THE EFFECTIVENESS OF COMPUTER AIDED INSTRUCTION IN MATHEMATICS FOR STUDENTS WITH LEARNING DISABILITIES

By

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Abstract

The purpose of this literature review was to examine the effectiveness of computer-assisted instruction for the improvement of mathematics performance for students with a learning disability. This review examined 15 different studies that focused on computers, mathematics, and students with learning disabilities. Five of the studies were literature reviews done by other authors, 4 more were recent studies, and 6 were older more historical studies. In general the results were positive for the effectiveness of computer-assisted instruction but in order for it to be effective it must be individualized for each student and combined with other interventions and teacher interaction. It can be effective but it is not the panacea for students with learning disabilities.

Chapter I: Introduction

Beginning with PL 94-142, students with learning disabilities are required to be educated in the “least restrictive environment” (Education of All Handicapped Children Act, 1975). Not only the law, placing students with learning disabilities in regular classrooms, regarded as mainstreaming, integration, or inclusion, is also advocated by educators and parents (Putnam, 1993). Over the past 20 years, as the process of inclusion was implemented, teachers were, and are, confronted with the challenge of developing appropriate approaches to meet the instructional needs of diverse students. Physically including students with disabilities into classroom with regular peers will not ensure accomplishment of their academic goals (Putnam, 1993).
“We live in a society in which mathematical knowledge is commonly portrayed as vitally important for economic success, and indeed for everyday functioning”, (Ginsburg, Klein, & Starkey, 1998, p. 402). Given such importance of mathematics in our society, many researchers in the field of special education have made efforts to facilitate the mathematics performance of students with learning disabilities (learning disability) over the past few decades (Fuchs et al., 2008; Gersten, Jordan, & Flojo, 2005). Learning disability defined as (Hunt & Marshall, 2006) a disorder in one or more of the basic psychological processes involved in understanding or using language. Evidences have demonstrated a majority of students with learning disabilities have serious difficulties learning mathematics with much lower mathematics achievement levels than their same-age peers without learning disabilities (Bryant, 2005; Fuches et al, 2008).

Some researchers argue that evidence exists demonstrating students with learning disability cannot fully benefit from mathematics instruction and curriculum in general education classrooms (Cawley & Miller, 1989; Cawley, Parmar, Yan, & Miller, 1998). More specifically, students with learning disability may struggle with the rapid pacing of introducing new mathematics concepts, and insufficient examples, explanations, practice, and review in general education classrooms (Salend, 1994).

To address the challenges of diverse learners, increasing student to teacher ratios, and limited instructional time, technology has been recommended by many researchers with high expectations for its potentiality and flexibility (Woodward & Carmine, 1993). Some researchers argue technology can adapt and individualize mathematics instruction for students with special needs (Bryant & Bryant, 1998; National Council of Teachers of Mathematics [NCTM], 2000).
Especially for students with learning disability, technology can offer a variety of individualized mathematics instructions to meet their special learning characteristics and to ensure their successful mathematics achievement in general education settings (Hasselbring, Goin, & Bransford, 1988; Symington & Stranger, 2000). As the quality and availability of technology has dramatically increased in the past decade, researchers and educators have made efforts to apply technology to the mathematics curriculum for students with learning disability to enhance their mathematics performance (Anderson-Inman, Knox-Quinn, & Horney, 1996).

One application of technology in education, computer-assisted instruction (CAI), is defined as the use of a computer to provide instructional contents (Aydin, 2005; Okolo, 1992a; Poplin, 1995). Given the growing number of mathematics CAI studies for students with learning disability, several studies in the field of special education have documented the overall effects of CAI on the mathematics performance of students with learning disability (Miller, Butler, & Lee, 1998; Swanson, Hoskyn, & Lee, 1999). However, several limitations regarding the systematic analysis of the effectiveness of CAI in mathematics for students with learning disability are found in these studies. First, the studies focused on all mathematics intervention studies, not just mathematics CAI studies (Mastropieri et al., 1991; Miller et al., 1998). Second updating literature including recent CAI studies published after 2000, for students with learning disability, is necessary. Third, the instructional principles and features embedded in CAI programs are critical factors closely related to students’ positive academic outcomes during CAI.

**Statement of Problem**

The purpose of this review of literature was to analyze the findings of Computer-Assisted-Instruction and the mathematics achievement of students identified with Learning Disability.
Disabilities. Particular attention was on the instructional features inherent in effective CAI programs.

**Research Question**

The following question guided this review of literature: How effective is computer-assisted instruction (CAI) on the mathematics achievement for elementary and secondary students identified with a learning disability?

**Definition of Terms**

Effect size. For the purpose of this literature review effect size is defined as a measure of the strength of the relationship between two variables in a statistical population, or a sample-based estimate of that quantity. Sample-based effect sizes are distinguished from test statistics used in hypothesis testing, in that they estimate the strength of an apparent relationship, rather than assigning a significance level reflecting whether the relationship could be due to chance. “In scientific experiments and observational studies, effect size is often useful to know not only whether a relationship is statistically significant, but also the size of the observed relationship. In practical situations, effect sizes are helpful for making decisions, since a highly significant relationship may be uninteresting if its effect size is small, (Rosenthal, Cooper, & Hedges, 1994, p. 231-33).”
Chapter II: Review of the Literature

This literature review includes a review of several existing literature reviews, a collection of newer studies that are within the last five years, and also a group of older, historically significant studies.

Examination of Five Literature Reviews

Seo and Bryant (2009) conducted a literature review of 11 studies. The authors of this meta-analysis used a search period of 1980 up to the time of their study in 2008. This 28-year period was chosen because studies of computer use in special education began in the early 1980’s (Seo & Bryant, 2009). Three categories were investigated: (1) Computer-assisted instruction versus teacher-directed instruction, (2) Comparison of computer-assisted instruction types, and (3) Enhanced computer-assisted instruction. Six studies were examined for the first category with mixed findings. The six studies showed students using computer-assisted instruction outperformed their counterparts but the effect sizes were not significant. Three studies compared the effects of two types of computer-assisted instruction (i.e., drill versus game, and tutorial versus drill with teacher strategy). The studies found different results and effect sizes were not large. Three studies reviewed enhanced computer-assisted instruction, the third category. The study outcomes varied depending on the instructional design variable embedded in the computer-assisted instruction program. The one program that showed a large effect size was the software that used retraining feedback as the variable. Since only one study for each instructional design variable was done there is a need for more research and no conclusions can be drawn from the study data. The authors of the meta-study concluded that the studies did not show conclusive impact on mathematics achievement of students identified with a
learning disability and the effect sizes were not large. “This equivocal finding is corroborated by other previous reviews on the mathematics interventions for students with LD, demonstrating inconsistent positive mathematics outcomes of CAI for students with LD” (p. 925)

Fitzgerald, Koury, and Mitchem conducted two literature reviews focusing on technology and students with disabilities spanning the years 1987-1995, and 1995-2008. In the recent literature review (Fitzgerald, Koury, & Mitchem, 2008) they comment on the lack of available studies focusing on high incidence disabilities and computer-mediated instruction (CMI). CMI different from CIA, changed from being a drill and practice approach to emphasize information-age skills, finding and evaluating information through the Internet, using presentation tools to demonstrate learning, and an increase in online inquiry oriented activities (Fitzgerald, Koury, & Mitchem, 2008). These technological changes, changes in curriculum, as well as mainstreaming students with disabilities bring about immense challenges for teachers and researchers to examine the effectiveness of CMI. Their review covered several core subjects such as reading, writing, mathematics, science, and social studies but for the purposes of this review, the focus will be on their mathematics and CMI findings. They examined 7 new studies in mathematics since the original 1987-1995 literature review. One of these studies, Irish (2002), is included in this literature review below. The studies they examined looked at fact fluency and mathematical problem solving from primary to secondary with a total of 251 participants.

Two studies examined computational fluency. No conclusions could be drawn about the effectiveness of CMI because the instructional design features of the software were not controlled. Five studies examined problem solving with mixed findings. Each of the software programs involved used a video anchor to facilitate anchor instruction. They concluded, CMI anchored instruction appears to offer great potential for effective instruction for students with disabilities, blending applied curricular approaches with strategy
support and instructional scaffolding in flexible, learner-controlled environments. The challenge is to intermix the prerequisite skills and explicit instruction need for students with disabilities to be successful in solving complex problems (p. 220).

There are concerns about skill transfer and about the need for explicit instruction to fill the skill gaps needed for the level of problem solving complexity required with current curriculum standards. They conclude that research in the past ten years has not enlightened knowledge about the effectiveness of CMI for students with disabilities. Finally from their research they argue that CMI or technology applications do not eliminate performance differences between students with and without disabilities.

Dugan, Cobb, and Alwell (2006) published a paper on the National Post-School Outcomes Center website in which the development of this paper was funded in part through the U.S. Department of Education, Office of Special Education Programs (Grant Award No. H324W010005). The purpose was to examine the effects of technology based interventions on students with a disability. First they analyzed 9 different literature reviews spanning 1986 to 2002, and determined that these studies gave evidence of the effectiveness of the technology based interventions. Thirty-nine studies satisfied the criteria for this review. Seven of the thirty-nine studies involved mathematics. As noted previously, the majority of the studies included in the review were published before 1992. These publication dates do raise concern regarding the relative age of the studies reviewed when consideration is given to the significant improvements in computer technologies over the last decade (Dugan, et. al., 2006). The authors of this study believe that the effectiveness of technology proves to be consistently effective over a time span of more than 30 years, but again comment on that lack of studies after 2000. Secondly they believe that despite the evidence of the effectiveness of technology as an intervention the integration of technology into the classroom has not kept pace with the continuing improvements of available technology.
The study titled “Technology-Based Practices for Secondary Students with Learning Disabilities”, (Maccini, Gagnon, & Hughes, 2002), researchers conducted a comprehensive review of the literature on technology-based practices for secondary students identified as having learning disabilities (learning disability) involving instruction and/or assessment measured some aspect of performance on a general education task or expectation (i.e., test). Technology-based practices included computer- or video-based interventions, multimedia programs, technology-based assessment, and verbatim audio recordings. Three practices appear promising for educating students with learning disability: (a) hypertext and hyper-media software programs; (b) videodisc instruction involving contextualized learning; and (c) multimedia software. Educational recommendations and directions for future research are offered based upon results.

A total of 389 secondary students participated in the studies targeted in the current review; 134 were labeled learning disability. The mean student age was 15.1 with a range from 12.8 to 15.5 years.

The number and duration of the instructional sessions varied among the studies. For example, the number of sessions ranged from two days to eight weeks and the length of sessions per day ranged from 13 minutes to 45 minutes. Over half of the lessons (N = 7, 64%) lasted 30 minutes each. Three studies (Horton & Lovitt, 1994; Horton, Lovitt, & Slocum, 1988; Kelly, Carnine, Gersten, & Grossen, 1986) did not report the number of sessions, and two studies (Horton et al., 1990; Torgesen et al., 1987) did not report session length.

In the studies reviewed, researchers combined technology-based practices with other instructional interventions, including content enhancements, study guides, learning strategies, and various approaches to assessment. Six categories of technology-based practices are described
in the following section: (a) computer-assisted adaptations; (b) videodisc adaptations; (c) hypertext study guides; (d) hypermedia study guides; (e) assessment formats; and (f) verbatim text recordings.

Perhaps the most referenced review regarding computer-assisted instruction is Xin and Jitendra’s (1999). Xin and Jitendra examined twenty-five studies, ten of which were unpublished. The years of these studies span from 1980 to 1996 with a total of 624 elementary and secondary students, and 68 post-secondary students. They examined the effects of instruction in solving mathematical word problems for students with learning difficulties. The study compares different instructional approaches such as strategy training, computer-assisted instruction, and representation techniques. All interventions yielded moderate to large effect sizes, with computer-assisted instruction obtaining the highest effect size of 1.8. This effect size is higher than several other studies noted in Xin and Jitendra’s article. “These differences in effect sizes may be a function of the differences in the manner in which effect sizes were calculated (between-subject vs. within-subject comparisons), content domains (basic skills vs. word-problem solving), type of CAI (e.g., drill and practice vs. tutorial), and population (general education or special education students vs. students with mild disabilities and at-risk students). Computer-assisted instruction is especially effective when empirically validated strategies and curriculum design principles are incorporated” (Xin & Jitendra, 1999, p. 218).

A collection of 4 other literature reviews and special education handbooks were culled for computer-assisted instruction, technology, and mathematics. One ninety-four page study did not include computer-assisted instruction in their study. Two of the studies list computer-assisted instruction only once in the entire paper. The fourth mentions computer-assisted
instruction but in regards to literacy and not mathematics. The author of one of the many reviewed articles mentions that the number of studies for computer-assisted technology and literacy compared to mathematics was 5 to 1.

**Recent studies**

**Selection Criteria.**

The criteria for selecting appropriate CAI studies for review were as follows:

- Studies needed to include students with learning disability who were in elementary or secondary grades as their participants.
- Studies needed to employ at least one within-group (i.e. pretest/posttest comparison), between group (i.e., treatment/comparison group), or single-subject design.
- Studies needed to focus on mathematics CAI as their independent variable and examine its effects on the mathematics performance of students with learning disability.
- Studies needed to examine students’ mathematics performance as their dependent variable.

Computer assisted intervention for children with low numeracy skills were studied by Räsänen (Räsänen, P., et al., 2009). Thirty Finnish speaking preschool children from middle to lower class families were randomly selected to participate in the study. The treatment was two computer games that focused on early math skills. The thirty were split randomly with fifteen students using Number Race (NR) game and the other fifteen using Grapho-game Math software (GGM). Thirty other students were selected with matching birthdays as the control group. They assessed verbal and spatial working memory once to get an estimate of general cognitive level. Four measures of number skills and a non-numerical control task were assessed twice before and twice after the three-week intervention period to evaluate the effectiveness of the two
computerized intervention methods. The data collected was quantitative, measuring skills in verbal counting, object counting, number comparison, and arithmetic.

They were successful in producing significant improvement in number comparison. However, their other expectations of improved performance in children with weak early number skills were not realized, and findings were mixed.

Räsänen chose 5 studies that examined early numeracy skills in sufficient detail to enable comparisons between intervention and control groups. The studies were dated 1986, 1990, 2006, 2006, and 2006 respectively. An average gain between the intervention and control groups was a moderate effect size of (.67) with a confidence interval of -.15 to 1.49. It is interesting to note that these estimates of gain are close to those from the early Institute for Mathematical Studies in the Social Sciences at Stanford studies from the 1960s (Räsänen, P., et al., 2009). In other words, current gains are the same as they were in the 1960’s. Anecdotal evidence seems to imply that the effectiveness of computer-assisted interventions and research about these interventions has not kept pace with the current possibilities in technology. Räsänen states, “Computer-assisted learning has not met its expectations” (Räsänen, P., et al., 2009, p. 18).

The purpose of the study “A Computer Game as a Context for Non-Routine Mathematical Problem Solving: The Effects of Type of Question Prompt and Level of Prior Knowledge”, (Lee & Chen 2009), was to investigate the effects of (a) question prompts, (b) prior knowledge, and (c) the interaction of question prompts and prior knowledge on junior high school students’ problem-solving performances in non-routine mathematical tasks. The question prompts in the study referred to a set of questions were domain specific and metacognitive-like, prompting students to attend to important aspects of a problem at different phases and assisting them to plan, monitor, and evaluate the solution process. The prior knowledge under
investigation was defined as the following four pattern reasoning styles: (1) recursive relationship, (2) functional relationship, (3) algebraic expression, and (4) knowledge about arithmetic sequences which are the prerequisite for exploring the Frog Leaping Online Game and for completing the major tasks.

Seventy-eight 9th graders from two classes of a public junior high school in northern Taiwan participated in the 6-week experimental instruction. Participants were randomly assigned to the specific-prompt group and the general-prompt group to receive the one-hour weekly treatment.

In the general-prompt group, procedural prompts were offered to help students complete the basic procedures of non-routine problem solving, while in the specific-prompt group, the supplementary elaboration and reflection prompts strongly related with the major tasks were provided to prompt students to articulate thoughts and elicit explanation.

Students did not encounter the tasks related to the frog leaping problem before and did not know the solution methods in the beginning. Therefore these tasks were non-routine problems for them and provided students with the opportunities to integrate their problem-solving skills and to apply their pattern reasoning into the context of the frog leaping problem.

The frog leaping problem. A computer game of the frog leaping problem was provided. The rules of the game are described as the following: (a) The pond includes seven stones and six frogs. One stone could only be occupied by exact one frog. The six frogs are divided into two groups and each group has three frogs. Three frogs are standing on stones in the left side, called the left group, and three frogs standing on stones in the right side, called the right group. An
available stone is between the left group and the right group. (b) A frog could either leap forward one stone on which no frog stand or leap forward over one frog and stop on the stone next to the overleapt frog. (c) The aim of the game is to have both the left group of frogs and the right group of frogs switch their positions. In other words, the left group of frogs moves to the right side and the right group of frogs moves to the left side.

In the study, four findings were concluded. Firstly, regardless of the simple task (Task 1) or difficult task (Task 2), students with high prior knowledge outperformed those with low prior knowledge in problem-solving performances. Secondly, specific prompts did not have a more positive effect than general prompts in solving the simple task (Task 1). Thirdly, students receiving specific prompts outperformed those receiving general prompts in performing the difficult task (Task 2). Finally, question prompts and mathematics attitude were not the significant predictors on predicting the problem-solving performance of simple task (Task 1) but they could predict the problem-solving performance of difficult task (Task 2).

Several questions have been raised as a result of our investigations. Firstly, despite the fact a significant interactive effect between type of question prompt and level of prior knowledge in problem-solving performances did not exist, a trend appeared that students in S/H group had higher means than the G/H, S/L, and G/L groups on the two problem-solving performances: reasoning for one variable and reasoning for two variables. Future studies should increase the number of sample size to examine the effective use of type of question prompt on students’ prior knowledge (King, 1992). Secondly, adding more scaffolding techniques to help students with low prior knowledge enhance their performance of non-routine problem-solving processes, seemed important. Therefore, methods to design effective scaffoldings for non-routine problem-
solving processes were deserved of future exploration. Thirdly, how effectively students internalize self-questioning when prompts are removed was also an important issue. Future research could use more strategies, such as worked examples, peer tutoring, expert modeling and so forth, to help students improve their non-routine mathematical problem-solving. Finally, because mathematical attitude was also an important factor to predict the problem-solving performance of reasoning for two variables in the study, future research should be designed to investigate the effects of various affective scaffolds in motivating students in solving complex, non-routine problems (Ge & Land, 2004).

The study ”Learning Multiplication through Computer-Assisted Learning Activities”, (Chang, Sung, Chen, & Huang 2008), develops and implements a computer-assisted learning (CAL) program with both multiplicative facts practices and the instruction of meaning behind these facts. The effectiveness of CAL on the development of multiplication abilities is also explored. Eight CAL activities are developed to teach multiplication to second grade elementary school students. The CAL program is comprised of three stages of instruction addressed in succession the basic concept of multiplication, the meaning and properties of multiplication and multiplication-related computation skills.

The study population was comprised of 42 second grade students from Taipei City (22 male, 20 female; the average age was 8 years). The students were assigned randomly to either a control or an experimental group, each of which comprised 21 subjects (11 boys and 10 girls). None of the students had received any instruction regarding multiplication prior to the study.

The independent variable was the group (control group of experimental group). The dependent variable was the posttest score for each learning stage, and the pretest score was the
covariance. Prior to the experiment, pretest scores were obtained. The experimental phase was conducted over a 3-week-long period in which all students received the same instruction. Thereafter, students in the control group continued to learn using traditional written materials while students in the experimental group learned using the CAL software-based exercises. After each learning session, all students took a 10-minute posttest.

The study revealed CAL improved comprehension of basic multiplication concepts in students with relatively low pretest scores (lower than 17.94) whereas CAL did not improve the same aspect beyond the improvement achieved using traditional materials for students with relatively high pretest scores (between 17.94 and 30). A similar outcome was observed in comprehension of the meaning and properties of multiplication, in which, CAL failed to affect outcome in students scoring above 24.46. Experimental and control group tests scores for multiplication-related computation skills did not significantly differ in the study. However, low-scoring students who are poorly motivated are likely to exhibit improved comprehension of multiplication if instruction is based on CAL, rather than on traditional materials. One reason for a lack of improvement for all students could be attributed to the relatively brief period of instruction in the study. Because remedial learning of multiplication is important to elementary school students, an important goal for future research is the best application of CAL.

The purpose of the pilot study, “The Effects of Computer-Assisted Instruction on Number Combination Skill in At-Risk First Graders”, (Fuchs, Fuchs, Hamlet, Powell, Capizzi, & Seethaler, 2006), was to assess the potential for computer-assisted instruction (CAI) to enhance number combination skill among children with concurrent risk for math disability and reading disability. A secondary purpose was to examine the effects of CAI on spelling. At-risk students
were assigned randomly to math or spelling CAI, which they received in 50 sessions over 18 weeks. Acquisition and transfer effects were assessed. The results indicated math CAI was effective in promoting addition but not subtraction number combination skill and that transfer to arithmetic story problems did not occur. Spelling CAI effects were reliable on acquisition and transfer spelling measures, with small to moderate effect sizes on transfer to reading measures. These results provide the basis for additional work with larger samples.

Participants were drawn from nine first-grade classrooms in three Title 1 schools in a metropolitan public school system. These 33 students were assigned randomly in blocks within classrooms to receive math CAI ($n = 16$) or spelling CAI ($n = 17$). Students in a class worked on spelling CAI while their classmates worked on math CAI.

The CAI software design was based on the following assumption: Repeated pairing of a problem stem with its answer in short-term memory should help children to commit the corresponding number combination to long-term memory for automatic retrieval. The computer-mediated treatment, which we referred to as FLASH, briefly presented a stimulus (a number combination for math FLASH; a word for spelling FLASH) on the computer screen. When the number combination or word disappeared, the computer screen prompted the student to retype the number combination or word from working memory.

Research assistants supervised FLASH sessions three times per week, 10 min per session. Students in the same classrooms worked simultaneously on different computers, on either math or spelling, consistent with their random assignment. Fifty 10-minute FLASH sessions were conducted over 18 weeks. As the sessions progressed, words or number combinations had
already been classified as mastered reappeared periodically for review. If these stimuli were missed, they were removed from the mastered set.

Students were pre- and posttested in groups on Number Fact Fluency (Author, 2003) with two subtests—addition and subtraction. Addition Fact Fluency comprises 24 addition fact problems, with sums or minuends from 0 to 18, presented horizontally on one page. Students have 1 min to write answers. The score is the number of correct answers. Story Problems comprises 14 brief story problems, involving sums or minuends of 9 or less, with change.

All testers were trained to 100% accuracy on all measures. Students were pretested within 2 weeks prior to the beginning of intervention, and posttested within 2 weeks after intervention ended.

The results indicated CAI on number combinations—designed to repeatedly pair problem stems with their answers in working memory so the facts could be established in long-term memory—did result in differentially strong improvement on addition number combination skill, which was statistically significant.

Despite the lack of significant results for subtraction and transfer to arithmetic story problems, the findings on the addition fact retrieval measure are noteworthy because the retrieval of number combinations represents a difficult type of competence to promote among students with math disability. Moreover, prior work (Hasselbring et al., 1988; Pellegrino & Goldman, 1987) has suggested the difficulty of remediating the deficit with older elementary students.
In sum, across arithmetic and spelling skills, the results of the pilot study suggest the potential for computer-assisted instruction to enhance outcomes among high-risk first graders when those children are supervised to ensure accurate use of the software.

**Older more historical studies**

The study “Using Peg- and Keyword Mnemonics and Computer-Assisted Instruction to Enhance Basic Multiplication Performance in Elementary Students with Learning and Cognitive Disabilities”, (Irish, 2002), describes the effectiveness of Memory Math, a multimedia software program developed to teach students with learning and cognitive disabilities to effectively use a peg- and keyword mnemonic strategy to learn basic multiplication facts. According to the math Standards (National Council of Teachers of Mathematics, 2000), accuracy with basic is a critical element in the development of new skills and achievement in higher levels of math. One avenue for improving accuracy on basic skills is computer-assisted instruction (CAI). The paper demonstrates CAI provides an effective mechanism for teaching students a mnemonic memory strategy to increase their independent performance and accuracy on tasks of basic multiplication.

The experimental study evaluated the effectiveness of the Memory Math (Irish, 2002) program, a single-subject, multiple-baseline, across subjects design was utilized to answer the following research questions.

1. To what extent did the implementation and use of Memory Math supplemented with regular class review result in changes in the accuracy of students with learning and cognitive disabilities on basic multiplication facts (twos through nines)?
2. To what extent did the implementation and use of Memory Math instruction supplemented with regular class review generalize to student accuracy on paper/pencil tasks of basic multiplication facts (twos through nines)?

The participants in the study were six students with learning and cognitive disabilities selected from five special education classrooms. The eligible students attended public school in an urban setting in a midwestern city of moderate size. Each had been identified as learning disabled (learning disability) in mathematics or cognitively disabled (CD) and in need of special education by their school districts. To be included in the study, the students with learning disability performed at a level approximately 2 or more standard deviations below their expected achievement level on a standardized test of mathematics. Students with CD had a performance score in math at least 2 standard deviations below the mean. Each student in the study had difficulty memorizing multiplication facts as reported by the special education teachers.

The primary intervention in the current study was a mnemonic keyword strategy delivered through computer-assisted instruction (CAI) supplemented with weekly classroom review. The CAI sessions lasted approximately twenty minutes and the classroom review 5-10 minutes. The author of the following study developed the multimedia software and provided the software to the classrooms. Memory Math (Irish, 2002) provided instruction in the use of mnemonic strategies and taught the students to successfully use these strategies to remember multiplication facts.

Data were collected for eighteen weeks. The study period included four phases: baseline, intervention, maintenance, and follow-up. The first student's baseline was 55% and at follow-up the score increased to 95%. The second student's baseline was 28% and at follow-up the score
increased to 35%. The third student's baseline was 43% and at follow-up the score increased to 88%. The fourth student's baseline was 22% and at follow-up the score increased to 100%. The fifth student's baseline was 12% and at follow-up the score increased to 25%. The sixth student's baseline was 55% and at follow-up the score increased to 100%.

Treatment control was demonstrated in all of the baselines (long or short) remained stable throughout the experiment. The number of baselines increased the predictive utility of the study. Validity was further enhanced by the utility of the study. Validity was further enhanced by the stability of the students' scores during baseline measurement.

That data provided evidence of experimental control to support Research Question 1. Five of six replications of the intervention demonstrated improved accuracy on the electronic probes. The data provided evidence of experimental control to support Research Question 2. All six students demonstrated increased accuracy on the paper/pencil probes. A visual analysis of the data across replications revealed every student demonstrated an increase and the increase of change or slope in the data points from baseline to maintenance was greater for the paper/pencil measure than the electronic quizzes. Every student was able to accurately retrieve a greater number of multiplication facts after intervention on the paper/pencil measure.

The study contains a number of limitations which make drawing extensive implications difficult. The population studied in the experiment is not representative of all students with CD and learning disability. The response tasks on the electronic and paper/pencil quizzes were different.
Computer-assisted instruction may be a viable alternative for delivery of strategy instruction related to acquisition, storage, and retrieval of basic multiplication facts. Specifically, the data would support the use of CAI in resource classrooms to enhance student performance in basic multiplication facts. The data indicated the length of treatment was significant with respect to the degree of change. The students who remained in the treatment phase the longest experienced the greatest gains. Probably then, large gains in multiplication performance with Memory Math (Irish, 2002) may require intervention periods of at least 10 weeks. The data also indicated the number of sessions per week was significant to the level and rapidity of change. Those students who interacted more frequently each week demonstrated the greatest increases during the Memory Math intervention, (Irish, 2002).

Studies to determine the long-term effects of mnemonic strategy use with basic facts are necessary. Improved performance on basic facts in multiplication cannot be achieved through mnemonic strategies alone. Likewise, accurate performance in basic facts does not ensure mathematical thinking. Accuracy with basic facts is a component of math proficiency. Taken together, the results of the study indicated Memory Math (Irish, 2002) CAI, supplemented with regular class review, resulted in increased accuracy on tasks requiring retrieval of basic multiplication facts and mnemonics and CAI are robust with regard to successfully teaching students to use a strategy to acquire, store and retrieve basic facts.

The study “Task Engagement and Mathematics Performance in Children with Attention-Deficit Hyperactivity Disorder: Effects of Supplemental Computer Instruction”, (Ota & DuPaul, 2002), examined the effects of using software with a game format (as a supplement to teacher instruction) to improve math performance of three fourth- to sixth-grade students with attention-deficit hyperactivity disorder. Following baseline (observation under normal classroom
conditions), the math software was introduced sequentially using a multiple baseline design across participants. Observational data were collected during the baseline and experimental conditions along with a set of curriculum-based math probes, which were used throughout the study. The hypothesis that math software with a game format would improve the academic performance and increase attention of all participants was partially supported. Implications for practice and further research are discussed.

The participants in the study were 3 male, Caucasian, fourth-, fifth-, and sixthgrade students exhibiting ADHD behaviors who were placed in a private school for children with learning disabilities. The students had been diagnosed privately by pediatricians or child psychologists as having either the predominately inattentive or combined subtype of ADHD.

A commercial math software package with game format was provided to the teachers by the investigator. The software package had been selected for use in the study based on grade-level suitability and cost. Math Blaster (Davidson & Associates) for ages 9 to 11 years offers over 50,000 different problems, online help and math tips, rewards earned throughout the game to keep the students motivated, and covers 15 essential math skills (e.g., addition, subtraction, multiplication) to help prepare for standardized tests. Math Blaster offers arcade-style games that develop essential math skills with six activities and six different difficulty levels adjust to a child’s ability. The specific activities (games) and difficulty levels varied across children and were individualized according to skills being taught by the classroom teacher. Reinforcement in the form of points was provided following each correct response.

All participants were given multiple math probes of varying degrees of difficulty and skill levels to assess their instructional levels. The participant’s instructional level was then
assessed by deciding which computational skills were present in and which skills were absent from the student’s repertoire. All participants underwent a baseline period of at least 2 weeks and until the data appeared stable using visual inspection. During baseline, participants received the typical math instruction of a regular school day. Baseline math instruction consisted of listening to teacher instruction (approximately 25 minutes), independent seatwork (approximately 25 minutes), and one-on-one instruction with the teacher, when necessary.

During the intervention phase, the impact of the math software package was examined. CAI took the place of independent seatwork during experimental sessions, whereas all other aspects of the math class remained the same as during baseline. During the intervention phase, the participants practiced math skills using the Math Blaster software package, in addition to typical classroom instruction (i.e., the initial 25 minutes of math class).

The results of the study indicate using software with a game format to supplement teacher-mediated instruction for math may be helpful in promoting attention and achievement among children with ADHD. Although math performance was raised only moderately, the significant increases in academic engaged time and significant decreases in off-task behaviors may result in more substantial increases in math performance for all participants, especially if the intervention was maintained over time. In addition, the generalization of the study to a public school setting with larger class sizes should not be compromised due to the self-sufficient nature of the intervention. A teacher’s instruction time will not be impacted when using the intervention. Although future research is warranted, these preliminary findings support the use of software with a game format to help supplement the math instruction of children with ADHD.
The empirical study “Computer-Assisted Cooperative Learning in Integrated Classrooms for Students With and Without Disabilities”, (Xin 1999), investigated the effects of computer-assisted cooperative learning in mathematics instruction within integrated classrooms for students with and without disabilities. A total of 118, 3rd-grade elementary students, 25 of whom had learning disabilities participated in the study. Placing students with disabilities in regular classrooms, regarded as mainstreaming, integration, or inclusion, has been advocated by educators and parents (Putnam, 1993, Haring & McCormick, 1996). In integrated learning environments, all children need to benefit from and be enriched through opportunities to learn from each other (Sapon-Shevin, 1992; Stainback, Stainback, & Jackson, 1992).

A total of 118, 3rd-grade students participated in the study. Of those, 25 were classified as learning disabled with their IEP (Individualized Education Plan) objectives in mathematics. All students were enrolled in three elementary schools located in both suburban and urban areas in a northease state of the United States. Forty percent were African American, 35% Caucasian, and 25% Hispanic or other. The students with learning disabilities had been receiving mathematics instruction in self-contained special education classrooms due to their academic difficulties. For the study, these students were included in the 3rd-grade regular classes. The students’ average mathematics level was at the 2nd-grade according to their district tests.

Two regular teachers and one special education teacher from three schools participated in the study. In each school, one regular teacher was randomly assigned to teach students in the whole-class learning group, while the other taught the cooperative learning group. These teachers shifted teaching assignments monthly in order to reduce the impact of teacher effects. The study employed a pre- and posttest control group design. The instruction was conducted over an entire
semester in the regular classrooms and the computer labs during regularly scheduled instructional sessions in mathematics.

The instruction materials used were two software packages. Software A, Mathkeys (MECC, 1994), designed to be integrated with the Houghton Mifflin Mathematics textbook (1989), and software B, Fraction and Decimal Maze (Great Wave, Inc. 1995). A supplemental software was Software C, Mathshop Jr. (Scholastic Inc., 1994). Instructional sheets, worksheets, quizzes were used as well.

Instruction in mathematics occurred in the regular classrooms during daily scheduled 30-minute periods. This was followed by a 20-minute session in the computer laboratory four days a week. The weekly quiz was completed on the fifth day of each week.

The computer-assisted cooperative learning was implemented following four stages. Stage 1: Students were introduced to cooperative learning. Groups of four students were assigned together in varying levels of achievement and a mix of genders. The groups then split into two students each when working on the computer. These groups were reformed monthly. The students began by playing a computer game in order to learn how to work together. Stage 2: The students worked with their partner at the computer. Stage 3: Working in a team. Stage 4: Competing with other teams.

Whole-class learning involved the teacher providing whole-class instruction on major concepts and procedures to solve problems in the specific unit of math class, then delivered the instruction sheet and worksheet to the students. In the lab, the teacher demonstrated the computer
program to the whole class and assigned students to work at the computer individually. Students were required to complete the worksheet daily and a quiz weekly.

Students' math achievement was measured by the mathematics subtest of Primary level 3 (Form J) of the Stanford Achievement Test (SAT) (Gardner, Rudman, Karlson, & Merwin, 1991). The test includes concepts, computation, and application and was administrated in group as a pre- and posttest. Regular education students' attitudes toward children with disabilities was measured with The Acceptance Scale (Voeltz, 1980). The Acceptance Scale consists of questions determine acceptance because they are willing to have social contact, or have actual contact with a disabled student. Also the questions determine non-acceptance by determining if a mild deviance consequation, or avoidance of a disabled student exists. The attitudes of the special education students were examined by interview. The interview questions were about the special education students attitudes about integrating into regular education classes and about working with their non-disabled peers.

The regular education students in the cooperative group had a mean pretest score of 53.43 and a mean posttest score of 77.76. The special education students in the cooperative group had a mean pretest score of 33.15 and a mean posttest score of 55. The regular education students in the whole group had a mean pretest score of 57.42 and a mean posttest score of 66.62. The special education students in the cooperative group had a mean pretest score of 33.25 and a mean posttest score of 47. Ninety percent of the disabled students in the cooperative learning group indicated a preference for being included in regular classrooms with their nondisabled peers. Zero percent of the disabled students in the whole class learning group indicated a preference for being included in regular classrooms with their nondisabled peers.
The results of the study demonstrated students with and without disabilities in cooperative learning groups statistically outperformed students with and without disabilities in whole-class instruction group. Although students in both cooperative and whole-class groups increased their math skills learning using computer-assisted instruction, a significant difference was obtained on the posttest between the two groups. Although the scores of Social Acceptance obtained by the regular students were not significantly different between the cooperative learning group and whole-class group, each disabled student involved in cooperative learning mentioned at least one nondisabled peer as his/her friend while few were mentioned by the disabled students in the whole-class group.

The results of the study seem to indicate computer-assisted cooperative learning approach can help teachers structure the integration among all students as the work toward their academic attainment and interpersonal goals in the classroom. Further research may be needed to clarify the present findings on effects of computer-assisted cooperative learning using a wider range of disabled children in different regions. Computer-assisted instruction has considerable potential to facilitate learning in integrated classrooms for students with and without disabilities.

The research study "Achievement in Basic Math Skills for Low Performing Students: A Study of Teachers' Affect and CAI", (Moore, 1988) was experimental involving the effect of computer aided instruction and a teacher's affect. The study investigated the effects of math instruction (with and without CAI) and the influence of teachers' personalities (rated positive and negative) on the achievement of 118 remedial math students.

The subjects in the study were 117 seventh- and eighth-grade students in the lowest level of remedial math at four different middle schools. Nearly half of the students were mainstreamed...
special education students who experienced a range of learning disabilities. The other students were regular education pupils who scored at least 3 years below grade level in basic math skills.

The students who were placed in remediation classes were randomly assigned to 12 different classes. Six of these classes used CAI as a major portion of instruction. Six of the classes were taught strictly from a textbook. The classes ranged in size from 12 to 18 students with one teacher. The curriculum in the CAI classes was determined by a comprehensive diagnostic test. Over half of the instruction was taught by the use of a special math sequence computer program (Milliken Math Sequence). The other half consisted of written assignments based on BIMPAK (Burnett's Individualized Math). The typical day began with the students picking up their assignments and starting up with their computer program. The teachers assisted students individually. The computer corrected completed assignments and guided the student to the next assignment. Homework was assigned daily and progress tests were given weekly. The computer program was individualized for each student, giving immediate feedback by problem with a daily student log and daily printout of success rate.

The curriculum in the classes did not use computers was based on direct instruction for the whole group, following Rosenshines model (Rosenshine, 1985) and using Mathematics for Individual Achievement (Denholm, Hankins, Herrick, & Vojtko, 1978) for a basic text. The teacher explained the objectives, established procedures, and modeled each skill. After the presentation of new concepts, three different types of practice were used. First the class worked through problems with the teacher, then with teacher guidance and then alone. The teacher provided individual help during the student work time and kept a record of homework assignments and weekly progress tests.
Using a series of interviews with the teachers of the classes, their next door colleagues, and their principals, the attitudes of the teachers toward low performing students were rated as positive or negative. Only the teachers who were "enthusiastically" endorsed as positive influences and whose who admitted they disliked teaching remedial students were asked to participate.

The study observed eight classes taught by four teachers. The students were randomly assigned to the different classes which resulted in 59 receiving CAI and 58 not participating in computer classes, and 61 in "positive" teachers' classes and 56 in classes where the teachers were rated as demonstrating "negative" affect. The study included four groups: positive and negative CAI, and positive and negative direct instruction. All students in the study were given a pretest in September. They received treatment for nine months and were given a posttest in May. The same instrument, the district math placement test, was used for both the pre- and posttest.

The effects of CAI and teachers' affect were examined by analyzing posttest scores. Statistical analysis was performed using the Statistical Packages for the Social Services (SPSS, 1983). All treatments were effective to some degree; however, Group 1 (CAI and positive affect) achieved the highest scores. Group 2 (CAI and negative affect) did not match the achievement of Group 3 (no CAI and positive affect).

Group 1 (CAI and positive affect) receive the highest scores (M = 16.73), and Group 4 (no CAI and negative affect) received the lowest scores (M = 9.96). For all students who received CAI, the mean was 13.63, compared with those not in CAI classes, who only achieved 12.29. The mean for positive teachers' classes was 15.51, compared with negative teachers,
which was 10.20. Additionally, no significant differences between special education and regular education students appeared.

Although teachers with positive affect produced better results regardless of the teaching method, CAI also improved the scores of students with negative teachers. Which suggests the attitudes, expectations, and interpersonal interactions of teachers may be more powerful on student learning than simply adding computer-assisted instruction. However, even with a negative teacher, CAI produced better results than instruction without it.

How we teach is more important than what we teach, some will argue. Teachers' attitudes, expectations, and interpersonal interactions with students may be more influential than how we teach, according to the following study. Those teachers who offer students mutual respect and who are warm and encouraging bring out the best in students regardless of the methods they use to teach.

Torgesen, Dahlem, & Greenstein (1987) conducted three experiments on the effects of verbatim text recordings or text information made available to students in auditory format. Generally, the procedures consisted of two components: (a) presentation of text passages; and (b) assessment of overall text comprehension. In terms of effective teaching practices, the verbatim text recordings were implemented to present new content information as part of the instructional cycle in the three experiments. Further, in Experiment 3, additional supports were added to the presentation of the material, such as worksheets and texts with color-coded features or "structural signals" to highlight important content information from the passages during the presentation of the new materials within the instructional cycle. As the intervention effects were variable, the researchers cautioned students with learning disability will need additional support to learn
content area instruction, such as teacher-led reviews. For example, Torgesen et al. (1987) noted, "the use of auditory supplements and worksheets should be regarded as a substitute only for normal text reading activities" (p. 38). Furthermore, instruction of how to teach students to use the tapes was not given in all three experiments. Future research should examine the effectiveness of systematic instruction in teaching students to use verbatim text recordings in content area classrooms and its effectiveness as one component of the instructional cycle.

Conclusion. The use of technology-based interventions shows great promise for improving the academic performance of students with learning disability on general education expectations. In the present review, technology-based practices with statistical and functional significance incorporated a variety of effective teaching principles within the five-stage instructional cycle to increase student acquisition and retention of tasks. Although "disabilities can impose barriers to full participation in school, at work, and in other important areas of life, assistive technology offers ways to surmount those barriers" (Lewis, 1998, p. 17). Now, more than ever, technology is a valuable tool with great potential for assisting students labeled learning disability.

The research study "The Effects of Computer Use on the Acquisition of Multiplication Facts by a Student with Learning Disabilities”, (Howell, 1987) was experimental involving a single student with a mathematics disability. Two investigations were conducted to determine the effectiveness of software use alone, or in combination with teacher-intervention, on the acquisition of multiplication facts.

The student selected for the study was a 16-year-old male sophomore in an urban high school. He has received special education services since first grade in the public schools. Tests
performed by the school psychologist indicated severe discrepancies between achievement and ability due to a psychological processing disorder, qualifying him for special education services in the school district. The psychological processing disorder affected the processing of both auditory and visual information. On the Wechsler Intelligence Scale for Children-Revised (Wechsler, 1974), he obtained a Full Scale Intelligence Quotient of 112. The student was functioning at the fifth-grade level in mathematics according to the Woodcock-Johnson Battery (Woodcock & Johnson, 1984) evidencing specific difficulties in the reproduction and recall of multiplication facts.

The study was done in a resource room classroom for learning disabled students with a single Apple IIe microcomputer and also in a computer lab with 15 Apple IIe computers with selected software for the study. The effectiveness of drill-and-practice programs in the acquisition of the multiplication facts seven through nine was investigated during a pilot study. After three sessions the pilot study indicated the student had not maintained the gains established from the drill-and-practice program; a second study was developed with a multiple baseline withdrawal design. The second study integrated tutorial-based educational software and a specific teacher intervention strategy on timed and untimed tests of the same multiplication problems. In all the study involved 30 sessions with the student.

The baseline data for the pilot study were gathered from a random sample of 20 multiplication problems presented to the student using paper and pencil. The intervention data were gathered by observing and recording the students performance as he answered 20 randomly generated multiplication problems on the computer. The software used in the pilot study was called "Galaxy Math" (Random House, Inc., 1984). The package allows the student to plan an
educational game in which the student races against time to answer randomly generated multiplication problems. The data collected were the average errors made with 20 problems, and the time the student spent on the drill.

The second study involved the experimental intervention software called "MemorEase" (Mind Nautilaus Software, 1985). The program is designed to stimulate the memorization of information by using "gradual recall" techniques derived from operant theory (Skinner, 1974). In the environment, the student is presented with a stimulus item (a multiplication problem) and asked to answer. The student was presented with 20 problems from the six to nine times table generated by the teacher, which was a self-pace activity. The second intervention was a teacher taught algorithm called "The Rule of Nines," and used the original drill-and-practice software as a reinforcement and maintenance for any gains made. The data collected were the average errors made with 20 problems, and the time the student spent on the drill.

The pilot study showed the following results. Errors increased from zero during session one to four during session three. The drill-and practice software was introduced and the errors decreased to one by session six. After the baseline condition was reintroduced, the error rate climbed to three errors per 20 problems by session nine. The second intervention period started with an increase in errors, but the subject's errors decreased from three during session ten to zero during session 11. After session 11 the error rate began to climb again.

The second study showed the following results. After the baseline was established the student was exposed to the tutorial software with the number of errors slowly decreasing to one error per 20 problems by the ninth intervention session. The error rate then stabilized for five sessions, at which point the second baseline period was initiated. The error rate climbed to an
average of five errors per 20 problems and the teacher intervention strategy was initiated. The error rate dropped to an average of less than one error per 20 problems during this phase. During the following up period the student was assessed with follow up probes having zero errors per 20 problems throughout the follow-up period.

These results indicate contemporary drill-and-practice and tutorial software may have an initial, but transitory, effect upon the number of errors and the amount of time required to successfully complete multiplication problems. Without a specific teacher intervention like the one introduced in the second study, which was designed to foster more adequate strategies for solving problems, any gains made during the computer interactions will not hold over time. The successful combination of directed teacher intervention and software use has been shown to be effective in remediating the student's specific mathematical disability, with the student retaining both knowledge and the new strategy one month after the final intervention period.

A primary limitation of the pilot study was the baseline and intervention periods were too short and may have introduced more variation in response patterns if five to ten days had been allowed for each period. In addition, the measure of rate of problems solved was not as sensitive a measure of behavioral change as having both timed and untimed tests of problem solution. The mode of testing is more realistic allowing the learner the opportunity to respond under low-stress and high-stress situations more closely resemble normal learning situations.

The rapid improvement in error rate evidenced as a result of the combination of teacher intervention and software indicates the combination may be a highly beneficial treatment for students with learning disabilities experiencing difficulties in certain areas of mathematics. In addition the teacher reported when she worked with the student at the computer, she was better
able to identify the strategies the student was using to solve problems, and which strategies were missing from his repertoire. The role of the teacher seems to have been vital - perhaps a key motivational variable in the maintenance of any gains attributed to the use of the computer and software.
Chapter III: Results and Analysis Relative to the Problem

Table one through three give a summary of the 15 study literature review of the previous chapter. Table one is a summary of five literature reviews, table two is a summary of four recent studies and table three is a summary of six older more historical studies.

Table 1 - Summary of five literature reviews

<table>
<thead>
<tr>
<th>Author</th>
<th>Date of Study</th>
<th>Number of Studies Examined</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seo &amp; Bryant</td>
<td>2009</td>
<td>11</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Fitzgerald, Koury, &amp; Mitchem</td>
<td>2008</td>
<td>7</td>
<td>Effective</td>
</tr>
<tr>
<td>Dugan, Cobb, &amp; Alwell</td>
<td>2006</td>
<td>9</td>
<td>Effective</td>
</tr>
<tr>
<td>Maccini, Gagnon, &amp; Hughes</td>
<td>2002</td>
<td>10</td>
<td>Effective</td>
</tr>
<tr>
<td>Xin &amp; Jitendra</td>
<td>1999</td>
<td>25</td>
<td>Effective</td>
</tr>
</tbody>
</table>

Four of the five literature reviews found computer-assisted instruction to be effective. Seo & Bryant, 2009 conclude that unequivocal evidence for the effectiveness of computer-assisted instruction is not supported by their literature study. They cite several methodological problems across their 11 studies that prevent them from making a clear analysis of the “true” effectiveness of computer-assisted instruction for the mathematics performance of students with learning disabilities, (Seo & Bryant, 2009). Methodological problems such as instructional variables with the computer-assisted instruction software, short length of interventions, technical adequacy (e.g., reliability and validity) of posttests, lack of assessing students’ achievement and generalization of skills, and finally the computer-assisted instruction with enhancements (i.e., cognitive strategy, feedback, practice, and mnemonics strategy) were critical and the most
promising at increasing achievement for students with learning disabilities. The other four literature reviews listed in the table found that even though some findings were mixed that overall computer-assisted instruction studies showed evidence of the effectiveness of computer-assisted instruction.

Table 2 - Summary of recent studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Date</th>
<th>Number of Participants</th>
<th>Grade Level</th>
<th>Length of Treatment</th>
<th>Focus of Mathematics</th>
<th>Type of CAI</th>
<th>Type of Student</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Räsänen</td>
<td>2009</td>
<td>30</td>
<td>Preschool</td>
<td>3 week</td>
<td>Counting, Number Comparison, etc.</td>
<td>Game</td>
<td>At Risk</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Lee &amp; Chen</td>
<td>2009</td>
<td>78</td>
<td>9th Grade</td>
<td>6 week</td>
<td>Problem Solving</td>
<td>Game</td>
<td>General Education</td>
<td>Effective</td>
</tr>
<tr>
<td>Chang, Sung, Chen, &amp; Huang</td>
<td>2008</td>
<td>42</td>
<td>2nd Grade</td>
<td>3 week</td>
<td>Multiplication</td>
<td>Game</td>
<td>General Education</td>
<td>Moderately Effective</td>
</tr>
<tr>
<td>Fuchs, Fuchs, Hamlet, Powell, Capizzi, Seethlar</td>
<td>2006</td>
<td>33</td>
<td>1st Grade</td>
<td>18</td>
<td>Adding and Subtracting</td>
<td>Game</td>
<td>At Risk, Special Education</td>
<td>Moderately Effective Ineffective for Skill Transfer</td>
</tr>
</tbody>
</table>

Räsänen, 2009 was the one of four of the recent studies that claimed the ineffectiveness of computer-assisted instruction. Räsänen’s study involved preschool age students and their findings were mixed. They employed two computer games aimed at improving early mathematics skills. The software focused on verbal counting, number comparison, subitizing, object counting, and arithmetic; after the intervention the only significant effect size was found with number comparison. This result was unexpected, therefore they concluded that computer-assisted instruction has not met its expectations despite gains in technology and availability. Despite concluding that computer-assisted instruction did not meet expectations Räsänen’s study implies computer-assisted instruction holds great potential for learning about the brain processes of learning. The remaining three studies found that computer-assisted instruction was
moderately-effective to effective for increasing mathematics performance in students with a learning disability.

**Table 3 - Summary of older more historical studies**

<table>
<thead>
<tr>
<th>Author,</th>
<th>Date</th>
<th>Number of Participants</th>
<th>Grade Level</th>
<th>Length of Treatment</th>
<th>Focus of Mathematics</th>
<th>Type of CAI</th>
<th>Type of Student</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irish</td>
<td>2002</td>
<td>6</td>
<td>1 4&lt;sup&gt;th&lt;/sup&gt; Grade 5&lt;sup&gt;th&lt;/sup&gt; Grade</td>
<td>2-10 weeks</td>
<td>Multiplication Facts</td>
<td>Drill and Practice</td>
<td>Special Education</td>
<td>Effective</td>
</tr>
<tr>
<td>Ota &amp; DuPual</td>
<td>2002</td>
<td>3</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; – 6&lt;sup&gt;th&lt;/sup&gt; Grade</td>
<td>7 – 20 days</td>
<td>Addition, Subtraction, Multiplication …15 skills total</td>
<td>Game</td>
<td>Special Education - ADHD</td>
<td>Effective for Increased Engagement, Ineffective for Increased Skill Level</td>
</tr>
<tr>
<td>Xin</td>
<td>1999</td>
<td>118</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Grade</td>
<td>1 semester</td>
<td>Concepts, computation, application, and problem solving</td>
<td>Progressive Drill and Practice with Feedback</td>
<td>25 of 118 Special Education</td>
<td>Moderately Effective Alone, Effective with Cooperative Learning</td>
</tr>
<tr>
<td>Moore</td>
<td>1988</td>
<td>117</td>
<td>7&lt;sup&gt;th&lt;/sup&gt; and 8&lt;sup&gt;th&lt;/sup&gt; Grade</td>
<td>1 Year</td>
<td>Fractions, Decimals, Percentages and Equations for baseline achievement, then software was individualized for each student</td>
<td>Progressive Drill and Practice with Feedback</td>
<td>About ½ were special education, all at risk</td>
<td>Effective</td>
</tr>
<tr>
<td>Howell, Sidorenko, &amp; Jurica</td>
<td>1988</td>
<td>1</td>
<td>10&lt;sup&gt;th&lt;/sup&gt; Grade</td>
<td>13 45 min sessions and 30 45 min sessions</td>
<td>Multiplication</td>
<td>Drill and Practice and Tutorial</td>
<td>Special Education</td>
<td>Ineffective Alone but Effective Combined with Teacher Intervention</td>
</tr>
<tr>
<td>Torgesen, Dahlem, &amp; Greenstein</td>
<td>1987</td>
<td>16</td>
<td>9&lt;sup&gt;th&lt;/sup&gt; – 12&lt;sup&gt;th&lt;/sup&gt; Grade</td>
<td>1 month, 6 wks 10 min, 8 wks 13 min</td>
<td>Assistive Comprehension for written content</td>
<td>Text recordings and video discs</td>
<td>Special Education</td>
<td>Effective</td>
</tr>
</tbody>
</table>

Table three summarized six older, more historical studies. The results of these six studies were that computer-assisted instruction was effective to moderately-effective with improving math performance of students with learning disabilities. Several studies from tables two and three were included in the literature reviews of table one.
It is apparent by examining Tables 1-3 that computer-assisted instruction in all its various forms can be an effective intervention in mathematics for students identified with a learning disability. There were several recurring limitations mentioned throughout the literature, (i.e., insufficient treatment length, diverse capabilities of available software, insufficient number of participants, teacher discomfort with computers). Also, there were two recurring concepts; without exception computer-assisted instruction seemed to be the most effective when it was applied intelligently and in combination with another intervention. Despite some studies finding computer-assisted instruction to be ineffective, these were the minority.
Chapter IV: Recommendations and Conclusion

Recommendation

My conclusion after this review is that research in the past decade is not always conclusive or corroborated by other authors. In general, the research shows that students with disabilities learn using well-designed software in computer-assisted instruction. They are able to learn and use explicit strategies on computers and in classrooms, but transfer and retention are not guaranteed. Software containing scaffolds and customizable features support better learning. Students appear to enjoy using computers as a tool for learning. Some studies found gains in learning from video anchors that concentrate learning and problem solving around real world situations. The potential for improving mathematics performance for students with learning disabilities using computer-assisted instruction is apparent, but not substantially better than other interventions that have been employed in mathematics instruction. This combined with the conflicting opinions about the effectiveness of computer-assisted instruction, makes me leery of encouraging large scale investment of time and money for a school district to put toward this particular intervention. Computer-assisted instruction is not a negative tool but it isn’t the panacea for the students with learning disabilities.

Areas for Further Research

Currently, true experiments in the field of computer-assisted instruction are limited. Problems in research design include small sample sizes, inappropriate interventions, unrepresentative samples, and lack of control groups.

Divergent results may occur because researchers have used different computer-assisted instruction games, which very often have been designed for a specific study and are not available
to other researchers to replicate the studies. Moreover, researchers have examined diverse outcome measures, ranging from exam performance to learning attitudes. These factors complicate comparison across studies. A high-quality intervention study should include testing before and after the intervention, an adequate control group, random assignment of participants to condition, and a sufficient number of participants. Standardized or criterion based tests should be used, for both specific learning and broader transfer. Follow-up testing to examine how well the skills are retained is also desirable. The effectiveness of this kind of intervention is typically measured by effect size (the ratio of the improvement to the standardized variance). The majority of studies examined the most basic mathematics skill, most studies did not examine the mathematics intervention needs of students at the secondary level.

**Summary and Conclusion**

Computer-assisted instruction can be an effective intervention in mathematics for students with a learning disability. In order to be the most effective it must be applied intelligently and with constant teacher interaction. It is also helpful when combined with other interventions. There are divergent opinions and a lack of research to unequivocally support its effectiveness. It is a tool that can be effective but is not necessarily the remedy for all difficulties for students with a learning disability.
References


