EFFECTS OF COMPUTER-BASED PROGRAMS ON MATHEMATICAL ACHIEVEMENT SCORES FOR FOURTH-GRADE STUDENTS

By

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ABSTRACT

The purpose of the research study was to identify the effects of computer-based programs on mathematical achievement, perceptions, and engagement of fourth-grade students. The 31 student participants were divided into two intervention groups, as a hands-on group and a computer-based group. Student achievement was measured by comparing the pretest and post test data. Students' perceptions of mathematics were determined using students' perception survey that was administered prior to implementation of the intervention and at the end of the seven-week intervention period. Student engagement was monitored using an 'engagement checklist' that was completed by the teacher-researcher within three times a week during the seven-week intervention period. The research findings showed that, there is no significant difference in the academic achievement among the intervention groups. All student participants showed a positive attitude related to mathematics. There was a significant difference in engagement among students in the computer-based group compared to the students in the hands-on group.

Keywords: Mathematics, Computer-Based Programs, Achievement, Attitude, Engagement.

INTRODUCTION

Testing results and various research studies have shown that, students in the United States lack important mathematical skills. Although steps have been taken to improve the achievement levels, mathematics is still an area of weakness across the nation. American students are deficient in their knowledge of basic multiplication facts. According to a report from the 'National Mathematics Advisory Panel' (2008), U.S. students cannot solve single digit addition, subtraction, multiplication, or division problems as quickly or efficiently as students from other countries (Codding, Archer, & Connell, 2010,). The deficiency affects their academics as well as their ability to complete real world task involving the single digit mathematical equations such as purchasing items, measuring ingredients, or calculating totals, and affects students well beyond their schooling age. Educators need more effective methods for increasing the students' fluency rates related to basic multiplication facts in order for students to be successful in school and the real world.

Students across the nation are showing weakness related to their knowledge of basic multiplication facts on State, National and International standardized tests. Gonzales et al. (2004) stated that, American fourth graders were outperformed by 11 of 25 countries participating in the Trends in International and Mathematics Science Study (TIMSS) test, and showed no significant growth from 1995-2003. Mathematics difficulties are widespread among U.S. school children (Jordan & Levine, 2009). Elementary school students' lack of knowledge of basic multiplication problems affects their educational performance in later years.

Mathematics has been a continuous area of focus for the research school for three consecutive years. Although the Criterion-Referenced Competency Test (CRCT) data showed improvements, mathematics continued to be an area of evident need. The Georgia Department of Education (2013) reported that, 32% of fourth-grade students did not pass the CRCT in Mathematics during the 2011-2012 school year (CRCT Statewide Scores section, para. 2).The following school year should have maximum number of fourth-grade students who passed the CRCT in

Mathematics. Statewide Longitudinal Data Systems (2013) reported that, 22% of the students in the school did not meet the standards on the Mathematic portion of the CRCT, which is an increase of 10% (CRCT Test Results section, para. 3). Despite the increase in the number of students passing the mathematics section of the CRCT during the 2011-2012 school year, the school's Continuous Improvement Plan included a Mathematics achievement goal, particularly for special education students, and a data monitoring process focused on student mathematical achievement was implemented due to the achievement gap among general education students and special education students in the field of Mathematics on the CRCT in 2011. The school should have included weekly on-site instructional visits, instructional summits, technology support, instructional modeling, and teaching resources, as its a targeted need related to mathematics achievement in its functioning.

A vital component of the Continuous Improvement Plan's goal of increasing students' mathematics achievement level was related to students' ability to correctly and accurately complete single digit multiplication facts. All students in the school did participate in progress monitoring of mathematical fluency through GRASP (Georgia RESA Assessment of Student Progress) testing. The students were scored based on their digits correct per minute, and the teacher-researcher used this opportunity to attempt to identify the most efficient intervention for increasing multiplication fluency rates based on GRASP data.

Review of the Literature

Mathematics was a core academic subject taught in the United States Public Education System (Smith, Marchand-Martella, &Martella, 2011). According to the National Mathematics Advisory Panel (2008), International and domestic comparisons show that, "American students achieve in mathematics at a mediocre level by comparison to peers worldwide" (p. 12). Elementary school students' low fluency rates with basic mathematical facts contributed to difficulties in mathematics in the later years. Students typically display the difficulties in mastering arithmetic combinations because of immature counting strategies (e.g. counting all, counting on fingers), which contribute to difficulties in developing computational fluency (Bryant, Bryant, Gersten, Scammacca, & Chavez, 2008). Some students have become accustomed to using the immature counting strategies, which also proved to be more time consuming.

Teachers across the nation face the challenge of assisting students at varying ability levels. According to Parkhurst et al. (2010) when teachers were faced with groups of students (e. g., an entire class) in need of remedial service, specific targets often vary across students. As students learned and grew academically, they are also being advanced academically at different rates. Jitendra et al. (2013) conducted a research study that tested the impact of instructional methods on small groups of students and found that, due to lack of funding, many teachers struggle to place their students in small group settings that are monitored by adults. Teachers are required to implement curriculum that focuses on conceptual learning and there is a lack of focus given to memorization of mathematical facts through fluency building in general education (Smith et al., 2011).

According to the National Mathematical Advisory Panel (2008), 32% of the students are at or above the 'proficient level' in Grade 8, but only 23% are proficient at Grade 12 based on the National Assessment of Educational Progress. Mathematical difficulties were prevalent in all grades, however, students at the high school level experienced less success in mathematics than younger students. According to Bryant et al. (2008), the 'Texas Early Mathematics Intervention-Progress Monitoring' helped to identify the students who needed two tier interventions in mathematics based on the response to intervention Program. Students were moved to the tier two level if they were consistently not meeting the grade level standards and teacher-created formal and informal assessments which can be useful for identifying and supporting struggling learners. Bliss et al.(2010) demonstrated that, using classroom baseline teacher-created assessments and achievement tests to identify students with mathematical difficulties could be beneficial to closely monitor the struggling students. According to Poncy, Skinner, and Axtell (2010), using teacher observations for identifying students showing difficulties in the area of mathematics, combined with the effectiveness of interventions and programs implemented were effective to improving student learning.

Educators have attempted to establish effective methods for helping elementary school students to be a master in basic mathematical facts. Gilbertson, Witt, Duhon, and Dufrene (2008) conducted a study to find a correlation between mathematical performance and on-task behaviors. Students were given a pre-intervention assessment to identify the facts that they had not yet mastered. Using a behaviorist model, students were offered rewards for mastery of all of their facts, instructed using flashcards and monitored periodically. When students met their goal, they were rewarded, and all showed an increased mastery of mathematical facts. Codding et al. (2010) identified the students' difficulties to become a master in mathematical facts and used a pre-assessment to identify the facts that had not been mastered. The student participated in 19 sessions where the facts were practiced using flashcards (Codding et al., 2010). As the student showed mastery of each fact, the fact was no longer studied during the sessions, and indicated improvement in fact mastery. Poncy et al.(2010) designed a study to evaluate the effects of the Detect, Practice, and Repair (DPR) on multiplication-fact fluency. The study was conducted with three student participants who received instruction through the DPR process. The students used the Cover, Copy, Compare (CCC) intervention to practice the facts which they had previously identified as having, but not mastered (Poncy et al., 2010). Finally, students were completing a timed one-minute fluency test over the facts they had practiced. Parkhurst et al.(2010) conducted a similar study that used a 'modified DPR' intervention. Parkhurst et al. (2010) used Microsoft PowerPoint slides for time-efficient feedback for students. The DPR intervention was found to be effective in assisting the participants' mastery of basic multiplication facts. Mong and Mong (2010) conducted similar research using the Cover, Copy, Compare (CCC) intervention and the Math To Mastery (MTM) intervention, during which the instructor modeled the correct way to complete a math probe for a student. The student was instructed to complete the same probe while the experimenter monitored and gave immediate instructional feedback when an error occurred. The intervention took place in 1-minute increments and the student completed a self-monitoring graph at the end of each segment. Mong and Mong (2010) found both interventions to be effective. However, the findings showed that, MTM was most effective in increasing students' digits correct per minute rate.

Bliss et al. (2010) conducted a study to test the effectiveness of the taped-problems intervention, in which students listen to a taped-problem set with basic multiplication facts and answers. Students were instructed to answer the multiplication fact before hearing the answer on the recording, and were assessed over the problems they had previously heard on the recording. The taped-problem intervention was effective for helping students to increase their mathematical fluency. Smith et al.(2011) tested the effectiveness of the Rocket Mathfact fluency based on curriculum program. The program was effective in helping students to build their fluency skills, as the CCC, MTM, DPR, phased rehearsal, and fact fluency curriculum interventions showed improvement in student achievement and increased students' mastery of multiplication facts.

Kiger, Herro, and Prunty (2012) conducted a study on the use of technology to master their basic mathematical facts. Students practiced the basic mathematical facts using an application on an iPod Touch device, and students using the technology scored higher than students using traditional flashcard methods. Kiger et al. (2012) also examined the flipped classroom, virtual field trips, educational applications, and educational gaming. School budget cuts have created a financial concern for implementing technology initiatives in school systems across the nation, but Kiger et al. (2012) proposed that students to bring their own device as a solution to the strict budgets. Kiger et al. (2012) also presented an evidence about implementing the technology which engages with students and improves student behavior. Students were more attentive and willing to practice educational skills when using a technology device, and provided more individualized instruction for students. The devices also provided an inconspicuous method for students to practice academic content, which they struggled to master.

Limitations of the research

While research on elementary multiplication fact fluency interventions is limited, researchers such as Vukovic and Siegel (2010), Bryant et al.(2008),Gilbertson et al.(2008), Smith et al. (2011) Mong and Mong (2010) have examined exciting ways to improve student mathematical foundations at the elementary level. Although Alter, Brown, and Pyle (2011) focused on students with emotional and behavioral disorders, gaps in the research exist particularly with regard to the special education students. Despite studies by Parkhurst et al. (2010) and Kiger et al. (2012), lack of research on the effectiveness of technology interventions in elementary math may be due to a lack of teacher familiarity of new technology uses for improving basic mathematics achievement, or a lack of financial resources needed to implement new technology strategies.

Purpose statement

The purpose of the current research study was to evaluate the effectiveness of computer-based multiplication fact drill programs on mathematical fluency for fourth-grade students as the teacher-researcher observed a lack of knowledge of basic multiplication facts among fourth-grade students. The teacher-researcher used multiplication probe assessments, and compared students' ability to master basic multiplication facts using a computer-based multiplication fact drill program and hands-on multiplication activities.

Research Questions

Research question 1

Will mathematical achievement scores be higher for fourth-grade students who use computer-based multiplication programs compared to students who participate in hands-on multiplication activities?

Research question 2

Will fourth-grade students who use computer-based mathematical programs have a more positive perception toward mathematics compared to students who participate in hands-on activities?

Research question 3

Will fourth-grade students participating in computer-based instruction be more engaged compared to students participating in hands-on activities?

Definition of Variables

Mathematical achievement scores

Mathematical achievement scores included students' test score on mathematical content. In the current research study, mathematical achievement was determined by students' grade level equivalent scores on the STAR (Standardized Test for the Assessment of Reading) mathematical assessment that was administered to students as a pre and post assessment.

Hands-on multiplication activity

Hands-on multiplication activity included an activity during mathematics in which students play games to increase their multiplication fact fluency. In the current research study, students alternated between two hands-on mathematical activities. For each activity, the students multiplied two factors to find a product. Rolling two dice or using two playing cards determined the two factors. Students multiplied the factors represented on the dice or playing cards to find the products.

Computer-based instruction

Computer-based instruction included the use of computers and technology by students to practice and learn new information. In the current research study, students received computer-based instruction from multiplication fluency programs. The instruction was provided through online programs which were designed to increase the students’ multiplication fluency by advancing the students through timed multiplication drills.

Student perception toward mathematics

Students’ perception toward mathematics refers to students' positive or negative attitudes related to mathematics. In the current research study, students' perception towards mathematics was measured prior to the implementation of the seven-week intervention period and at the conclusion of the intervention using a teacher-researcher created survey.

Student Engagement

Student engagement referred to the length of time students spent actively participating in the assigned activity. Student engagement was measured twice a week using an engagement checklist completed by the teacher-researcher.

Methodology

Participants

The study was conducted in a rural county located in the Northeast region of Georgia. The United States Census Report estimated the county population to be approximately 13,630 people (United States Census Bureau, 2013, section 1). The district's demographics included 66% Caucasian students, 25% African American students, 6% Hispanic students, and 3% multiracial students (Governor's Office of Student Achievement, 2011, section 1). Information from the 2010-2011 school district's report card identified the following subgroups as 70% students are economically disadvantaged, 9% students with disabilities, and 2% students with limited English proficiency(Governor's Office of Student Achievement, 2011, section 1).

Student participants (N=31) in the study were in the fourth-grade, ranged from nine to ten years of age, and were all general education students. The students were divided into two comparable groups based on their ability level for the research study. Students were ranked from highest achievement scores to lowest achievement scores on the Mathematics section of the Criterion Referenced Competence Test from the previous school year. The teacher-researcher created two groups, 'a computer-based instruction group' and 'a hands-on activity group', with equal ability levels using the students' ranking. The computer-based instruction group received multiplication practice from computer programs. The hands-on activity group participated in hands-on multiplication games. The demographics of the groups are shown in Table 1.

Characteristics		Computer-based Instruction Group N=16	Hands-on Activities Group N=15
Race	Black	2	5
	White	14	9
	Hispanic	0	1
Gender	Male	6	10
	Female	10	5
Economically Disadvantaged		9	8

Table 1. Demographic Data for Computer-Based Instruction and Hands-on Multiplication Activities

The students' achievement scores on the Mathematics section of the CRCT were taken from the previous school year. The students' mathematical averages were determined from the first semester of the school year. The students' achievement on the Mathematics section of the CRCT and the mean of the Mathematical class averages are displayed in Table 2.

		Computer-based Instruction Group N=16	Hands-on Activities Group N=15
CRCT Mathematics	Mean	850	851
	SD	29	30
Mathematics	Mean	84	87
Averages	SD	6	6

Table 2. Students' Achievement in Mathematics in the Criterion Referenced Competency Test

In the current study, the teacher-researcher facilitated activities for both the computer-based instruction group and the hands-on activity group. The teacher-researcher assisted the Computer-Based Instruction Group in selecting the correct websites for their instruction. The teacher-researcher explained the hands-on multiplication activities and provided the required materials for the Hands-on activities group.

Intervention

Students in both the Computer-based Instruction Group and the Hands-on Activity Group received instruction aligned with the Common Core Georgia Performance Standards for 60 minutes of a day over a seven-week period. The mathematics lessons for each group included direct instruction, guided practice, independent practice, technology integration, and hands-on activities, and the structure for each lesson varied among small group, whole group, and independent activities. Prior to participating in the interventions, all of the student participants took the STAR Math Assessment as a pretest. The students also completed the teacher-researcher created survey to assess their perception of Mathematics before participating in the intervention. The students were divided into the intervention groups based on their pretest results from the STAR Math Assessment in order to align comparable ability groups. The computer-based instruction and hands-on activities intervention was implemented for15 minutes a day during the seven-week intervention period.

The Computer-based Instruction Group received basic multiplication fact instruction through online programs including 'First in Math' and 'Math Magician'. The students used classroom computers with Internet access. The First in Math online program gave the students a pretest to assess their previously mastered multiplication facts. Based on the pretest results, the program assigned students multiplication drills on facts they had not previously mastered. Math Magician provides repeated practice of basic multiplication facts for students.

The Hands-on Activity Group received basic multiplication fact instruction through hands-on activities such as Dice Multiplication, Playing Card Multiplication, and Multiplication Matching. Each of the hands-on activities required the students to work with a partner. The dice and playing cards needed to complete the hands-on activities which were provided by the teacher-researcher. To complete the Dice Multiplication game, the students were each given two dice. The students were instructed to take turns rolling two dice. The students rolled the dice to determine two factors, and multiplied the factors to find the product. The student with the highest product was identified as the winner for the round. In order to complete the Playing Card Multiplication game, the students were given a deck of playing cards. The students were instructed to stack the cards face down on the table and take turns flipping two cards over. The teacher-researcher explained that the two numbers showing on the cards were the factors. The students were instructed to multiply the factors to find the product. The number cards in the deck represented the number value. For the purpose of the activity, the Jack cards represented eleven, the Queen cards represented twelve, and the Ace cards represented one. The King cards were not used during this multiplication game.

The teacher-researcher completed an observation checklist twice a week during the intervention period to monitor student engagement in the computer-based instruction and the hands-on activities intervention groups. At the end of the seven-week intervention period, all of the student participants completed the STAR Math assessment as a post test. The post test results were compared to the pretest data to monitor student growth and achievement. At the end of the seven-week intervention period, the students also completed the teacher-researcher created survey again to assess their perception toward mathematics.

Data Collection

The teacher-researcher used four data collection instruments to collect data for the hands-on activities group and the computer-based instruction group. The data collection instruments were used to measure the students' academic achievement, perceptions toward mathematics, and engagement during mathematics.

The STAR Math assessment was created by Renaissance Learning Enterprise. The teacher-researcher administered the assessment to the computer-based instruction group and the hands-on activity group prior to the implementation of the intervention as a pretest and as a post test at the conclusion of the seven-week intervention. The assessment was administered through individual computers to each student participant in the school computer lab. The STAR Math assessment was an adaptive test and the test questions were automatically selected based on the students' responses to previous questions. The difficulty level of the STAR Math assessment was adjusted according to the students' responses as they moved through the test. STAR Math pretest scores were used to identify each students' grade equivalent in mathematics. The grade equivalent was specified by the grade level year and the month of school for the specific year. For example, students who received a grade equivalent score of 3.2, the grade level was identified as third-grade, second month of school. The validity and reliability was determined by extensive testing implemented through the Renaissance Learning Enterprise. The teacher-researcher's school system confirmed the validity and reliability of the STAR Math test through research provided by the Renaissance Learning Enterprise. The test results were used to compare student growth after the interventions. The students' scores on the STAR Math pretest and posttest were compared by the teacher-researcher to evaluate student academic gains after the computer-based instruction and the hands-on activity interventions were implemented.

A survey was given to student participants to determine their attitude towards mathematics. The survey was created by the teacher-researcher using a Likert-scale. The survey included five statements that were written to determine the student participants' perception of mathematics. Each statement included a five-point scale. The scale ranged from 1 (strongly disagree) to 5 (strongly agree). The validity and reliability of the Student Perception Survey was assessed by a team of six fourth-grade teachers using information provided by the School Counselor about student perception. The student perception survey was administered prior to and at the conclusion of the seven-week intervention in order to monitor changes in students' perceptions toward mathematics. The teacher-researcher read the directions aloud to the students and explained that the survey was optional. The student participants completed the survey independently and anonymously. The results of the surveys were used to compare students' perceptions toward mathematics prior to and at the conclusion of the intervention.

A Student Engagement Checklist was created by the teacher-researcher to monitor the student participants' engagement during the implementation of the interventions. The teacher-researcher completed the student engagement checklist twice a week throughout the research study while the students worked individually in their intervention groups. Student engagement was measured by the length of time students spent actively participating in the assigned intervention activity. The on-task behaviors included to completing the activity, focusing on the activity without being distracted, continuing the activity until time was called by the teacher-researcher. Once off-task behaviors were observed, the on-task time period was recorded by the teacher-researcher. Off-task behaviors included talking to students in other groups, leaving group or assignment, and completing other tasks.

The teacher-researcher recorded field notes three times a week during the seven-week intervention period. The teacher-researcher recorded information related to student participants' academic progress, engagement during interventions, willingness to complete assigned tasks, observed strengths and weaknesses of each intervention, and limitations observed through the implementation of the research study.

Results

Students' mathematical achievement was measured using data collected from the STAR Math pretest and post test. Students' achievement scores were determined using the grade level equivalent score on the STAR Math pretest and post test. The pretest was administered prior to the seven-week intervention period, and the post test was administered at the conclusion of the seven-week intervention period. Students' pretest and post test grade level equivalent scores are compared in Table 3.

The mean increase for the computer based instruction group and the hands-on group was not statistically 2. It was 0.51 on students' achievement scores who participated in the computer-based group intervention and 0.53 on students' achievement scores who participated in the hands-on group intervention. Adding each students' achievement scores within the specific intervention group and dividing the sum by the total number of participants calculated the mean for the computer-based instruction group, and the hands-on students in the hands-on activity group responded to the students' perceptions survey questions using a Likert-scale that ranged from 1 (strongly disagree) to 5 (strongly agree). The hands-on activity group's responses to the students' perceptions survey are shown in Table 4.

Students' responses indicated that, over half of the students in the hands-on intervention group enjoyed mathematics prior to the seven-week intervention period and at the end of the seven-week intervention period. The percentage of

Intervention Groups	Pretest		Posttest		Mean	Comparison of Means	
	Mean	SD	Mean	SD	Increase	t-value	P
Computer-based Group N=16	5.54	0.82	5.94	0.81	0.40	-1.37	0.18
Hands-on Group N=15	5.75	0.91	6.23	0.96	0.48	-1.41	0.17

Table 3. Comparison of Students' Pretest and Posttest Scores

students who agreed with each statement at the beginning of the seven-week intervention period decreased after the implementation of the intervention on all of the survey statements except, 'I am good at mathematics' and 'I like solving math problems'. After the seven-week intervention period, the students' responses in the hands-on group showed that, they had more confidence related to mathematics and enjoyed mathematics. Students' responses indicated that, some students no longer enjoyed learning new things in mathematics and they felt that, they did not make good grades in mathematics after the seven-week intervention period.

Students in the computer-based instruction group also completed the survey by responding to five statements about mathematics using a Likert-scale that ranged from 1 (strongly disagree) to 5 (strongly agree). The computer-based instruction group's responses to the students' perceptions survey are shown in Table 5.

Survey Statements	Pre-Intervention			Post-Interventions		
	Strongly Agree/ Agree	Do Not Know	Strongly Disagree/ Disagree	Strongly Agree/ Agree	Do Not Know	Strongly Disagree/ Disagree
I enjoy mathematics.	80%	7%	13%	80%	0%	20%
I like learning new things in mathematics.	93%	7%	0%	87%	7%	7%
I am good at mathematics.	67%	20%	13%	73%	7%	20%
I usually make good grades in mathematics.	73%	20%	7%	60%	7%	13%
I like solving math problems.	80%	0%	20%	93%	7%	0%

Table 4. Responses to Students' Perceptions Survey for the Hands-on Group

Survey Statements	Pre-Intervention			Post-Interventions		
	Strongly Agree/ Agree	Do Not Know	Strongly Disagree/ Disagree	Strongly Agree/ Agree	Do Not Know	Strongly Disagree/ Disagree
I enjoy mathematics.	69%	6%	25%	87%	0%	13%
I like learning new things in mathematics.	81%	13%	6%	75%	13%	13%
I am good at mathematics.	56%	38%	6%	75%	6%	19%
I usually make good grades in mathematics.	75%	25%	0%	87%	6%	6%
I like solving math problems.	63%	0%	37%	63%	6%	31%

Table 5. Responses to Students' Perceptions Survey for the Computer-based Group

The majority of students in the computer-based instruction group enjoyed mathematics at the end of the seven-week intervention period. Students' responses showed that over half of all students in the computer-based instruction group agreed with all of the statements at the end of the seven-week intervention period. The percentage of students who agreed with the statement "I like learning new things in mathematics" decreased after the implementation of the intervention. Students' responses for the computer-based instruction group indicated that, majority of students had more positive perceptions of mathematics at the end of seven-week intervention period when compared to the students' responses prior to the intervention period. The number of students in the hands-on group who agreed with the statement "I enjoy mathematics" remained constant on the post-intervention survey, while the students in the computer-based instructional group who agreed with the statement increased on the students' perception survey. Data collected from the students' perceptions survey also showed that, more than half of the students in the computer-based instruction group and the hands-on intervention group believed that they were good at mathematics and liked solving math problems by the end of the seven-week intervention period. The data also showed that over half of the students in each intervention group also agreed with the statement, "I like solving math problems."

The data collected from the students' perceptions survey also showed that, the number of students who liked learning new things in mathematics decreased in the hands-on group and the computer-based instruction group when the results of the students' perceptions surveys were compared. While there was a decrease in the means for each intervention group when comparing to the number of students who liked learning new things in mathematics, the computer-based instruction group and the hands-on group showed that, the majority of students agreed with the statement, "I like learning new things in mathematics at the end of the seven-week intervention period". The computer-based instruction group and the hands-on group showed that, majority of students had positive perceptions of mathematics at the end of the seven-week intervention period. However, the percentage of students with positive perceptions of mathematics decreased in the hands-on intervention group from the pre-intervention survey compared to the post-intervention survey.

Students' engagement during the intervention period was monitored by the teacher-researcher using an engagement checklist. The teacher-researcher completed the engagement checklist twice a week during the intervention period. Students' engagement time was determined by the amount of time students were on-task during the intervention activities. The teacher-researcher recorded the students' time on-task when an off-task behavior was observed. The percentage of students in each intervention group who remained on-task during the intervention periods is shown in Table 6.

The majority of students in the computer-based instructional group and the hands-on instructional group were consistently engaged throughout the entire fifteen-minute intervention period. The computer-based instructional group's and the hands-on instructional group's engagement data are displayed in Table 7.

The current research study was conducted to compare students' engagement in the computer-based instructional programs and the hands-on activities used to increase the multiplication fact fluency. The data collected using the engagement checklist showed that the computer-based instructional group was significantly more engaged during the intervention periods, (M = 91%, SD = 5.84) than the hands-on activity group (M = 84%, SD = 7.84). Based on Cohen's study, there is large effect (t(26) = 2.54, p = 0.02, 2 = 1.05) on the engagement of students who participated in the computer-based instructional intervention when compared to the hands-on activity intervention.

	Computer- based Group N=16		Hands-on Group N=15	
	Day 1	Day 2	Day 1	Day 2
Week 1	94%	81%	80%	100%
Week 2	100%	88%	80%	87%
Week 3	88%	88%	93%	87%
Week 4	94%	94%	73%	87%
Week 5	81%	100%	73%	94%
Week 6	81%	94%	88%	80%
Week 7	94%	88%	80%	80%

Table 6. Students' Weekly Engagement

Intervention Groups	Engagement Time Mean	SD	t-value	P
Computer-based Group N=16	91%	5.84	2.54	0.02
Hands-on Group N=15	84%	7.84		

Table 7. Students' Average Engagement Time

Throughout the intervention period, the teacher-researcher observed that students in the hands-on intervention group were off-task most often when they were playing the multiplication dice game. The students playing the multiplication dice game spent a large amount of their instructional time retrieving dice that had been rolled across desks and onto the floor or to other parts of the room. Other students playing the multiplication card game were not been assigned.

Students in the computer-based instruction group used multiplication games that timed performance and provided immediate feedback. The computer-based multiplication programs also offered students' rewards for showing progress in mastering their multiplication facts. The teacher-researcher observed students in the computer-based instruction group discussing their scores in the multiplication programs and comparing their progress. Students in the computer-based instructional group experienced technical difficulties with their Internet connection during some of the intervention periods. When an Internet connection problem occurred, the students used a new laptop computer and continued the intervention activity.

Throughout the intervention period, the teacher-researcher documented the field notes to record important information related to the current research. Evidence in the field notes showed that students in the hands-on intervention group were off-task more often than students in the computer-based instruction group. Students in the hands-on group spent a significant amount of time retrieving dice that had been rolled across the room. The teacher-researcher also noted that, the students in the hands-on intervention group were working with a partner, which contributed to some of their off-tasks behaviors. Students in the computer-based instruction group participated in individualized instructional activities, which did not require them to interact with their peers. The teacher-researcher noted that, students in the computer-based instruction group were excited to begin the fifteen-minute intervention period on each day. The students in the computer-based instruction group and the students in the hands-on multiplication group often asked when they would be able to play the online multiplication games. Students in the computer-based instructional group were more engaged throughout the seven-week intervention period when compared to students in the hands-on intervention group.

The teacher-researcher decided that she would not use the hands-on intervention games in the future as students' engagement during the hands-on activities as well as the students' enthusiasm showed the teacher-researcher that other intervention activities may be more beneficial for students. The teacher-researcher may implement a research study in the future that would allow all of the students to participate in the computer-based instruction interventions.

Discussion and Conclusion

In order to determine the effectiveness of computer-based instructional programs on students' achievement, perceptions, and engagement related to mathematics, the teacher-researcher implemented a seven-week intervention study. The students were divided into two intervention groups, a hands-on group and a computer-based instruction group. Throughout the seven-week intervention study, the hands-on intervention group participated in multiplication fact fluency games and the computer-based instructional group practiced multiplication facts using the computer-based programs, Math Magician and First in Math.

In order to answer the research question one, the teacher-researcher administered a pretest prior to the implementation of the intervention period and a post test at the conclusion of the intervention period. While there was not a statistically significant increase in the means the computer-based instruction group (M=0.40) and the hands-on intervention group (M=0.48), both intervention groups showed academic gains as shown in Table 3. Evidence from the pretest and post test failed to indicate that the computer-based intervention had a significant effect on students' academic performance when compared to students who participated in hands-on multiplication fact fluency based activities. Like Smith et al.'s (2011) findings, the results of the current study showed academic growth for students during the programs focused specifically on drill and practice multiplication activities. Results from the current study, like Kiger et al.'s (2012) findings, indicated that students who participated in multiplication interventions that included technology scored higher on post tests than students who practiced multiplication facts using flashcards. Parkhurst et al.'s (2010) findings supported the results from the current study showing that technology was effective for providing timely feedback to students and increasing student achievement.

In order to answer the research question two, the teacher-researcher administered a perception survey prior to the intervention period and at the conclusion of the intervention period. The results of the students' perceptions survey showed that, over 56% of the students in both the hands-on group and the computer-based instructional group responded 'strongly agree' or 'agree' to all of the statements on the students' perceptions survey. The results of the students' perceptions survey showed that, majority of the students had positive attitudes towards mathematics prior to the intervention period as well as at the conclusion of the intervention period. Results did show a positive impact of the interventions on students' responses to the statements "I am good at math and I like solving math problems" as shown in Table 4.

In order to answer the third research question, an engagement checklist was completed by the teacher-researcher twice a week during the seven-week intervention period. Students' time on-task and off-task was recorded. Off-task behaviors included talking to students in other groups, leaving group or assignment, or completing other tasks. The results from the engagement checklist showed that students in the computer-based instruction group were significantly more engaged throughout the intervention periods than the students who participated in the hands-on multiplication games.

Evidence from the field notes also supported the conclusion that students in the computer-based instruction group were more engaged. The teacher-researcher recorded that two students in the hands-on intervention group attempted to use their cards and dice to play games other than the assigned intervention activities. The teacher-researcher also reported that, students who used the dice for the hands-on multiplication games spent a large amount of their intervention time retrieving dice that they had rolled uncontrollably. Similar to the findings of Kiger et al (2012), this study found that, students' engagement increased with implementation of technology. Students were more engaged when technology was included in the intervention activity. As per Gilbertson et al. (2008) findings, this study consistently showed that, students were more engaged when a reward was offered for mastery of specific facts. Throughout the current study, students received online awards on the computer-based instruction program when they mastered a specific multiplication fact. The computer-based instruction group was more engaged throughout the intervention period.

Effects on Student Learning

Throughout the seven-week intervention period, the students participated in drill and practice activities through hands-on games and computer-based programs that specifically focused on multiplication facts. The current study showed that, the hands-on intervention and the computer-based intervention were effective for helping students to increase the mastery of multiplication facts as well as to increase the mathematical achievement. The computer-based instruction group and the hands-on intervention group showed mean increases when pretest and post test data were compared. Students' increased mastery of basic multiplication facts will help them to be more successful in the future as they complete more advanced multiplication problems. Based on mastery of the basic multiplication facts, students will likely be able to recall facts more quickly and accurately. Bryant et al. (2008) found that, students were using time-consuming strategies to compute basic multiplication facts, and during the current research study, the student participants were able to recall facts more efficiently and complete multiplication problems in a timely manner. The effects on student learning from the intervention implemented during the current research study may continue to have a positive effect on student academics beyond the current school year.

Factors Influencing Implementation

There were several factors that influenced the implementation of the current-research study. During the intervention period, the research school was experiencing technical difficulties related to the wireless Internet server. Throughout the first three weeks of the seven-week intervention period, the students in the computer-based instruction group who were using net book computers to access the online multiplication fact fluency program experienced the connection problems. During the online intervention activities, the net book computers would disconnect from the Internet. When this occurred, the students attempted to reconnect to the Internet or get another computer. The school systems' technology department resolved the connection problem during the fourth week of the current study.

Implications and Limitations

The implications of the current research study have changed the teacher-researcher's current practices. Evidence from the findings showed that, a mean increase in academic achievement for both, the computer-based instruction group and the hands-on intervention group. The results showed the teacher-researchers' drill and practice interventions are necessary for assisting students in mastering basic multiplication facts. Based on the students' academic growth throughout the current research study, the teacher-researcher will implement drill and practice interventions in the classroom in the future. This study was implemented during a geometry unit and served as a review of the multiplication unit. In the future, the teacher-researcher will begin the interventions at the beginning of the school year during the place value unit. After all students have mastered the basic multiplication facts, the teacher-researcher will not continue the implementation of the drill and practice interventions each day. However, monitoring the students periodically is essential to ensure retained knowledge of basic multiplication facts. The teacher-researcher will also increase the time of drill and practice interventions before beginning the multiplication unit in an attempt to prepare students for more advanced multiplication activities.

As increasing mathematical achievement scores were a focus for the research school, the teacher-researcher shared the findings of the current research study with the entire staff. The teacher-researcher presented the results of the current research study during a faculty meeting and showed the students' academic gains from each intervention group in addition to the students' engagement time during the intervention period. The teacher-researcher also shared the students' perceptions survey for the other teachers to administer to their own students. All teachers at the research school will attempt to implement a drill and practice intervention to help students master their basic multiplication facts. The teacher-researcher's administrators are also intended to share the findings of the current research study with the district's primary school administrators during a district wide administration meeting in order for the drill and practice activities to begin in early elementary classrooms.

With the demands and time constraints which are required for the current statewide curriculum, teachers struggle to provide time for multiplication drill and practice activities. According to the National Mathematics Advisory Panel (2008), students are not excelling in mathematics compared to students in other countries. Many students struggle to master basic multiplication facts and therefore experience difficulties in mathematics. The current research study provided results, which showed that the drill and practice period helped struggling students to become the master of basic mathematical facts. By helping students master basic multiplication facts, teachers build the foundational skills which help the students to succeed in mathematics courses. This study implemented a computer-based multiplication fluency intervention that may help the teachers to meet the needs of all of students and allow each student to gain the knowledge necessarily to be successful in mastering basic multiplication facts.

Students in third-grade through eighth-grade may benefit from the current research study, as they use multiplication facts throughout the school year to complete mathematical problems. With the implementation of the Common Core Standards, students across the nation need to master multiplication facts. The current research study may provide a knowledge to teachers across the nation with examples of intervention activities that increased fourth-grade students' mastery of multiplication facts.

The current research study may also be more valid if additional teachers implemented the intervention. The teacher-researcher was aware of the students' behavior trends, and may have showed bias related to the student engagement when completing the student engagement checklist. The teacher-researcher also assigned student partners within the hands-on group for the completion of the hands-on activities. The teacher-researchers' bias may also have played a part in the selection of each partner group. Further research is needed to validate the findings of the current research study.

The computer-based intervention group and the hands-on intervention group showed academic gains in mathematical achievement scores post intervention. While both the computer-based intervention and the hands-on intervention yielded positive academic growth in mathematics, the students in the computer-based intervention group were more engaged overall.

The current research was limited to data collected in a fourth-grade classroom, which focused on the mastery of multiplication facts. Future research is needed on the effects of computer-based programs and the necessity to increase mastery in addition or subtraction facts for students across grade levels. Research conducted in numerous classrooms including special education and inclusion classrooms may yield more generalized results.

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