, leading to the need for a more efficient and cost-effective method of instruction (Niemiec & Walberg, 1989). Early machines for education purposes included "the Drum Tutor" by Pressey in 1924 and Skinner's teaching machine in the early 1950s (Niemiec & Walberg).

Skinner's programmed instruction, an outgrowth of Thorndike's behaviorism, influenced the development of CAI (Niemiec & Walberg, 1989; Reiser, 2001b; Saettler, 1990). Mastery learning by Block and Bloom also affected CAI program development (Block, 1971; Saettler, 1990). Suppes (1967) indicated that his initial computer tutoring program was designed to assist students to master mathematics concepts while following a programmed instruction model. The growth in education practices guided by constructivism based upon concepts from Piaget, Kant and Dewey, and Vygotsky (McInerney and McInervey, 1994; Piaget, 1973b; Slavin, 1994; Von Glaserfeld, 1984; Vygotsky, 1978) possibly limited the initial wide-spread implementation of early CAI. The relatively new field of cognitive psychology contributed to the development of the concept of "mental models" while work in artificial intelligence by Marvin Minsky contributed to CAI refinement (Brady, 2007; Newell & Simon, 1972; Zhu & Simon, 1987).

During the 1960s and 1970s, research was initiated to develop CAI at Stanford University by Patrick Suppes and Richard Atkinson; PLATO (Programmed Logic for Automatic Teaching Operations) by Donald Bitzer at the University of Illinois at Urbana-Champaign; and LOGO programming language by Seymour Papert at the Massachusetts Institute of Technology (Brady, 2007). These researchers and their programs had varying effects upon the development of computer-assisted instruction.

Behaviorism and the systems approach developed by Skinner's research in programmed instruction were very instrumental in the development of CAI (Reiser, 2001b). When computer tutorial programs such as CAI were introduced into the schools, there was some resistance from educators who had begun to adopt constructivist approaches to instruction while the computer programs were obviously based upon behaviorist learning theory (Atkinson, 1969; Cuban, 1986; Saettler, 1990; Suppes, 1967). CAI at Stanford was strongly influenced by mastery learning while the LOGO program emphasized Piaget's constructivist ideas about learning and the PLATO project was highly engineering oriented (Brady, 2007).

Intelligent tutoring systems (ITS) combined Suppes's work on understanding the patterns of student error with Simon's work on using computers to simulate human behavior. The computer could now learn to understand the student's problems and level of knowledge in order to begin to bring the student's mental model into line with that of an expert. In this situation, the computer would become a "smart" tutor (Brady, 2007).

ITS based upon behaviorism developed from the artificial intelligence work of the 1950s and 1960s. Urban-Lurain (1996) indicates that over time behaviorism was gradually replaced by constructivism and the idea that human thought was "information processing." Researchers in the ITS field moved away from direct instruction and toward communication. Intelligent tutoring systems were influenced by recent work in cognitive science. According to Urban-Lurain, an understanding that humans do not think like computers was a major result of the work in artificial intelligence and intelligent tutoring systems.

Computer-Assisted Instruction at Stanford

Computer-assisted instruction traces its origins to 1963 at Stanford University's Institute for Mathematical Studies in the Social Sciences. Patrick Suppes and Richard C. Atkinson directed the program to explore the use of computers as tools for improving instruction. Developing programs to improve instruction in basic mathematics and reading was the initial focus of the project. Local public school students were bused to Stanford and given instruction by way of the computer. The program grew after initial positive results (Atkinson, 1968).

Suppes and Atkinson desired to simulate the instructional interactions that are found in tutoring. Providing effective, individualized, one-on-one tutoring to all students was the goal of developing their computer system. Suppes's (1967) idea was to develop a tutorial program that was patient, individualized and capable of establishing the steps needed in order to help each child learn. Suppes's (1978) background in philosophy formed the basis for his plan for computer-assisted learning. One of the objectives at Stanford was to ultimately have computer-based courses that would provide a "much more natural interaction between student and computer program" (Suppes, 1978, p. 21). Suppes (1967) saw the rapidly developing technology of computers as a path to follow in order to provide something close to individualized tutoring.

Suppes (1967) stated that computers do not offer a cure for all the problems related to instruction, but technology does offer the possibility of educational fulfillment at a depth on the individual level that was not conceivable 50 years previous.

Computer Curriculum Corporation and SuccessMaker®

The Computer Curriculum Corporation (CCC) was established in 1967 by Suppes and Atkinson to market the computer programs they developed at Stanford (Mintz, 2000; Suppes, 1978). The SuccessMaker® educational software (Pearson Education, Upper Saddle River, NJ, www.pearsoned.com) was a result of that work. According to Thrall and Tingey (2003), the purpose of the research that lead to SucccessMaker® was, "to emulate a human expert tutor who discerns and responds to the individual instructional needs of each student and provides essential information to the classroom teacher” (p. 1).

By 1997, CCC had become the largest publisher of electronic instructional materials for K-12 schools. Pearson Education, Inc., currently owns CCC and provides SuccessMaker® to more than 16,000 schools in the United States (Pearson, 2008). SuccessMaker® is marketed internationally as well. The SuccessMaker® program was introduced by CCC in the United Kingdom in 1994 (Pearson Education, 2004).

Education Theory

Several learning theories as well as psychological research had an impact upon the development of CAI. Behaviorism by Thorndike (Niemiec & Walberg, 1989; Saettler, 1990), mastery learning by Block and Bloom (Block, 1971; Saettler, 1990) and constructivism by Piaget, Kant and Dewey, and Vygotsky (Dalgarno, 2001) contributed to the development and use of CAI. The new field of cognitive psychology (Newell & Simon, 1972; Zhu & Simon, 1987) also had an impact upon CAI. The predicted effects of CAI upon improved learning relative to learning theories are summarized in Table 1.

Table 1

Predicted Effect by CAI Based upon Learning Theory

Theory	Description	Explanation
Behaviorism	Practice with reinforcement establishes the desired behavior/ learning.	CAI can increase learning when immediate response is provided after each practice attempt.
Mastery learning	Quality instruction with sufficient time to learn leads to high level learning.	CAI can increase learning by patiently providing individual reinstruction of skills missed or learned incorrectly and present however many practice problems are necessary for mastery.
Human problem solving	The mind is an information system. Students can learn from examples alone.	CAI can increase learning because students are able to learn from examples alone.
Constructivism	The utilization of authentic training tasks, real world materials, and an active approach to engaging learner during training process.	CAI can increase learning when the computer program actively engages the student but may not if it is the only method of instruction used. CAI in its expanded form of internet resources can provide a very individualized and student-centered learning experience.

Mastery Learning

Mastery learning theory along with programmed instruction is alluded to as the basis of Suppes's (1967) computer tutoring program plans. There were six main components of CAI: (a) content coverage and dynamic ordering of concepts, (b) distributed presentation of instruction based on strands, (c) initial adaptive placement, (d) learning models for judging mastery, (e) retention models for assigning review, and (f) decisions on tutorial intervention (Block, 1971; Dalgarno, 2001; Saettler, 1990). The multiple concepts of task analysis, objective specification, and criterion-referenced testing, developed during the 1960s, were used in instructional design and in developing instructional computer programs (Reiser, 2001b).

Human Problem Solving

Herbert Simon and several colleagues also contributed significant concepts to information processing and computer-assisted instruction. Newell and Simon (1972) suggested that the human mind could be thought of as an information processing system.

Newell and Simon's (1972) work at Carnegie-Mellon University using computers to simulate human behavior contributed to intelligent tutoring. Intelligent tutoring developed from the Stanford tutoring program by combining artificial intelligence with a comprehensive database of domain knowledge. Newell and Simon also reported on the nature of expertise. Determination was made that experts had specific and more efficient strategies for solving problems than those of novices.

Human problem solving theory viewed a human as a processor of information. When man was solving problems, he was an information processing system. A computer is an example of an information processor. It then followed that the metaphor could be used "that man is to be modeled as a digital computer" (Newell & Simon, 1972, p. 5). A model was developed that was "a precise symbolic model on the basis of which pertinent specific aspects of the man's problem solving behavior can be calculated" (p. 5).

Zhu and Simon (1987) further related that students can learn from studying examples alone without lectures or direct instruction. The idea was considered possible that a computer could choose the examples, present them to the student, monitor the student's performance, and sequence the instruction.

Constructivism

Reiser (2001b) states that instructional design and technology has been influenced by the new field of cognitive psychology and by the ideas of "constructivism." Constructivism places emphasis upon the utilization of authentic training tasks, real world materials, and a more active approach to engaging learners during the training process.

Early adoption of and use of CAI in schools was hampered by at least two conditions. First, the cost of main frame computers required to run the programs in the early years of development was quite high. Second, when the drill-and-practice component was implemented in schools, it was labor intensive and behaviorist theory upon which it was based was going out of style with educators who were adopting constructivist practices (Atkinson, 1969; Piaget, 1973a; Saettler, 1990; Suppes, 1967).

Growth of constructivism led to significant changes in teaching and learning practices. Constructivist theories of teaching and learning also had consequences for computer assisted learning (Dalgarno, 2001). In the field of psychology, the cognitive view of learning overshadowed the behaviorist view. Dalgarno related that the behaviorist view of learning places emphasis upon repetitive conditioning of learner responses while the cognitive view emphasizes the learner's cognitive activity and the mental models formed during the process (Dalgarno, 2001).

The opinion by many educators from university researchers to classroom teachers was that learning would become more productive and meaningful when the new computer technology was placed into the schools. Assistance in instruction was expected to take the form of CAI drill and practice and tutorials that would provide the systematic practice that students with disabilities in particular required in order to master skills (Woodward, 2001).

A discussion of studies related directly to CAI that present both arguments concerning the contribution of CAI to the improvement of student academic success follows. Dissertations completed over the last 9 years utilizing data from studies conducted in elementary, middle-school and high-school mathematics classrooms that use CAI along with numerous scholarly articles and book chapters dealing with the effects of CAI are reviewed.

Prior Research

Sixteen dissertations written from 2000 through 2007 concerning the use of computer-assisted instruction (CAI) in mathematics in elementary, middle-school, and high-school settings report mixed results as shown in Table 2. The elementary studies reported 37.75% statistically significant positive results while none of the middle-school and high-school studies reported significant gains with CAI over traditional instruction alone. Only 18.75% of the dissertations reported statistically significant improvement with CAI over the whole range of grade levels studied (Jackson, 2005; Rivet, 2001; Whitaker, 2005). A positive change although not at statistically significant levels was reported in 43.75% of the studies (Arbuckle, 2005; Ash, 2005; Clark, 2005; Irish, 2001; Mintz, 2000; Vietti, 2005; Wood, 2006), and negative or no measurable differences were reported in 37.5% of the studies (Atkins, 2005; Hodges, 2001; Phillips, 2001; Rosales, 2005; Soeder, 2001; Taepke, 2007).

These dissertation studies involved very limited populations and generally short times of intervention. One study involved several schools in the same district. A few studies were conducted at two schools while the rest were conducted at only one school. Each study also involved only one type of school setting such as rural, suburban, or urban.

Various experimental methods were incorporated. Ten studies utilized a quasi-experimental treatment and control group method. Five studies used a one-group pretest-posttest method. Lastly, one research study involved the use of two groups with repeated measures.

The sample size for the studies varied from 6 to 2,000. About one third of the studies evaluated data from less than a year of intervention. More than one half of the studies compared data after one year of intervention while less than one fifth of the studies compared data for 3 years of intervention. The individual characteristics of the limited populations studied may have contributed to the differences in the results reported.

Various computer programs were the focus of the dissertation studies including the following: Memory Math, Milliken Math, Destination Math® (Riverdeep Inc., San Francisco, CA, www.riverdeep.net), Orchard, Accelerated Math™ (Renaissance Learning, Inc., Wisconsin Rapids, WI, www.renlearn.com), Cognitive Tutor, Carnegie

Learning Geometry Curriculum, and SuccessMaker®. The programs have different functional characteristics, design aims, and operational requirements. These differences may have contributed to the varying results as well.

The combined dissertation studies involved data from more than 6,000 students, 57 schools, and 17 school districts across seven states in the United States. Almost two thirds of the elementary studies included fifth grade either alone or in a grade combination. Even though this seems to be a broad cross-section from which to obtain reliable and valid results, the studies did not provide definitive results at least in part possibly because the studies ultimately were too narrow in scope dealing with only one school and in one type of setting.

Table 2

Results of 16 Dissertation Studies Reported from 2000-2007

Level of change	Elementary		Middle school		High school		Total	
	N	%	*N*	%	*N*	%	*N*	%
Significant change	3	37.75	0	0.00	0	0.00	3	18.75
Positive gains	3	37.75	2	40.00	2	66.67	7	43.75
Negative or no gain	2	25.00	3	60.00	1	33.33	6	37.50
Total	8	100.00	5	100.00	3	100.00	16	100.00

Reports from Additional Scholars

Several scholarly articles and book chapters regarding the effectiveness of CAI were examined. Christmann, Lucking, and Badgett (1997) state the situation colorfully and accurately when they say, “The literature is legion in its number of studies confirming the effectiveness of computer-assisted instruction (CAI) in the promotion of academic achievement” (p. 31). Numerous studies have reported upon CAI at all school levels from kindergarten through university. Christmann et al. (1997) reviewed more than 1,000 published papers to obtain the 28 studies that met their meta-analysis study criteria. The studies’ conclusions are grouped as follows: 57% were significantly positive with CAI, 33% showed no statistical significance, and 10% were significantly negative. The purpose of the research was to determine whether the results were different among the responses to computer-assisted instruction of secondary urban, rural and suburban students.

Effect size is the standardized difference between means which provides a standardized size of an observed effect. Effect size allows for the comparison of results that measured different variables or used different measurement scales. Cohen’s *d* is defined as the difference between the means divided by the standard deviation of either group when the variances of the two groups are homogeneous. Cohen (1988) suggested that an effect size of $d = .2$ could be considered a small effect, $d = .5$ a medium effect, and $d = .8$ a large effect.

An overall small mean effect size of 0.172 was calculated from 42 effect sizes in the 28 studies. The rural effect size was 0.077, the suburban effect size was 0.137, and the urban effect size was 0.388. CAI instruction seemed to be most effective in urban settings, followed by the suburban settings, and then by the rural settings, but they are all small effect sizes. Cohen (1988) suggested that effect size of 0.20 to 0.49 is a small effect size. Tallmadge (1977) and Slavin (1990) suggested that an educational effect size of 0.25 or more should be considered educationally significant. With these suggestions in mind, Christmann et al. concluded that the urban effect size results of 0.388 indicate a small but educationally significant finding.

Kulik (2003) prepared a meta-analysis report for SRI International focused on controlled evaluation studies since 1990 and reviews of studies prior to 1990. The study was funded by the National Science Foundation. The report reviewed nine controlled evaluation studies on instructional technology and reading. The controlled studies of reading utilizing Integrated Learning Systems (ILS), most of which used tutorial instruction as a basic methodology, had an effect size of 0.06 meaning that there was almost no difference in reading scores compared to traditional reading classrooms. Kulik went on to state that, based upon studies conducted over three decades, CAI "does not make meaningful contributions to reading improvement in elementary schools" (p. v).

Kulik (2003) reported that there were three statewide correlation studies concerning Accelerated Reader management programs: 5,000 schools in Texas, 740 schools in Tennessee, and 500 schools in Illinois. He reported no statewide studies in mathematics. Sixteen controlled studies in mathematics reviewed by Kulik had a small effect size of 0.38 which is large enough to be considered educationally meaningful.

Even though Kulik's (2003) assessment is that technology studies have been conducted only at specific grade levels, in specific subjects, and on specific instructional outcomes leading to "patchy" overall results, his meta-analysis did provide tentative conclusions. ILS makes little or no improvement in reading programs, computers can help to improve writing skills, and instructional technology improves teaching programs in mathematics and in the natural and social sciences.

Included in the meta-analysis by Lipsey and Wilson (1993) were 622 studies concerning computer-assisted instruction. It was concluded that there were strong patterns of evidence regarding the success of treatments in general. After applying several statistical analysis procedures to lessen the likelihood of internal validity concerns, Lipsey and Wilson determined that the grand mean treatment effect for CAI was a small but statistically significant effect size of 0.47 standard deviations.

Reports from SuccessMaker® Studies

The following presentation of dissertations and other scholarly studies of the implementation of the SuccessMaker® program in K-12 public schools reveals a mix of results. Underwood, Cavendish, Dowling, Fogelman, and Lawson (1996) reviewed the results of the implementation of SuccessMaker® in the United Kingdom and found positive results for mathematics but not for reading in their six-month study. Underwood et al. reported a “substantial” effect size for mathematics of 0.4. Cohen (1988) considers 0.4 a small effect size.

Underwood et al. (1996) reported a concern voiced by others about the use of CAI. The concern stems from the idea that if children sit in front of a computer screen all day they will not develop normally. Underwood et al. pointed out that with the SuccessMaker® CAI program, the optimal time with the computer was approximately 30 minutes per day, and that a longer duration led to a lower level of motivation and to poor behavior.

Mintz (2000) reported positive but not statistically significant results in her study of mathematics CAI with the SuccessMaker® program. Even with the advances in technology incorporated into SuccessMaker®, Mintz (2000) concluded in her study dealing with mathematics instruction, “Gains in critical-thinking skills were made, although not significant ones. Based on the research, it is imperative that the traditional instruction be compatible with the computer-assisted instruction” (p. 64).

Phillips (2001) concluded that session length of five weeks was not long enough to establish trends in his study that used a repeated-measures approach alternating the use of the SuccessMaker® program by students in his 2 groups for 1 week, then the traditional approach for 1 week.

Pearson Digital Learning (2002) provides a synopsis of 12 studies reported between 1994 and 2001 concerning results of the implementation of SuccessMaker® in public schools primarily in the United States, but the one report presented above from the United Kingdom is also included. The schools in the United States were located in five different states. Only four of the studies, 24%, reported significant gains. Three of the studies included a comparison of SuccessMaker® with the following programs: Success-for-All, Jostens Learning, GLOBAL (UK). SuccessMaker® was rated best out of the four.

Reports about Ineffectiveness of Technology

Even though the effects of CAI are generally positive, there are several researchers who hold an opposing view. They suggest that CAI and technology in general are not effective. One reason given for the ineffectiveness of early technology is that it was not constructivist in nature.

According to Carbonell (1970), the role of early computer-assisted instruction was seen as that of diagnosing exactly what knowledge was missing and providing that knowledge to the student. One reason that the application was not successful may be that the process did not provide opportunities for construction of knowledge. Another may be that it was very “difficult to make real-time, microdetailed estimates of what a person knows” (Osin & Lesgold, 1996, p. 626).

When the effects of these early uses of media were measured, there was evidence of little or no improvement in students’ performances (Cuban, 1986; Reiser, 2001a). Technology had not changed the way instruction was delivered. It was used as a supplement to the instructional practices at the time. Reiser also suggested that a major drawback to the use of technology in schools was the high cost of developing technology based instruction and the cost of the delivery system itself.

Reports on Limited Utilization of Computers and CAI

Ten years after Papert’s claim that each child in school would have a computer, there still was little effect being seen with computers in education according to Reiser (2001a). Reiser predicted that computers, the Internet, and other digital media would have a greater impact than their predecessors had but more slowly and to a lesser extent than their proponents predicted. Cuban (1986; Cuban & Cuban, 2007) goes even farther and says that computers were used by very few teachers and students in mathematics classrooms.

In the early 1980s, according to Cuban (1986), parents raised thousands of dollars to buy microcomputers to be placed in schools for children to use. Once again the predictions were heard about how computers would affect how schools were organized, how teachers would teach, and how students would learn. The quest for ever higher classroom productivity continued.

As inexpensive desk-top computers became available, promising that each student could work with a personal computer, the claims for a classroom revolution were renewed. Cuban (1986) expected that the cycle begun with CAI 20 years before ". . . of predicting extraordinary changes in teacher practice followed by academic studies of computers' classroom effectiveness, in turn followed by teacher reports about glitches in hardware, software, and logistics" (p. 73) would be seen again. Using one computer in the classroom to tutor a student, to provide a learning center, for drill and practice for a student, for enrichment, or to reduce a teacher's paperwork or grading time are familiar and appealing uses of technology for teachers. These uses of the computer would assist teachers who are required by policymakers to be in a classroom with thirty students for a specific period of time, maintain order, and motivate the students to learn subject matter and skills desired by the community (Cuban, 1986).

A study conducted by Levin, Glass, and Meister (1987) revealed that peer tutoring (students teaching students) was far more cost-effective than a CAI drill program, reducing class size from 35 to 30 or even 20 students, or increasing instruction time in math and reading in that order. Saettler (1990) also suggested that the cost of CAI was too high for the results achieved. Cuban (1986) makes a cautious endorsement of using computers in the classroom by saying that teachers should use computers to ". . . cope with the routine, often tedious, student learning problems that machines can do patiently" (p. 100).

According to Cuban and Cuban (2007), the availability of computers to students has increased dramatically. In 1984 in U.S. schools, there were 125 students per computer while in 2002, there were 4 students per computer. From 1994 to 2002, the percent of schools wired for Internet rose from 35% to 99%. In 2000, more than 67% of students lived in homes in which there was at least one computer.

While computer availability has become a reality in schools, the use by teachers is still limited. Cuban and Cuban (2007) wrote that in 2001 about 40% of teachers use computers hardly ever, 50% use computers once a month, and only 10% integrated computers in their lessons on at least a weekly basis. Similarly, Becker, Ravitz, and Wong (1999) reported data from the 1998 national survey, Teaching, Learning, and Computing, indicated that only 5% of elementary school teachers had students use computers in varied and complicated ways.

Data is not available to support the claim that computer use leads to improved mathematics test scores according to Cuban and Cuban (2007) even though analyses and meta-analyses of many studies indicate that CAI does produce gains in test scores. Cuban and Cuban relate that close examination of meta-analyses shows that when the same teacher taught the control group and the experimental group, the student scores between groups were not as great as when different teachers taught the computer-using group and the control group. To Cuban and Cuban, this situation suggested that the teachers were making the difference in scores and not the use of the computer.

Larson and Strehle (2002) of Massachusetts Institute of Technology stress that a serious problem with videotape and other technologies that came before computers in schools was the inability to provide the opportunity to interact with an instructor and to provide individual instruction. Computer technology, on the other hand, does make individual instruction possible and allows for frequent interaction with the teacher and other students as well as providing real time assessment and response to individual learning needs. “Learning is recognized as a social experience, best for most students in [*sic*] not delivered in isolation from teachers and other students” (p. 30).

Gap in the Literature

No statewide study of the effectiveness of SuccessMaker® use in Texas mathematics classrooms was located during the review of the literature. There are 140 school districts in Texas that are using the program with no scientifically researched evidence of its effectiveness (K. Kleine, personal communication, February 27, 2008). Schools are using other programs and processes as well in an attempt to enhance traditional mathematics instruction in search of improvement in the percentage of students passing the annual mathematics Texas Assessment of Academic Skills.

Summary

The history of the development of CAI depicts the ever improving nature of computer programs. CAI began as an electronic form of programmed learning based upon behaviorist learning theory and mastery learning. CAI development progressed over 30 years to become an intelligent tutoring system (ITS) that incorporated developments guided by mastery learning, human problem solving theory, and constructivist learning theory along with advances in artificial intelligence.

ITS was made possible through the integration of artificial intelligence technology, human problem solving, and expert modeling with understanding the patterns of student errors and a vast domain database. The product was a smart tutorial computer program that could understand a student's problems and level of knowledge in order to guide the student to develop a mental model that more nearly resembled that of an expert.

During this period of development, schools were encouraged to acquire computers and programs. Initially, the costs were prohibitive for widespread adoption. Eventually, the costs declined and personal computers became available so that by 2002 there was a computer for every four students nationwide (Cuban & Cuban, 2007). By 1997, SuccessMaker® CAI program was in use in 16,000 schools in the United States (Pearson, 2008).

Numerous studies comparing CAI to traditional instruction were conducted after the implementation of CAI in the school setting. Prior research regarding the effectiveness of CAI in improving student success in mathematics produced mixed results. Only 18.75% of recent dissertation studies found statistically significant mathematics improvement with CAI while 24% of SuccessMaker® specific studies reported statistically significant results (Pearson Digital Learning, 2002). Kulik (2003) found a small but statistically significant effect size of 0.38 in his meta-analysis of studies concerning mathematics improvement using CAI while Cuban and Cuban (2007) argued that upon closer examination of meta-analyses it appeared that the teachers were making the difference in scores, not the use of computers.

It was also noted that 140 Texas school districts were using SuccessMaker® (K. Kleine, personal communication, February 27, 2008) while no report of research concerning the effectiveness of SuccessMaker® in Texas schools was located. This study was intended to fill the gap in statewide research literature concerning the effectiveness of SuccessMaker® in Texas schools.

CHAPTER III

METHODOLOGY

A quasi-experimental design was developed to determine the effectiveness of SuccessMaker® educational software (Pearson Education, Upper Saddle River, NJ, www.pearsoned. com) use at fifth grade on a statewide basis. Considering the low percentage of studies that produced statistically significant results, it was expected that this study would also reveal that SuccessMaker® use does not result in a statistically significant improvement in percentage of students passing the mathematics Texas Assessment of Knowledge and Skills (TAKS) at fifth grade in Texas. Level of statistical significance set prior to data collection was $p < .05$.

The initial step in the development process was to determine the participants for the study. Four conditions supported the decision to use fifth-grade level of public schools in Texas as the unit of analysis. First, Texas is the second most populated state in the United States (U.S. Census Bureau, 2000), thereby potentially having one of the largest groups of students affected by decisions to use computer-assisted instruction (CAI). Second, SuccessMaker® CAI is utilized by more than 11% of the school districts in Texas (K. Kleine, personal communication, February 27, 2008; Texas Education Agency, 2009). Third, Texas Education Agency maintains an extensive public education database that is readily accessible. Finally, fifth grade is the first point at which passing the mathematics (TAKS) is required in order for a student to be promoted generating keen interest in programs or processes that promote increased mathematics skill development at that level (Texas Education Agency, 2008).

Description of the Participants

The unit of analysis for this statewide study was the fifth-grade level of elementary school campuses in Texas. Treatment campuses used SuccessMaker® CAI while control campuses did not use SuccessMaker®. Potential treatment (30) and control (30) districts and associated campuses (treatment – 135, control – 144) were matched by similar demographics depicted in Table 3. Treatment and control groups at the district, campus, and fifth-grade levels were shown in Tables 4, 5, and 6 to be comparable by way of independent samples mean *t*-test. The *t*-test results were not statistically significant because the two groups were quite similar in their demographic composition which was the desired condition.

Selected districts and subsequently their associated campuses provided representation from all geographic areas of Texas. The study group districts also included a large range in student enrollment (109 - 56,955 students). Subpopulations were determined by district wealth, economic disadvantage, and ethnicity.

Table 3

Characteristics of Combined Potential Districts and Campuses in the Study Sample

Characteristic	*M*		*SD*		Minimum		Maximum	
	District	Campus	District	Campus	District	Campus	District	Campus
	N = 60	*N* = 279						
Mobility (%)	5.5	7.1	1.65	3.17	2.8	1.0	8.9	20.4
White (%)	52.6	36.6	16.73	24.21	.9	.3	74.5	89.8
Economic disadvantage (%)	52.9	57.0	15.73	23.63	13.4	1.1	100.0	100.0
Student/teacher (ratio)	13.3	14.7	2.11	1.74	8.5	8.5	16.9	19.3
Enrollment (thousands)	6.5	.6	10.44	.20	.1	.050	57.0	1.4
Population density/sq. mi.	375.0	375.0	1264.82	1264.82	1.0	1.0	9091.0	9091.0
Median household income (thousands of dollars)	36.2	36.2	13.01	13.01	21.6	21.6	94.6	94.6

Table 4

Comparison of Sample Selection Criteria for Potential District Groups

Characteristic	Districts CAI	Non-CAI	Mean diff.	Mean *t*-test	*df*	*p*
	n = 30	*n* = 30				
Mobility (%)	5.36	5.62	-.26	-.616	58	.540
White (%)	51.38	53.75	-2.36	-.544	58	.589
Student/teacher (ratio)	13.18	13.44	-.26	-.475	58	.637
Economic disadvantage (%)	53.86	51.95	1.91	.466	58	.643
Enrollment (logged)[a]	3.35	3.38	-.03	-.184	58	.854
Population density (logged)[a]	1.46	1.71	-.24	-1.034	58	.305
Median household income (logged)[a]	4.53	4.54	-.01	-.250	58	.803

Note: $N = 60$.
[a]Logged values for enrollment, population density, and median household income were used for comparison because raw data was not normally distributed.

Table 5

Potential Campuses Comparability

Characteristic	Campuses CAI	Non-CAI	Mean Diff.	Mean *t*-test	*df*	*p*
	n = 135	*n* = 144				
Mobility (%)	7.30	6.97	.33	.858[a]	265	.392
White (%)	37.51	35.67	1.84	.641[a]	267	.522
Student/Teacher (ratio)	14.67	14.69	-.02	-.108	277	.914
Economic Disadvantage (%)	54.30	59.50	-5.20	-1.858*[a]	271	.064
Enrollment (count)	575.33	530.34	44.99	1.909*	277	.057

Note: $N = 279$. Enrollment (count) was normally distributed
[a]Equal variances not assumed
$^*p < .10$

Table 6

Final Fifth-grade Levels Comparability

Characteristic	Fifth grades Treatment	Control	*M* Diff.	*M* *t*-test	*df*	*P*
	n = 39	*n* = 65				
Mobility (%)	6.39	6.75	-.36	-.568	102	.571
White (%)	42.12	43.06	-.94	-.202	102	.840
District wealth (dummy wealthy = 1)	.23	.31	-.08	-.842	102	.402
Student/teacher (ratio)	14.15	14.47	-.33	-.750[a]	62.535	.456
Economic disadvantage (%)	54.45	54.30	.15	.033	102	.973
Enrollment (count)	521.18	525.77	-4.59	-.104	102	.917
Population density (logged)	2.16	2.32	-.16	-.738	102	.462
Median household income (logged)	4.59	4.63	-.04	-1.357[a]	98.864	.178

Note: N = 104. Enrollment (count) was normally distributed
[a]Equal variances not assumed

Materials

Data was collected from the Texas Education Agency public information database, U.S. Census Bureau, and principals for all of the schools in the control and the treatment groups for the timeframe of the study from 2005-2007. No individual student scores were accessed. Only group data was obtained for district, campus, and fifth-grade levels. No direct contact with students occurred. Statistics related to school setting including school district property wealth, enrollment count, population density, and median household income were obtained. Mobility percentage, economic disadvantage percentage, and ethnicity of subgroups in the sample were identified for analysis of their effects.

Questionnaire responses were obtained from principals either by mail or by telephone interview to verify the use of SuccessMaker® and to ascertain specific alternative practices implemented at control group schools. No data from questionnaires were utilized in the statistical analyses.

Three years of TAKS data was not available for every fifth-grade level used in the study. At some campuses, fifth-grade level was so small that passing percentage data was not reported at the state level for all 3 years or there was no fifth-grade level at the campus for 3 years. Consequently, the number of final fifth-grade levels was 104 instead of the 110 total responding.

Procedures

When using quasi-experiment instead of a randomized experiment, Cook and Payne (2002) suggest that considerable attention needs to be paid to the quality of the match between treatment and control groups. Even though schools are quite varied, there are commonalities. Several of these commonalities were used to select the 30 treatment districts from the total that use the SuccessMaker® program. A control group was selected to match the group of treatment districts. First, districts were selected that were comparable on demographic characteristics. District campuses that contained fifth grade were then compared demographically to determine their comparability. Finally, the fifth-grade levels that composed the study sample were determined to be comparable.

District Selection

The first step in the selection process was to select the 30 districts for the treatment group based upon their similarity of demographics. The next step was to select the 30 districts for the control group that matched the treatment group based upon the following seven types of data listed in the 2006-2007 Texas Education Agency Academic Excellence Indicator System (AEIS) reports (Texas Education Agency, 2007d) or in the 2000 U. S. Census reports (U.S. Census Bureau, 2000): mobility percentage at the time of the test, white ethnicity percentage, student to teacher ratio, economic disadvantage percentage, enrollment count, population density, and median household income.

After collecting the selection criteria data for the two groups of districts, an independent samples mean *t*-test was performed to determine that there was no statistically significant difference, $p < .05$, between the two groups that might influence the study results. When collected data was determined to be skewed, a log transformation was performed so that normally distributed data was compared. The results shown in Table 4 above are not statistically significant indicating that the two groups of school districts were comparable.

Principals at all of the potential study group schools were asked to indicate on a questionnaire whether the SuccessMaker® program or some alternative intervention was actually used at their school. The principals' responses ultimately placed the districts, campuses, and their corresponding fifth grades in either the treatment group or in the control group. Responses were received from 52 of the initial 60 districts yielding an 87% district participation rate. The process used in the initial selection of the districts for the study sample was applied again in order to determine that the sample was still normally distributed and comparable.

Campus and Fifth Grade Selection

The selection criteria for individual campuses from the selected districts were compared in order to determine that the campuses also were comparable. The *Texas School Directory, 2006-2007* (Texas Education Agency, 2007c) listed 144 potential control group campuses from the control group districts. There were 135 potential treatment group campuses from the treatment group districts listed. These two groups combined for a total of 279 schools.

District level data concerning population density and median household income analyzed earlier for the district evaluation was not duplicated. Only unique school level data was analyzed to determine school comparability based upon the following five selection criteria listed in the 2006-2007 Texas Education Agency, Academic Excellence Indicator System (AEIS) reports and in the 2000 U. S. Census reports: mobility percentage at the time of the test, white ethnicity percentage, student to teacher ratio, economic disadvantage percentage, and enrollment count. Table 5 presented above indicates that there were no statistically significant differences between the groups of campuses $p < .05$.

Principal questionnaire responses were received from 110 campuses. The process used in the initial campus and district selection for the study sample was applied again in order to determine that the final fifth-grade sample was still normally distributed. As indicated in Table 6 above, no statistically significant *t*-test results were obtained for the final fifth-grade levels $p < .05$.

It had been determined that the districts and schools in the study sample were comparable. At this point in the study, it had not been ascertained that they were comparable to the state population.

State Level Comparison

A comparison of the combined district group to the whole state was made using the following four criteria: mobility percentage at the time of the test, white percentage, economic disadvantage percentage, and student/teacher ratio. At the district level, the average percentage of white students in the school districts was higher than the state average while the average student/teacher ratio at the district level was lower than the state average as indicated in Table 7.

However, at the campus level depicted in Table 8, when the demographic characteristics were compared to the state average, the campus sample had a higher mobility rate compared to the state average. The elementary campuses in the sample were quite comparable to the state average otherwise. On average, campuses in the sample generally had a higher rate of mobility suggesting that the passing rate results might be expected to be lower than the state average as a higher mobility rate may be expected to contribute to a lower passing rate. Independent samples *t*-tests were not conducted and statistical conclusions were not drawn concerning this data because of the anticipated large difference in standard error because of the extreme difference in sample sizes.

Table 7

Combined District Group to State Comparison for 2007

Criteria	State *M*	District group *M*
	N = 1222	*N* = 60
Mobility (%)	5.4	5.49
White (%)	35.7	52.57
Economic disadvantage (%)	55.5	52.90
Student/teacher (ratio)	14.7	13.31

Note: Independent samples *t*-tests were not performed because of the anticipated large difference in standard error because of the extreme difference in sample sizes.

Table 8

Combined Campus Group to State Comparison for 2007

Criteria	State *M*	Campus group *M*
	N = 8096	*N* = 279
Mobility (%)	5.4	7.13
White (%)	35.7	36.57
Economic disadvantage (%)	55.5	56.98
Student/teacher (ratio)	14.7	14.69

Note: Independent samples *t*-tests were not performed because of the anticipated large difference in standard error because of the extreme difference in sample sizes.

Identification of Variables

Dependent variable: Passing percentage on the annual mathematics TAKS test.

The passing percentage of the fifth-grade level on the TAKS mathematics tests administered to the treatment group and to the control group campuses was the dependent variable. A major factor in the campus and district accountability ratings assigned by the Texas Education Agency and Adequate Yearly Progress assigned by the U.S. Department of Education is annual mathematics TAKS passing rate.

The mathematics TAKS test is a criterion-referenced test designed to measure the degree to which a student has learned and is able to apply the knowledge and skills required for each grade level according to the Texas Essential Knowledge and Skills. The test was mandated by the Texas Legislature in 1999 and implemented spring 2003 (Texas Education Agency, 2007a). Test reliability data can be located on the Texas Education Agency website at http://www.tea.state. tx.us/student.assessment/ resources/techdigest/index.html.

Independent variable: Use of SuccessMaker® CAI software.

Using the computer-assisted instruction educational software SuccessMaker® was the independent variable dummy coded (Use SuccessMaker® = 1). SuccessMaker® use was chosen as the independent variable for three reasons: (a) more than 11% of the school districts in Texas use the program according to the publisher, (b) there is no statewide research that reports on the effect of using the program, and (c) program evaluation is a major source of information for curriculum and instruction policymakers.

The quasi-experimental design utilized in this study requires the use of statistical control techniques that estimate the size of the relationship between the independent and dependent variable by controlling for the effects of expected third variables (Meir, Brudney, & Bohte, 2006). Several control variables that were considered as possibly contributing either positively or negatively to the passing rate were used in the regression analysis. Student mobility percentage, economic disadvantage percentage, ethnicity, enrollment count, district property wealth, student/teacher ratio, population density per square mile, and median household income were utilized as control variables.

Mobility

Student mobility was coded as a percentage. Students who move during the school year may miss instruction as a result of different instructional timing between schools or simply by not being in attendance while moving. A high mobility rate at a school may be a predictive factor in a lower overall passing rate.

Economic disadvantage.

Economic disadvantage was coded as a percentage. The economic disadvantage percentage is determined at the state level based upon the reported number of students who qualify for free or reduced-price meals through the National School Lunch Program. Qualifying family income levels are at or below 130% of the poverty level to be eligible for free meals and between 130% and 185% of the poverty level for reduced-price meals. “For the period July 1, 2008, through June 30, 2009, 130 percent of the poverty level is $27,560 for a family of four; 185 percent is $39,220.” (U.S. Department of Agriculture, 2008, p. 2).

Ethnicity.

Ethnicity was coded as percentage of students that were white. The white percentage was incorporated into the regression model as a control variable so that the effect of a change in ethnicity could be assessed.

Property wealth.

District property wealth was included as a control variable dummy coded (Wealthy = 1) to assess whether or not there was a difference in passing rate between schools that are designated wealthy and those that are not wealthy. The Texas Education Agency (TEA) assigns districts to the category of wealthy. For example, a wealthy district was one that had property wealth of at least $319,500 per weighted average daily attendance (WADA) for the school year 2007-2008 (Texas Education Agency, 2007b).

Student/teacher ratio.

Student/teacher ratio was coded as number of students per teacher. Student/teacher ratio was included as a control variable and as one of the comparability factors.

Enrollment count.

Enrollment was coded total number of students. Enrollment was used as one of the comparability criteria as well as a control variable. It was included to determine the effect a change in enrollment would have upon the passing percentage.

Population density.

Population density information obtained from the 2000 U.S. Census was coded as number of persons per square mile. Population density of the school districts was used as a comparability factor of the district and campus level groups chosen for the treatment and control groups as well as a control variable in the multiple regression model.

Median household income.

Median household income was coded as dollars. Median household income data was also obtained from the 2000 U.S. Census. Median household income of the school districts was used as another comparability factor of the district and campus level groups chosen for the treatment and control groups as well as a control variable in the multiple regression model.

Data Analysis Procedures

Because of the inherent problems when using test results generated with the Texas Assessment of Knowledge and Skills over multiple years, scores when used were converted to *z*-scores for analysis. SPSS® Graduate Pack 16.0 for Windows statistical and data management package (SPSS Inc., Chicago, www.spss.com) was used for data analysis to develop descriptive statistics, correlations, and multiple regression analysis. These methods were utilized in order to quantitatively answer the research question about the impact of SuccessMaker® CAI on mathematics performance on the TAKS by students at fifth-grade level in Texas. Graphs and tables were developed from the data obtained in order to develop a visual depiction of the results of the study. Multiple regression was used so that the effect of control variables and the independent variable could be analyzed.

Effect sizes and confidence intervals were generated where appropriate for reporting the results of the study in order to place the results in proper context. Possible outliers were identified at the district, campus, and fifth-grade levels. Their removal created no significant difference in the mean passing percentage. None of the data was considered to be actual outliers.

Correlation coefficients.

Pearson product-moment coefficients were developed in order to establish effect sizes to use in conjunction with the results of multiple regression analysis. Pearson product-moment correlation coefficient, r, is the standardized covariance. A correlation coefficient of 0 means there is no effect while 1 indicates a perfect positive effect and -1 indicates a perfect negative effect. Effect sizes of $r = .1$, $r = .3$, and $r = .5$ can be considered small, medium, and large effects respectively. Squaring the value of r yields the percent of variance in the dependent variable that is accounted for or explained by the independent variable. For example, $r = .1$ considered a small effect when squared yields .01 or 1% of the variance in the dependent variable explained by the independent variable (Cohen, 1988; Field, 2005).

Development of the multiple regression model.

In order to conduct multiple regression analysis of the data collected for the final fifth-grade groups, variables were added to the list of initial demographic variables used in the comparability analyses. The independent dummy variable, SuccessMaker® use, and control dummy variable, district wealth, were added to the model. Preliminary models were run using the district and campus data while the fifth-grade level data was being accumulated in order to develop a final model for application at fifth grade.

Checking whether regression analysis assumptions were true was necessary in order to be able to draw conclusions about the population based upon the regression analysis done on the sample (Field, 2005). Homoscedasticity, normally distributed errors, independence, and linearity assumptions of the regression model were checked in addition to the possibility of perfect multicollinearity. SPSS® was used to conduct a variance inflation factor analysis. The result was a factor less than 10 for each of the variables, indicating that multicollinearity was not a problem. A Durbin-Watson test result of 1.911 was obtained indicating there was almost no correlation between the errors. The standardized residuals were plotted against the standardized predicted values of the dependent variable. The resultant histogram of the standardized residuals and normal probability plot along with the other analyses indicated that the model assumptions were met.

Summary

The research design and methodology presented in this chapter were used to determine the relationship between utilization of SuccessMaker® CAI and passing percentage on the TAKS test in mathematics for fifth-grade levels in Texas relative to a control group of matched fifth-grade levels that did not use SuccessMaker® CAI. By way of *t*-tests, analysis was conducted to determine that the districts, campuses, and final fifth grade treatment and control groups exhibited comparable and not statistically significantly different characteristics. Data was also checked for normality. A logarithmic transformation was conducted on any set of data that was skewed so that only normally distributed data was analyzed. Descriptive statistics were developed and correlation coefficients and multiple regression analyses were conducted to determine statistical significance and effect size.

CHAPTER IV

RESULTS

Descriptive statistics, Pearson product-moment correlations, and multiple regression analyses were conducted using SPSS® Graduate Pack 16.0 for Windows statistical and data management package (SPSS Inc., Chicago, www.spss.com). Data from fifth-grade levels of Texas public schools was analyzed to determine statistical support for a causal claim that the computer-assisted instruction (CAI) program, SuccessMaker® educational software (Pearson Education , Upper Saddle River, NJ, www.pearsoned. com) had an impact on the percentage of students passing the mathematics Texas Assessment of Knowledge and Skills (TAKS).

Descriptive Statistics

State Level and Study Group Passing Trends Comparison

Final fifth-grade control group and SuccessMaker® treatment group trends in passing percentage on the annual mathematics (TAKS) were positive as indicated in Figures 1 and 2. These trends over the timeframe of the study approximately paralleled the statewide results. A sharp divergence of the lines might have indicated the treatment produced a statistically significant difference in passing percentage over time. Even though there was a sizable positive gap between the study group performance and that of the statewide fifth-grade performance, no statistical conclusions were drawn by way of an independent samples *t*-test because of the anticipated large difference in standard error because of the extreme difference in sample sizes.

Figure 3 depicts an overlapping of the control and treatment groups passing percentages, suggesting no statistically significant difference. The lack of a difference in the results between the two groups may indicate selection bias. A concerted effort was made to select participants based on characteristics other than passing percentage, but it might be that the resultant campus control group was composed of a sample of exceptional campuses rather than a normally distributed sample of the state population.

Figure 1. Fifth-grade control and state TAKS mathematics average passing rates: 2005-2007.

Figure 2. Fifth-grade treatment and state TAKS mathematics average passing rates: 2005-2007.

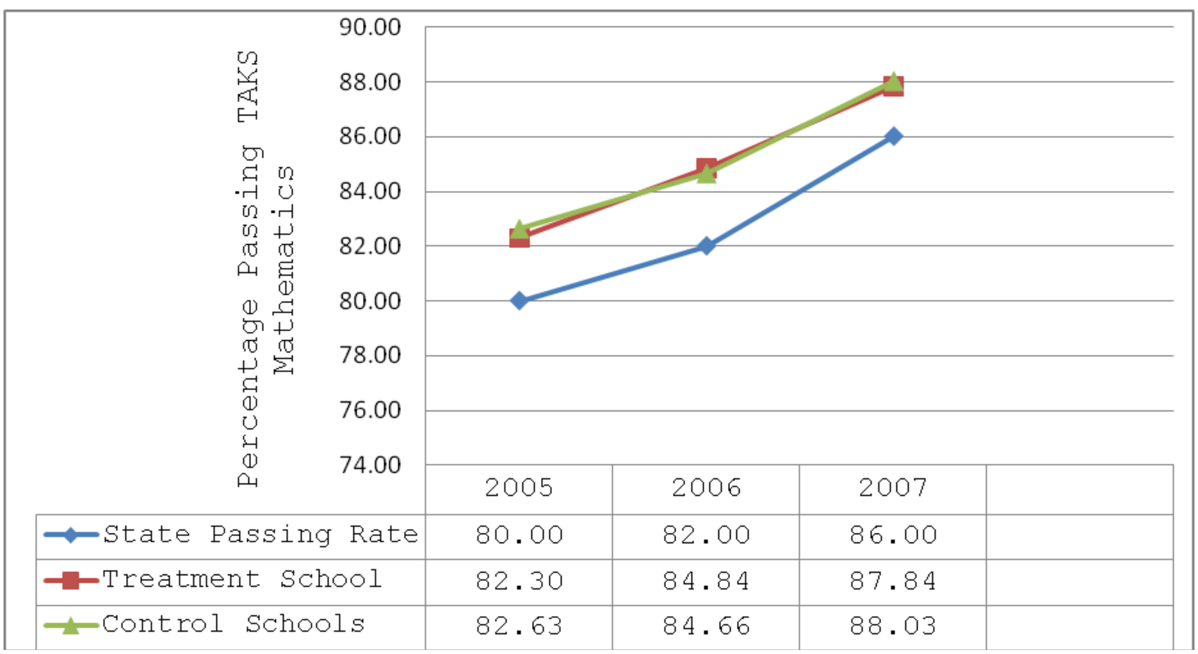

Figure 3. Fifth-grade treatment, control, and state TAKS mathematics average passing rates: 2005-2007.

Types of Improvement Approaches

Questionnaire data received from 110 principals revealed a higher than anticipated utilization level of CAI in the control group schools. Principals reported that 41% of the control group alternative improvement approaches were also CAI programs as related in Table 9. Some type of CAI was utilized on 62% of the campuses composing the entire study group. Table 10 lists 15 different CAI programs in place on control group campuses. Three additional CAI programs were also utilized in conjunction with SuccessMaker® on 16 treatment campuses.

Table 9

Frequency Distribution and Types of Improvement Approaches Used

Type	Treatment group	%	Control group	%	Total study group %
	n=39		*n*=71		*N*=110
CAI	39	100	29	41	62
Tutoring	0	0	19	27	17
Traditional	0	0	17	24	16
After-school	0	0	6	8	5
Total	39	100	71	100	100

Note: CAI = Computer-assisted instruction
Tutoring = Teacher tutoring
Traditional = Traditional instruction
After-school = After-school programs

Table 10

Final Campus Computer-Assisted Instruction Software Use

Software	Group		
	Treatment	Control	Total
SuccessMaker®	39		39
Study Island	13[a]	17	30
e-Path®	5[b]		5
Brainchild®	1		1
Riverdeep		5	5
MySatori™		4	4

(table continues)

Table 10 *(continued.)*

Software	Group Treatment	Control	Total
Understanding Math		3	3
CEI®		2	2
Accelerated Math™		2[c]	2
Rosetta Stone		1	1
Fast Math		1[d]	1
Incredible Tutor™		1	1
Symphony Math		1	1
Plato®		1	1
A+®		1	1

Note: [a]Thirteen cases of Study Island used in conjunction with SuccessMaker®
[b]Three cases of e-Path® used along with SuccessMaker® and Study Island and two cases of E-Path® with SuccessMaker®
[c]Two cases of Accelerated Math™ used in conjunction with Study Island
[d]Fast Math used in conjunction with Study Island

Fifth-grade Passing Percentage Comparison

Three-year means of the passing percentage on the mathematics TAKS at the fifth grade between types of academic improvement approaches used are presented in Table 11. There were only 1.96 percentage points separating the lowest passing rate from the highest.

Table 12 displays the one-way ANOVA results of the mathematics improvement approaches. The results yielded no significant differences between groups in regard to overall mathematics TAKS passing percentage $F(4, 99) = 0.144$, ns.

Table 11

Mean TAKS Passing Percentage for Types of Improvement Approaches in Final Fifth-grade Group (3-year Average): Math 2005-2007

Type	*N*	Mean Passing %	*SD*
SuccessMaker®	39	84.59	11.27
Other CAI	25	86.23	10.71
Tutoring	18	85.48	6.32
Traditional	17	84.45	7.64
After-school programs	5	84.27	8.49

Note: Total *N* = 104

Table 12

ANOVA for Mean TAKS Passing Percentage at Fifth Grade by SuccessMaker® and Alternative Improvement Approaches: Math 2005-2007

	Sum of Squares	*df*	Mean Squares	*F*	*p*
Between groups	55.141	4	13.785	.144	.965
Within groups	9482.832	99	95.786		
Total	9537.973	103			

Bivariate Results

The results in Table 13 revealed that SuccessMaker® use at the fifth-grade level was not statistically significant and was negatively correlated with mathematics passing percentage at fifth-grade level (r = -.04, p >.05). SuccessMaker® use accounted for less than 1% of the variance in mathematics passing percentage (r^2 = .002). The 95% confidence interval (CI) for r ranged from -.218 to .166.

District wealth was positively correlated with math passing percentage at fifth grade (r = .38, p < .01) with a medium effect size, while accounting for approximately 14% of the variance in the mathematics passing percentage (r^2 = .144). The 95% CI ranged from .203 to .533. Percentage of white students was positively correlated with mathematics passing percentage (r = .29, p < .01) with a small effect size while accounting for approximately 9% of the variance in the mathematics passing rate (r^2 = .086). The 95% CI ranged from .108 to .460. Median household income (logged) was positively correlated with mathematics passing percentage (r = .39, p < .01) with a medium effect size and accounted for approximately 15% of the variance in the parameter estimate ($r^2 = .154$). The 95% CI ranged from .216 to .543.

Alternatively, percentage of economic disadvantage students was negatively correlated with mathematics passing percentage ($r = -.51$, $p < .01$) with a large effect size and accounted for 26% of the variance in the parameter estimate ($r^2 = .264$). The 95% CI was from -.642 to -.357.

To interpret while holding all other variables constant, when a fifth grade was on a campus in a wealthy district, when the percentage of white students in fifth grade increased, or when the median household income increased, the fifth-grade math passing percentage increased. Conversely, when the percentage of economic disadvantage students increased, the fifth-grade math passing percentage decreased.

Table 13

Pearson Product-Moment Correlations among TAKS Math Passing Percentage and Variables for Final Fifth-grade Treatment and Control Groups

Variable	1	2	3	4	5	6	7	8	9	10
1 Math 3-Year Passing (%)	1.0									
2 SuccessMaker® (dummy)	-.04	1.0								
3 Wealthy (dummy)	.38***	-.08	1.0							
4 Mobility (%)	-.18**	-.06	-.06	1.0						
5 White (%)	.29***	-.02	.29***	-.25***	1.0					
6 Stu/teach (ratio)	.22**	-.08	-.00	.06	-.21**	1.0				
7 EcoDis (%)	-.51***	.00	-.43***	.21**	-.73***	-.12	1.0			
8 Enrollment (count)	.17**	-.01	.08	.02	-.25***	.66***	-.04	1.0		
9 PopDen (logged)	.09	-.07	.01	.00	-.46***	.56***	-.06	.48***	1.0	
10. MHI (logged)	.39***	-.11	.36***	-.00	.16	.30***	-.53***	.31***	.37***	1.0

Note: N = 104
Stu/teach = Student/teacher
EcoDis = Economic disadvantage
PopDen = Population density
MHI = Median household income
**p < .05 (1-tailed). ***p < .01 (1-tailed)

Multivariate Results

After calculating the descriptive statistics and Pearson product-moment correlations, linear multiple regression analysis was conducted with fifth-grade level data. This process was utilized in order to determine the combination of demographic and operational variables that maximized the predictive capacity of the final fifth-grade model. The final fifth-grade model yielded an adjusted $R^2 = .29$ indicating the model accounted for 29% of the variance in the mathematics passing percentage on the TAKS as related in Table 14. There was an expectation at the outset of this study that there would be no support for a causal claim by SuccessMaker® for improving mathematics passing percentage on TAKS based upon previous studies involving one school or groups of a few schools. The results of this statewide study were consistent with that expectation. SuccessMaker® use was not a good predictor of change in passing percentage on the mathematics TAKS ($B = -.448$, $p > .05$). The 95% CI for B ranged from -3.798 to 2.902.

There was only one statistically significant predictor developed in the process. Percentage of economically disadvantaged students was a statistically significant negative predictor of percentage of students passing the mathematics TAKS ($B = -.211$, $p < .01$) with 95% CI from -.365 to -.057). Percentage of economically disadvantaged students exhibited a large effect size ($r = .51$) accounting for 26% of the variance in the passing percentage ($r^2 = .26$).

Standardized coefficients in Table 19 indicated that percentage of economic disadvantage students ($\beta = -.490$), percentage of white students ($\beta = -.206$), and student/teacher ratio ($\beta = .189$) had the greatest effect at the fifth-grade level.

To interpret, when the percentage of economically disadvantaged students increased by 1% at fifth grade it could be predicted with 99% confidence that the passing percentage on the mathematics TAKS would decrease by .21%. Similarly on average, one standard deviation increase in the percentage of economic disadvantage students would result in a .49 standard deviation decrease in the mathematics TAKS passing percentage.

Table 14

Final Fifth-grade Model for Multiple Regression Analysis of TAKS Passing Percentage (3-year Average): Math 2005-2007

Variable	*B*	*SE B*	β	*P*
SuccessMaker® (dummy)	-.448	1.687	-.023	.791
Wealthy	3.951	2.028	.185	.054
Mobility (%)	-.419	.274	-.134	.129
White (%)	-.086	.077	-.206	.265
Student/teacher (ratio)	.910	.585	.189	.124
Economic disadvantage (%)	-.211***	.078	-.490	.008
Enrollment (count)	.001	.005	.020	.862
Population density (logged)[a]	-1.653	1.227	-.185	.181
Median household income (logged)[a]	5.357	6.074	.100	.380
(Constant)	67.582**	31.546		.035

Note: N = 104. β = standardized coefficient.
[a]Logged values for population density and median household income were used for comparison because raw data was not normally distributed.
Adj. R^2 = .292, F = 5.722***.
**$p < .05$. ***$p < .01$.

Summary

There was no statistical support for a causal claim by SuccessMaker® of superior performance relative either to traditional instruction or to any of the alternative mathematics improvement approaches studied in the present research. Correlation coefficients and multiple regression beta coefficients for the variable SuccessMaker® use were not statistically significant at the fifth-grade level.

Trends in the passing percentage during the timeframe of this study revealed that the results of the study group schools and the statewide results were almost identical in improvement from year to year. It was noted that the study group passing percentage was higher at 88% than the statewide average at 86%, but no statistical comparison was made between the study group and the state passing percentages because of the extreme disparity in sample sizes.

Three variables exhibited medium to large effect size correlation coefficients. The large negative effect size for percentage of economic disadvantaged students (r = -.51) accounted for 26% of the variance in the passing rate, while the opposite medium positive effect sizes for median household income (r = .39) and district wealth (r = .38) accounted for 15% and 14% respectively of the variance in mathematics TAKS passing percentage.

Adjusted R^2 for the final fifth-grade multiple regression model indicated that the model explained 29% of the variation in the math passing rate, thus leaving 71% unexplained. The regression model indicated that SuccessMaker® use was not a good predictor of passing percentage on the mathematics TAKS. Percentage of economically disadvantaged students was the only variable included in the multiple regression model that was a statistically significant factor impacting the percentage of students passing the annual mathematics TAKS at fifth grade.

The findings reveal that there were still 12% of fifth-grade level students in 2007 who had not achieved proficiency in mathematics even with the various improvement interventions implemented at the study group schools. It did not matter which improvement program was utilized. The result was essentially the same. There was little improvement over the statewide average passing percentage.

So what is to be made of these findings? Even though several improvement approaches including CAI were utilized on 93 of the 110 responding campuses, there was still a crisis in mathematics education for 12% of the study group students. The situation exists that on average 12 of every 100 fifth-grade students did not reach proficiency on the end of year mathematics TAKS. Additional research is required at the campuses to determine the specifics of the situation regarding teacher effort, student effort, parental support for the programs, and special needs concerns in order to develop an improvement plan that meets the educational needs of the individual students who still are not achieving success in mathematics education.

Encouragement can be taken in that, while percentage of economically disadvantaged students was a large negative predictor, campus instructional processes were meeting the needs of this subgroup to a large extent. More than 50% of the students on average were classified as economically disadvantaged students, while only 12% of students did not pass the mathematics exam; therefore, it would appear that many in the subgroup did pass.

Considering the apparent ineffectiveness of the improvement programs investigated, it might be appropriate to consider avenues that would result in a greater amount of teacher instruction time. For example, in order to provide a more extensive extended day/year program, a different work schedule for teachers working in specialized areas such as bilingual and special education might need to be considered.

CHAPTER V

CONCLUSIONS, DISCUSSION, AND RECOMMENDATION

The current research explored the comparative benefit of SuccessMaker® educational software (Pearson Education, Upper Saddle River, NJ, www.pearsoned.com) computer-assisted instruction (CAI) used at fifth grade in Texas public schools relative to alternative academic improvement approaches. This study sought to answer the question: Does SuccessMaker® CAI impact mathematics performance among fifth-grade levels? The target unit of analysis was the fifth-grade level of Texas public schools.

General Results

One-way analysis of variance yielded no statistically significant difference in passing rate means between SuccessMaker® computer-assisted instruction (CAI) and control group alternative improvement approaches, $F(4, 99) = 0.144$, ns. A possible explanation for this development was that both sets of campuses were more innovative in their educational approach. Both groups in the study did not rely solely upon the traditional instructional method. In the control group, 6 schools indicated that after-school programs were used, 19 provided teacher tutoring, and 29 or 41% of the control group participated in computer-assisted instruction other than SuccessMaker®.

At the fifth-grade level, SuccessMaker® use was not a good predictor of mathematics Texas Assessment of Knowledge and Skills (TAKS) passing percentage ($B = -.448$, $p > .05$) according to the multiple regression model. The effect size was very small ($r = -.04$), accounting for less than 1% of the variance in mathematics TAKS passing percentage ($r^2 = .002$). The argument that SuccessMaker® CAI had a greater impact on learning than alternative improvement approaches at fifth grade was not supported by the results of multiple regression analysis.

Multiple regression analysis standardized coefficients at fifth grade predicted that the relative influence upon the passing rate would occur from greatest to least in the following order: percentage of economically disadvantaged students (negative), percentage of white students (negative), student/teacher ratio, and district wealth. These variables were followed by population density (negative), mobility percentage (negative), median household income, the use of SuccessMaker® (negative), and enrollment. Relative influence indicated by standardized coefficients also indicates the ineffectiveness of SuccessMaker® as a predictor of mathematics (TAKS) passing percentage.

Multiple regression analysis at fifth grade indicated that 29% of the variance in the average passing percentage of the mathematics TAKS test was accounted for in the model by the variables listed above ($R^2 = .292$). There was only one statistically significant predictor developed in the process: Percentage of economically disadvantaged students was a statistically significant negative predictor of percentage of students passing the mathematics TAKS ($B = -.211$, $p < .01$) with 95% confidence interval for B from -.365 to -.057). Percentage of economically disadvantaged students exhibited a large effect size ($r = .51$) accounting for 26% of the variance in the mathematics passing percentage ($r^2 = .26$).

Weaknesses identified in this study were related to the limited size and narrow focus of the study. This study was undertaken with the intention of improving upon the design of earlier research and particularly to address perceived shortcomings in recent dissertations. Specifically, the dissertation studies involved (a) very limited populations -- small number of schools, generally only one district, and one type of school (urban, suburban, or rural); (b) short intervention times; and (c) low power limiting the generalizability of the results.

Weaknesses Addressed

The current study sample size was still relatively small, but the sample was more diverse. The final study group represented 52 school districts that were categorized as small, mid-sized, and large as well as rural, suburban, and urban. Final regression analysis model results were based upon a sample size of 104. The study was conducted utilizing multiyear data from 2005-2007.

Another weakness identified in the study resulted from the use of multiple computer-assisted programs at both the treatment and control schools, confounding the results. Principal questionnaire responses indicated that 41% of the control group utilized CAI software. There were 15 different software packages in use at the study group schools. Some campuses used multiple packages at the same time. Also confounding the results, there were 16 (41%) of the 39 treatment group campuses that also used one or more software packages in conjunction with SuccessMaker®.

Other possible weaknesses in the study were related to threats to internal validity. Limiting the conclusions from this study and the utilization of multiple regression techniques reduced the threats to internal validity (Campbell& Stanley, 1963; Langbein, 2006). History as a concern was lessened by the inclusion of a large sample of fifth-grade campuses in Texas that have implemented the use of SuccessMaker® software so that external events at one school would have minimal effect upon the overall results. Maturation was not a cause for concern because a pretest and posttest were not used.

Testing as a threat to internal validity was not an issue in this case because obtrusive measures such as a survey were not utilized. The principal questionnaire was used to determine the placement of the fifth grade in either the treatment or control group.

Instrumentation threat was addressed by using the percentage meeting the cut-off score as the difference measure rather than change in standard score from pretest to posttest. Regression artifacts were controlled by insuring that the control group and experimental groups were similar on factors other than pretest scores (Campbell & Stanley, 1963; Cook & Payne, 2002).

Selection bias was addressed by using a large sample from all the schools using the intervention and using several control variables in the multiple regression model. Selection bias still might have contributed to the narrow difference in passing percentages between the treatment group and the control group. The control group might have been an uncharacteristic sample from the whole state population since its performance on the mathematics TAKS was more like the treatment group than the whole state average.

Attrition was lessened because of the inclusion of a large sample of the population of interest and since attrition affected all of them similarly, in that only those students who were at the school on the October snapshot date and who tested in the spring were included in the calculation of percentage of passing the TAKS.

Multiple treatment interference and contamination between treatment groups were concerns because even though there was only one treatment and the control group schools were separated from the treatment, multiple computer-assisted instruction programs were used at both the treatment and control group schools to some extent.

The implemented research design addressed the concerns regarding threats to internal validity and greatly lessened their effects. Campbell (1969) reminds researchers that threats to validity need to be considered but that the possibility of a threat should not invalidate the results of a study.

Discussion

Mastery learning and constructivist learning theories predicted that CAI would result in increased student learning. Even though study group average mathematics passing percentage was higher than the statewide average, the trend in the passing performance of the students in the study group paralleled rather than diverged from the overall state passing performance during the timeframe of the study as would be expected from the predictions. Further, multiple regression analysis determined that use of SuccessMaker® did not predict a statistically significant difference in passing percentage on the mathematics TAKS at fifth grade.

Mastery learning theory suggests that all students can achieve mastery level when they are provided quality instruction and sufficient time to learn (Block, 1971). Using CAI allows for individual differences in skill acquisition to be addressed. If a student had missed instruction or not understood a concept, individual instruction and practice to develop mastery could be provided by the computer program in a timely manner. Similarly, teacher tutoring and after-school programs designed to provide additional individual mathematics instructional assistance contribute a greater amount of time for students to learn. Predicted beneficial effect of CAI based upon mastery learning theory was not borne out by the results of this study.

Additionally, constructivist learning theory (Dalgarno, 2001; Piaget, 1973a) suggests that active learning is more productive than traditional instruction. Student-centered lessons and active engagement on the part of the student contribute to successful learning. CAI targets individual student needs and provides a setting in which the student is actively interacting with the program. Again, teacher tutoring and after-school programs provide similar additional student centered activity. As with mastery learning theory, predicted beneficial effect of CAI based upon constructivist learning was not evident in the results of this study.

Contributions to the Literature

The present study makes several contributions to the literature of computer-assisted instruction. First, it adds to the knowledge concerning the effectiveness of the SuccessMaker® software at the elementary level. Multiple regression analysis yielded a negative and not statistically significant result for SuccessMaker® use compared to alternative improvement approaches at fifth grade in Texas schools ($B = -.448$, $p > .05$). Effect size was small ($r = -.04$) with SuccessMaker® use accounting for less than 1% of the variance in math passing percentage ($r^2 = .002$).

Second, the present study adds to the limited number of multiple school district studies concerning the effectiveness of SuccessMaker® software (Mintz, 2000; Pearson

Digital Learning, 2002; Phillips, 2001; Underwood, Cavendish, Dowling, Fogelman, & Lawson, 1996). This study utilized data from 52 school districts.

Third, this research study makes a contribution toward filling the gap in the research literature at the statewide level concerning the impact of SuccessMaker® CAI on the passing percentage for mathematics TAKS among fifth-grade levels. This study compared SuccessMaker® to a group of other CAI programs consisting of 15 different software packages used in the Texas elementary school sample as well as to teacher tutoring, after-school programs, and traditional instructional programs. One-way ANOVA yielded no significant differences between groups in regard to overall mathematics TAKS passing percentage $F(4, 99) = 0.144$, ns.

Fourth, this research study indicates that 41% of the control group schools as well as the SuccessMaker® treatment group schools used computer-assisted instruction in contradiction of the literature that says that computer use is limited (Becker, 2000; Cuban and Cuban, 2007).

Finally, this study data does not support the contention that the constructivist philosophy held by educators limits their acceptance and use of CAI technology because it is strongly behaviorist oriented (Atkinson, 1969; Cuban, 1986; Saettler, 1990; Suppes, 1967).

The results of the present study emphasize that there are factors that have a negative effect and others that have a positive effect upon student success. Administrators are challenged to minimize the negative effects of identified variables while attempting to maximize the positive effects of others in order to increase the percentage of students passing the mathematics TAKS. Results of this study provided administrators with assistance in their professional practice.

Contributions to Practice

First, results of this study provide administrators with additional research-based information that does not support recommendations concerning the use of computer-assisted instruction. Since this study indicated that the use of SuccessMaker® was not a good predictor of increased passing percentage on the mathematics TAKS, an administrator would be remiss in recommending the adoption of the program without additional research information.

Secondly, administrators are urged to be cautious when making recommendations for any specific program based upon the results in this study. There was no statistically significant difference reported between the passing rates attained by any of the approaches used in the study group. Because of the number of different CAI programs used and because several were used simultaneously, it cannot be said which computer programs performed better or if in concert they worked better than singly.

Implications for Policy

The present study also contributes to the program evaluation process. This process of evaluation is consistent with the No Child Left Behind policy which requires decisions to use programs and materials in schools to be based upon results of scientific research.

Policy implications related to the outcome of the study are possible. Since SuccessMaker® use was determined to not be a good predictor of mathematics passing percentage, an administrator cannot recommend with confidence that an expansion of the use of CAI to all school campuses directed by policy change at the district level would lead to improved mathematics passing rates for fifth grade over another alternative improvement program.

Secondly, the large negative effect size (r = -.51) for the percentage of economically disadvantaged students accounted for 26% of the variance in the passing percentage (r^2 =.26). The characteristics of the elementary schools when compared to the districts indicated that the percent of economically disadvantaged students was likely to increase in the districts. This situation suggests that policy changes might be necessary in order for schools to continue to improve the student passing percentage.

Future research into the effect of an individualized instruction program compared to the traditional group instruction may be warranted. Each of the alternative academic improvement approaches identified in this study contained the concept of additional individual instruction.

Future Research

The results of this study suggest that it might have been the additional efforts by the teachers and students that made the positive difference in the passing percentage of the study group compared to the state average. Statistical conclusions were not drawn concerning the passing percentage difference by way of independent samples *t*-tests because of the anticipated large difference in standard error because of the extreme difference in sample sizes. In order to conduct the alternative improvement programs, additional effort on the part of teachers and students was required. Research is recommended to determine the impact of the additional effort by teachers and increased time on task by students on passing percentage on the mathematics TAKS.

Financial effectiveness was not addressed by this study. It is recommended that a study be devised to compare the cost effectiveness of the different programs or processes utilized in the schools. Even though there was no statistically significant difference in the success rates of the various programs, it might be learned that the cost effectiveness of one program is statistically significant compared with the others. Retention of a cost-effective program that provides a small improvement might be desired at the local level.

Summary of Conclusions

Examining the use of SuccessMaker® CAI in Texas was important because 140 school districts were employing the software, and there was no statewide scientifically researched assessment of its effectiveness. Furthermore, the National Mathematics Advisory Panel (2008) recommended that more rigorous studies on topics of mathematics education be conducted, such as randomized controlled designs or methodologically rigorous quasi-experimental designs, in order to inform practice that may lead to improved mathematics skill development.

This study sought to determine the impact SuccessMaker® CAI had on the passing percentage on the mathematics TAKS among fifth-grade levels. Results indicated that use of SuccessMaker® CAI is not a good predictor of mathematics passing percentage (B = -.448, p >.05) with a small effect size (r = -.04) accounting for less than 1% of the variance in the passing percentage on the mathematics TAKS (r^2 = .002). The 95% confidence interval of B ranged from -3.798 to 2.902.

The overall conclusion from this study suggests that there might be no substitute for hard work (effort) on the part of educators and students in order to achieve high levels of success by all students (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 1999; Simon, 2002). No magic bullet to solve the educational challenge to improve student success rates on the mathematics TAKS was identified by the results of this study. It appears that study-group schools, through additional work, achieved a higher level of success (88% versus 86% in 2007) on the mathematics TAKS than that achieved by the total state student population at fifth grade. Unfortunately, there were still 12 of every 100 fifth-grade level students who did not achieve proficiency on the mathematics TAKS.

Schools in the study indicated that additional individual instruction of some type was provided beyond the accepted traditional instructional practice. Additional effort by teachers was required to identify individual student needs, to prepare appropriate instructional material to be used in tutoring or after-school programs, or to provide and monitor computer-assisted instructional opportunities. Participation in these additional instruction and practice opportunities required additional effort by students. SuccessMaker® computer-assisted instruction as one vehicle for additional instruction and practice did not appear to be as successful at achieving increased percentage of passing on the mathematics TAKS as other computer-assisted instruction programs or teacher tutoring provided at control group schools.

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