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Peer Learning Strategies versus Computer-based Fact Programs of Basic Subtraction Facts at the Second Grade Level

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Abstract

The purpose of this action research project was to determine if peer-learning strategies increases students' subtraction fact fluency at the second grade level more than computer-based fact programs. Students were split into two research groups, one utilizing peer-learning strategies and games, and the other utilizing a computer-based fact program. Quantitative data consisting of pre- and post-test data as well as weekly progress monitoring data was collected over four weeks. Data examined digits correct per minute, as well as accuracy of subtraction facts. After the four weeks of intervention, the computer-based group increased in more digits correct per minute.

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Mastering basic math facts has been a goal of elementary educators for decades, and is part of mathematics standards. Second grade students are expected to fluently add and subtract basic facts. Standard 2.OA.B.2 states students should, "Fluently add and subtract within 20 using mental strategies" (Iowa Core, 2019, p. 21). Subtraction is one of the building blocks of future math practices, so it is imperative students possess a strong understanding of subtraction. Furthermore, it is important students can fluently subtract basic subtraction equations to allow for more freed thought processes of complex mathematical problems in the future. However, students often have difficultly mastering these basic facts, which often leads to math deficiencies throughout a child's education. The National Center for Education Statistics states in 2017 only 40 percent of fourth graders scored at or above the proficient level, with only eight percent of fourth graders performing at the advanced level (Mathematics Performance, 2018). Placing more emphasis on basic fact acquisition can help improve students' performance in all grades.

Fact fluency is often associated with speed and accuracy. Much debate on how students should become fluent permeates curricular discussions. Past and present practices such as timed tests, using flashcards, and games all claim to make students fluent with basic facts. Many computer-based programs offer practice of basic facts, which is a growing trend in many classrooms. Students often learn best from their peers; thus employing peers as a way to teach and enhance fluency of basic subtraction facts should be examined.

Teachers need to find the most effective strategies for their own particular students to gain fact fluency. Is using computer-based programs, specifically the program FASTT Math, standing for Fluency and Automaticity through Systematic Teaching and Technology, adequate for fact automaticity and accuracy? How does it compare to peer-based, hands-on practice? In this action research paper, the use of peer learning strategies in the scope of teaching subtraction facts will be compared to a computer-based fact fluency program to identify which makes students more or less proficient with subtraction facts. Second grade students will engage in two subtraction fact interventions, one using the FASTT Math fact fluency program and the other utilizing peer learning groups. Data will be collected through pre- and post-assessments, with weekly progress monitoring during four weeks of intervention.

Review of the Literature

What is Fact Fluency?

Fact fluency is “the ability to rapidly and accurately respond to the four math operations” (Berrett, & Carter, 2018, p. 224). It is generally agreed being fluent with basic facts involves recalling facts quickly and accurately. The ways in which students become fluent vary widely. According to research by Berrett and Carter (2018), becoming fluent in the basic operations of addition, subtraction, multiplication, and division evolves in stages. These stages correlate with Piaget’s stages of cognitive development, consisting of counting and concrete levels of understanding, calculating, and then to automatic recall. All children progress through these stages at different paces, just as children progress through the stages of development at different paces. Baroody (2006) also believes fact fluency is developmental, and children typically progress through three stages: counting strategies, reasoning strategies, and mastery.

Becoming fluent with basic operations is an important topic in education. National test scores and recent research by many including Berrett and Carter (2018); Poncy, Fontonelle IV, and Skinner (2013); Musti-Rao and Plati (2015); Gross, Buhon, Shutte, and Rowland (2016) tell a tale of United States children lacking proficiency in math scores at all levels. These researchers believe deficiencies in basic math facts is the underlying cause of this problem. Musti-Rao and Plati (2015) cited evidence from the National Mathematics Advisory Panel that American students are "struggling with basic computation skills" (p. 418). They further suggest that most curricula in United States schools do not provide sufficient practice to become fluent with facts. Developing fluency in the basic operations of addition, subtraction, multiplication, and division further promotes the development of more complex mathematical thinking. The ability to respond to basic facts fluently frees limited cognitive resources for other, more complex work. If students need more time solving basic equations, their limited cognitive abilities are used up and tire before even addressing more complex math concepts. But if most curricula do not provide sufficient fact practice, teachers must find the most successful ways to improve speed and accuracy for students.

The benefits of attaining fluency in basic facts far outweighs the disadvantages. When students compute basic computation facts quickly and easily, more complex thought processes are saved for more difficult math functions and concepts as mentioned above. Smith, Marchand-Martella, and Martella (2011) state being fluent in basic math skills makes students more successful in solving multi-step problems, and lays the foundation for mathematical concepts of time and money. Being fluent also increases effort and motivation in math classes. Ramos-Christian and colleagues (2008) found students with math fluency are able to "maintain skills longer, stay on task longer, and resist distractions" (p. 543). Students with more advanced forms of fact fluency also endure lower levels of math anxiety and are more likely to engage in math activities.

Traditional Strategies for Fact Fluency

Poncy et al. (2013) suggest the need for class-wide procedures to address fact fluency deficits among our students as a result of failing tests scores in mathematics. In past decades, timed tests and flashcards prevailed as ways to practice facts. While those tactics seem old and outdated, they still represent conventional ways to practice basic facts and achieve fluency at many levels. Some argue however, "premature demands for quick performances can induce anxiety and undermine understanding" (Isaacs & Carroll, 1999, p. 508). Practicing educators believe children gradually master more and more facts as they improve in simple fact strategies. Demanding speed too early in children's learning can be harmful. Instead, Isaacs and Carroll (1999) suggest, "brief, engaging, and purposeful practice distributed over time is usually most effective" (p. 511). They continue to say choral drills, flashcards, games, and computers can be useful ways to practice fact fluency. They believe periodic timed tests serve a purpose, but are not needed frequently, especially for primary students (Isaac & Carroll, 1999).

Before achieving fluency, young students must first be taught strategies to compute. These include direct instruction of strategies, such as using ten-frames with a focus on parts and wholes, doubles facts, using derived facts, ten-facts, and counting strategies. For young students, working with manipulatives to understand addition and subtraction concepts should be encouraged; and as students improve in concrete understanding and their use of strategies, increasing the amount of practice with a particular skill in the way of achieving speed could be effective (Burns, Kanive, & DeGrande, 2012). A study by Ramos-Christian, Schleser, and Varn (2008) examined the speed and accuracy of preoperational and concrete operational students in first and second grades. They found students at both stages were similar in accuracy, but students at the concrete operational stage were more rapid in their response to solving math problems. Consequently, students need to pass to the concrete operational stage before achieving the speed component of fluency. This leads to the principle that speed should not be stressed at certain ages of math learning, rather a focus on understanding and accuracy needs to come first (Ramos-Christian et al., 2008). Thus, developmental levels of students need to be taken into consideration before pushing fact speed.

To achieve fact fluency, elementary level teachers must make time in their day for basic fact instruction and practice. Effective instructional practices for building fluency include modeling, drill and practice, with appropriate ratios of known and unknown facts, and immediate and corrective feedback. The latter is often harder for teachers to provide in the traditional form of drill and practice on worksheets often due to the time constraints of correcting worksheets (Berrett & Carter, 2018). Musti-Rao and Plati (2015) suggest repeated response opportunities, immediate feedback, and goal setting as effective ways to improve accuracy and rate for students. Whatever the strategy, most research points to daily practice in some form to become fluent.

Intervention Strategies

Researchers have examined many types of interventions to achieve proficient fluency of basic facts. These commonly consist of cover copy compare, taped-problems procedure (TP), detect-practice-repair, and explicit timing. All have shown to be effective interventions through studies of individual students, or as class-wide interventions. Class-wide interventions are important at the elementary level as they reach many students in one brief setting. All mentioned interventions also involve some form of repeated practice, a key to achieving fluency. Mong and Mong (2010) state, “repeated practice is crucial for building automaticity in students with calculation deficits”, which is a belief of educators as well (p. 285).

Cover copy compare is a strategy consisting of five steps. First, students look at a fact problem with the answer. Second, they cover the problem with a card. Third, students write the solution to the problem without the answer shown. Fourth, they uncover the problem and solution. Fifth, students compare answers. If students' responses are incorrect, they must repeat this process with the correct response. According to Mong and Mong (2010), the cover copy compare strategy has been found effective in improving both accuracy and speed for all math computation skills at all levels.

With the taped-problems strategy, students listen to an audio recording of a problem and then write the correct answer on the corresponding taped-problems fact sheet. If they make an incorrect answer, they correct the response. This follows the ideas of immediate, corrective feedback, and repeating practice. Students try to beat the tape by writing their answer before it is given. The positive effectiveness of taped-problems was found in groups, individually, and can be used as a whole class procedure. However, the pacing of the tape may not be appropriate for certain students, which may impact effectiveness of this procedure for students with slower processing time or higher achieving students who work quickly (Miller et al., 2011).

Detect-practice-repair (DPR) is a teacher-directed model in which students identify math problems being hard or wrong from a worksheet, copy them down, and then end with a quick timed assessment of the facts during each class period. DPR also includes students graphing their own performance, encouraging ownership of the intervention. In a class-wide study that individualized instruction in basic fact fluency for fifth graders, Poncy et al. (2013), found the Detect-practice-repair strategy made substantial gains for students in multiplication and division, but not for those students who were working on subtraction facts. It was indicated those students struggling with subtraction were learning disabled students. It can then be assumed that DPR would be an effective practice for non-learning disabled students.

Explicit timing consists of a simple, class-wide intervention that involves students completing a math worksheet for a short, specified amount of time. Explicit timing intervention can be completed in a very short time period, and does not involve as much preparation as other interventions, a positive to many educators. Combining explicit timing with goal setting and immediate feedback has been shown to be effective according to a study by Gross, Buhon, Shutte, and Rowland (2016). In this research, they examined the use of explicit timing intervention with group-oriented contingencies. The class following independent group-oriented contingencies showed the greatest gains in increasing addition fluency, indicating the idea of rewarding students based on meeting goals serves as an effective way to encourage fact fluency.

One example of an explicit timing procedure is the Rocket Math program. Rocket Math utilizes daily, one-minute timings, with students working to meet their individual goal of digits correct per minute. This paper-based timing program is used to achieve mastery of facts by learning one or two new facts during each of 26 levels of instruction for all four-computation operations. In this program, students first practice facts verbally with a partner. Then they take a one-minute timing at their level. If they accurately meet their goal of the number of fact problems correct, they move on to the next level. In a study by Smith, March, Martella and Martella (2011), the effects of Rocket Math were examined on one first grade student identified to be at risk for school failure. The program was shown to be effective in improving math fluency facts in the area of addition. The program runs similarly for subtraction, multiplication, and division, and it could be suggested the benefits would be positive for those areas as well. One disadvantage of the Rocket Math program is the amount of time required for teachers to check students' daily work. While the program itself takes only a few minutes of classroom instruction, the demands on the teacher are higher with the need to prepare materials and correct timing sheets.

Phillips (2013) suggests another quick, individual intervention for home or school to practice specific troubling facts for students. First, identify equations needing practice and focus on those for a specified period. He suggests quizzing the student on those specified facts in short periods. If the student is unable to respond, the adult tells the correct answer instead of encouraging incorrect guessing. This ensures the student hears the correct answer to retain it, and is quizzed frequently to remember the fact, consistent with ideas of repeated practice to achieve fluency.

Games

Moving beyond conventional methods, research by Godfrey and Stone (2013) proposes elementary students can achieve fact fluency through games over time, with strategy instruction and discussion. Games that focus on students' abilities to explain their thinking and use relationships between numbers can promote and enhance fluency. Godfrey and Stone (2013) suggest the use of games to practice students' working number, the number in which students work on combination sets until they master fluency of this number. The working number for each student is found through a hiding assessment, in which cubes are used and some hidden. Students must identify the number of hidden cubes quickly to assess knowledge of combination sets for that number. Games with number cards, dice, and whiteboards are then used to practice relationships of numbers, eventually moving to automaticity. It was noted, though, that the efficacy of using games to achieve fluency rests in the rich discussions of number combinations children comprise while playing. Teachers must model their thinking of making relationships and solving equations for students to engage in this type of discourse. Teacher monitoring and guiding discussions during this fact fluency development is key (Godfrey & Stone, 2013).

Instruction and practice of basic facts should occur simultaneously. Phillips (2003) states math fact instruction "should involve serious instruction embedded in the context of engaging activities" (p. 359). He also encourages metacognition, the thinking about a person's thinking, while teaching students to work with numbers. This metacognition should help students see how numbers relate to each other when working with them, how they go together, and what they know about numbers. This thinking about the relationships of numbers promotes the skill of decomposing numbers and the ability to manipulate them in ways to increase fluency of facts. Phillips (2003) recommends the routines of a class structure focusing on improving basic fact skills, including a warm-up activity, such as dice games, automaticity check (traditional paper-pencil page), numbers in context using a story problem, strategy instruction (such as doubles, or doubles plus 1), and a game that practices the focus strategy. The key to playing games for practice is to play with students individually or in small groups to discuss strategy use and talk about the reasoning for solving problems, just as Godfrey and Stone (2013) indicate. The teacher can then assist students in focusing on specific number relationships and concepts for particular facts.

A disadvantage for this technique includes it may take an entire class period to complete all of these steps; this may not suffice in a classroom environment with other students and curricular content to cover. However, working with facts in this prescribed routine provides a variety of ways for students to solve problems, time to talk about findings, and opportunities to apply their ideas and create their own understanding. Allowing students practice of their own working number makes this approach very differentiated, a great way to meet each child's individual needs. With these practices, computational fluency will emerge as students use flexible strategies and work in engaging ways (Phillips, 2003).

Peer Learning Strategies

Peer Assisted Learning Strategies (PALS) is a program using student pairings with roles as coach and player, as well as individual practice of skills. PALS is used two to three times per week, in addition to a schools regular math curriculum. This strategy is deeply researched in the area of special education and found to be very effective for both reading and math, at all age levels. Baker, Gersten, Dimino, and Griffiths (2004) found in a study that teachers who had used PALS for several years highlighted increased student achievement from the intervention in mathematical concepts and skills. Teachers also cited positive impacts on social development of students, such as learning to work with a variety of peers as partners, and how to be encouraging and supportive of others.

PALS uses dyads of students in academic settings, in both math and reading. Math practice with PALS focuses on computation skills and math concepts. To form pairs, the class is ranked and split down the middle. Top students from each half are paired, so top students are not paired with lowest scoring partners. Pairs act as tutors to each other, performing prescribed activities from a PALS folder prepared by the teacher. Fuchs, Fuschs, and Karns (2001) claim one way for students to enhance learning is to explain math processes to others, a key component of the PALS program. In additional studies by Fuchs et al. (2001), the PALS approach proves successful even for young kindergarten learners, with results especially promising for middle and low-achieving students and those with learning disabilities.

Peer Assisted Learning Strategies is a set program that involves extensive teacher training and preparation of materials. While widely effective, the efficiency of use may deter some teachers from this form of intervention. The student roles of the coach and player can carry over to other types of activities and fact practice. The research does suggest forming correct pairings of students to tutor and coach to assure effectiveness of the program. Overall, PALS can be an effective way to improve skills and achievement levels of computation skills for a wide range of learners.

Computer-Based Fact Fluency Programs and Apps

In a technology-driven world, computer-based math programs have become popular ways to practice basic computation skills. Numerous programs exist, all claiming to increase speed and accuracy of students' facts. Some programs require subscriptions and schools must pay for the programs, while some are free to educators. The appeal of computer-based fact programs is high among students, who enjoy their colorful, video game-like tasks, and teachers, who cite time-saving reasons as an advantage of their use (Berret & Carter, 2018). In the realm of educational research, these programs are relatively new and few studies have evaluated the effectiveness of them in comparison to traditional fact fluency practices. Therefore, more research of the effectiveness of computer-based fact programs should be warranted.

In a study by Berrett and Carter (2018), a specific computer-assisted instruction program was examined in regards to multiplication fact fluency of third graders. Over the course of five to nine weeks practice with this program, researchers found students were more fluent in their basic multiplication facts and were able to sustain the increased fluency over several weeks after the computer-assisted instruction ended, proving an advantage of the program. This study is limited in its research of only one particular program and did not take into account the natural increase in achievement of students through regular fact practice (Berrett & Carter, 2018). The improvements shown in student progress, however, suggest the program would be successful for students practicing any computation skills at any age level.

Other devices exist that could also be used to increase students' fact skills and proficiency. Ipads have become very popular at the elementary level in many United States schools. Their ease of use and finger-taping procedures make them a favorite among young students. Many applications for Ipads and other hand-held devices abound for the practice of early math skills, including addition and subtraction facts. In a study by Musti-Rao and Plati (2015), they evaluated the effectiveness of the Ipad app Math Drills App compared to a teacher-directed Detect-practice-repair model of intervention. More positive results for fluency were shown with the app, citing reasons of student completion of more fact problems for practice in the similar short amount of time as the Detect-practice-repair intervention. Such conclusions indicate technology programs used to increase fact fluency are more efficient and effective to implement than traditional methods of practice requiring more preparation and materials (Musti-Rao & Plati, 2015).

Another consideration in using technology for basic fact practice consists of assessment objectives. While computer programs may be used more readily for practice, most assessment of skills occurs in the form of paper-pencil worksheets. The transfer of computer-based fact practice to paper-pencil assessments was examined in research by Rich, Duhon, and Reynolds (2017). In this specific study, the participants were divided into three groups to practice three modalities of basic subtraction fact practice: paper-pencil only, computer-based only, computer-based with paper-pencil once weekly. Participants were given pre- and post-tests in both paper-pencil form and computer-based form to identify if practice in the assigned modalities transferred to assessment type. All groups demonstrated growth in their accuracy of fact fluency. The mixed modality group of computer-based practice with once per week paper-pencil practiced showed similar growth on both post assessment forms while the other groups showed less growth on opposite modality assessments. This study concluded the form of practice for basic fact acquisition should be considered and varied to produce the most efficacious results for growth of skills in basic fact acquisition.

Furthermore, this study by Rich et al., (2017) questions the generalizations of any computer-based learning program and how student growth on the device or program applies to other learning and assessment forms for all subject matters. Questions regarding the ability of young learners to transfer skills practiced in one modality and assessment in another modality may need further examination according to Rich et al., (2017). It is also important to remember many students, especially those with learning disabilities, need to understand the concept conceptually before moving to computation, and computer based programs may not be the most useful tool for those students still at the concrete operational stage of development (Burns, Kanive, & DeGrande, 2012).

Ideas of computer-assisted instruction being more engaging and motivating to students bear consideration as an advantage of use. Such computer programs provide vivid graphics and video game-like challenges that make learning exciting for students and incite them to continue on their quests while improving basic fact knowledge. These programs are also found to increase time on task for students, and because of the automaticity of the programs, students are exposed to more equations in a shorter amount of time than with traditional fact practice methods, gaining in net practice (Berret & Carter, 2018). The advantages of computer-assisted instructional programs appeal to many educators as well. Computer-based fact programs provide immediate feedback to students about accuracy of responses. Programs often can produce many types of reports and graphs to track student data and progress, thereby saving teachers hours of checking and reporting. They also alleviate some planning time as the programs typically provide differentiated instruction based on student responses, tailoring needs to each individual child (Berret & Carter, 2018).

Students with Special Needs

Students with special needs or learning disabilities are part of most classrooms and require specialized instruction and modifications or accommodations within the regular classroom. Becoming fluent in basic mathematics facts is equally important for these unique learners. According to Calhoon and Fuchs (2003), up to one-thirds of special education math time is devoted to remedial instruction in math deficiencies. They also found high school students with learning disabilities in mathematics only complete basic addition facts as well as third grade students without disabilities. Students with special needs typically require more time and practice with skills to become proficient, thus even more instructional time devoted to fluency of basic facts is needed for students with special needs than typically developing students.

As previously mentioned, counting strategies typically represent first ways in which students solve basic fact equations. Most students often internalize efficient counting strategies, and eventually these lead to automaticity with more advanced strategies and practice over time. Students with learning disabilities, however, do not often select efficient strategies to solve problems and, as such, benefit from direct strategy instruction for solving basic facts (Tournaki, 2003). In addition to this elementary level insight, findings from a study of PALS use at the secondary level with students with disabilities found the program is successful in improving computational skills among students with special needs. Teachers and students alike enjoyed the program and recognized the benefits to their learning. It reiterated previous findings by Fuchs, Fuchs, and Karns (2001) that PALS is successful in teaching computation skills to students with disabilities (Calhoon & Fuchs, 2003).

Tournaki (2003) examined the use of strategy instruction versus drill and practice among students with and without learning disabilities in a second grade classroom. Teaching strategies equips students with the procedural knowledge to derive answers to unknown problems. Students with learning disabilities were found to become more automatic with strategy instruction rather than drill and practice. Even more surprisingly, students who did not receive any extra fact practice did not increase in accuracy. This finding suggests that all students benefit from even brief periods of fact practice in any form to maintain and enhance proficiency and free their minds for more complex math problems.

Recent research by Iseman and Naglieri (2011) examined students with Attention-deficit/hyperactivity disorder (ADHD), another common concern among elementary children that can affect academic performance. They performed an intervention with students diagnosed with ADHD utilizing cognitive strategy instruction in the area of planning during math instruction and work. Classroom teachers in control and experimental groups taught district curriculum with additional computation worksheets as the intervention. Experimental groups were given 10 minutes of strategy discussion in the area of planning, allowing students to talk about how they would solve the problems on the worksheet, which problems to focus on first, and what computation strategies they would use. Then, they would complete the math worksheet. Students in the experimental group with planning discussion had significantly higher scores than those without the planning session. Students were tested on basic computation facts again one year later, and those in the experimental planning group maintained higher computation scores. This information suggests students with ADHD would need additional time or assistance in planning how they would solve basic math facts to help them become fluent with computation skills.

Successful methods for students with special needs also work for general education students. With this in mind, it is important to consider interventions and practice models to reach all learners. Teaching students with special needs or those with focus and attention problems should be explicit and systematic, employing strategy instruction in both mathematics functions and cognition. Other research has found “that when students identified with a learning disability in math extensively practiced multiplication facts, they retained them, generalized them, and increased fluency to a level typical for their grade” (Burns, Kanive, & DGrande, 2012, p. 184). This suggests that most strategies useful for all students work effectively for students with special needs as well, given considerations, more time, and adaptations as needed to meet all students’ learning goals.

Methods

Participants

This action research took place in a second grade classroom of 22 students in a rural Iowa elementary school. The class comprised of students with a wide range of academic abilities and included two students with Individualized Educational Plans (IEP) with mathematics goals for computation. This study did not require parents or students’ knowledge of research taking place. For the research, the class was split into two groups: a computer-based learning group utilizing the district's program FASTT Math and a group utilizing peer learning strategies and games. Both methods of fact practice were in addition to regular classroom instruction, and occurred over four weeks in the spring.

Data Collection

The purpose of the research was to determine which fact practice method was more effective in increasing students' fluency of basic subtraction facts: peer learning groups or computer-based programs. Data was collected with the same pre- and post-assessment worksheet, from Carson-Dellosa Publishing as seen in Appendix A. Data was initially collected before the intervention started with a basic subtraction fact worksheet used as a pre-assessment for a baseline score. The worksheet consisted of 100 problems covering facts 0-18 of single digit subtraction and students were given three minutes for the assessment. Weekly progress monitoring probes were given during the four weeks of intervention. These probes were the same format as the pre- and post-assessment with 100 single digit subtraction problems, but different forms, with subtraction facts organized in different orders, also utilizing three minutes of timing.

To determine the intervention for the students, stratified sampling was used. Students were first placed into three groups based on skill level of current performance with basic addition and subtraction facts: low, middle, and higher achieving. Within each group, random selection by pulling names out of a cup was used to assign students to the peer learning group or computer-based learning group. To make even pairs for the peer learning groups, ten students were assigned to the FASTT Math group, and twelve assigned to the peer learning group. To form pairs, the teacher paired higher achieving students with a lower achieving student, also noting behaviors and personalities of students.

Students utilizing the FASTT Math computer based program worked individually for fifteen minutes each day. The students have their own unique login information and are given a pre-assessment upon initial login of the program. This assessment determines students' known facts, and identifies study facts that they complete each day. The program requires students to practice three study facts per lesson by looking at the facts, say them in their head, memorize, and then type the facts in equation form with the answer, a similar process to the cover copy compare strategy. After practice of the study facts, students complete a timed assessment completing a variety of known and unknown facts, which helps to determine the next day's lesson, or focused study facts. The program ends with students playing a game to practice facts. Lessons move quickly and students are allowed to complete two lessons within one day, which takes up the fifteen-minute period.

Students participating in the peer learning fact group were identified as player one and player two, with player one being the stronger math student. Player one students would act as coaches first, and then roles reversed. Instruction in the strategies used was given before the intervention started. Partner groups alternated days of strategies used, but ended each day playing a game. The two strategies used for practice of facts was a teacher-adapted form of cover copy compare and a hiding assessment. Students would quiz each other with subtraction flash cards for two minutes, setting aside any facts answered incorrectly. Next, students would look at the incorrect fact, cover it, write the equation with answer, and compare the answer to the flashcard. The second strategy practiced was hidden cup practice. The teacher would place certain numbers of cubes into each peer group's cup, starting with ten cubes and increasing each session. Students would first count all the cubes to identify the day's number to practice. Next, students would take turns dumping out some cubes from the cup. The partner would then determine the remaining cubes in the cup to find the missing number. The fifteen-minute session ended with peers playing a basic subtraction game. The games were Roll-Say-Keep, Spooky Math, Spaghetti and Math Balls, Let's Go Apple Picking Math, Pumpkin Patch Math, and Subtraction Dominoes (Appendix C). Games were played by partners for 2-3 days, then rotated to the next group so all groups had the opportunity to play each game.

Findings

Data Analysis

Quantitative data analysis showed both the peer-learning group and the computer-based group increased in digits correct per minute and in accuracy of subtraction facts completed. The peer-learning group had a mean of 9.3 digits correct per minute at the start of the intervention. The computer-based learning group had a mean score of 10.4 digits correct per minute, indicating both groups were comparable and of similar abilities, as shown in Table 1. Accuracy of the two groups were comparable as well, with 90.5% accurate for the peer-learning group and 93.5% accurate for the computer-based fact group (Table 1).

Table 1

Mean Pre- and Post-test Assessment Scores

	Digits Correct per Minute			Accuracy		
Group	Pre-test	Post-test	Increase	Pre-test	Post-test	Increase
Peer Learning Group	9.3	14.0	+4.7	90.5%	98.8%	+8.3%
Computer-based Group	10.4	16.4	+6.0	93.5%	96.9%	+3.4%

At the conclusion of the intervention, the computer-based fact group had a larger increase in digits correct per minute with a mean score of 16.4 digits correct per minute, an increase of six digits per minute. The peer-learning group had a mean score of 14.0 digits correct per minute, an increase of 4.7 digits per minute. However, the opposite was found for increases in accuracy as the peer-learning group grew 8.3 percent in accuracy of total facts completed compared to just 3.4 percent increase for the computer-based group.

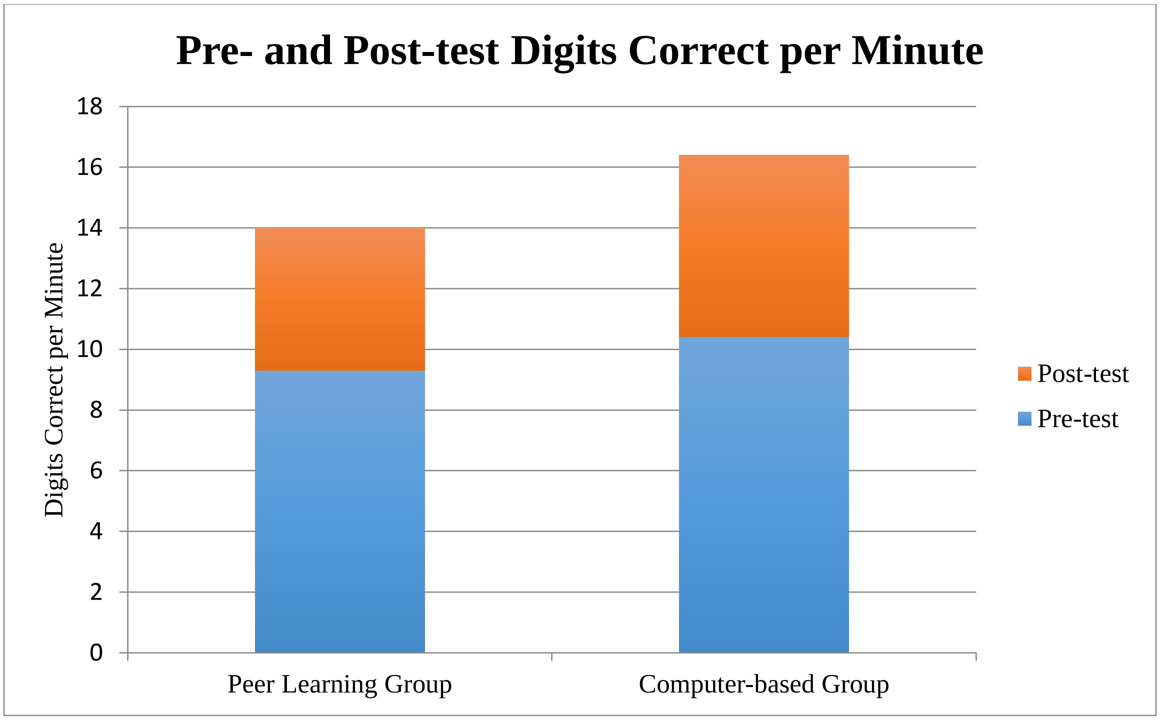

Figure 1. Pre- and Post-Test Digits Correct per Minute.

Table 2 shows pre- and post- assessment scores of individual students in the peer-learning group. The mean increase in digits correct was 4.7 digits per minute. One student, student D, did not grow in digits correct per minute from the initial assessment to final assessment. The highest gain in digits correct per minute was from student C with an increase in 12.6 digits per minute.

Table 2

Peer Learning Group Assessment Scores

	Digits Correct per Minute			Accuracy %		
Student	Pre-test	Post-test	Increase	Pre-test	Post-test	Increase
A	9.3	15.0	+5.7	90.3	97.8	+7.5
C	12.0	24.6	+12.6	100.0	100.0	+/-0.0
D	10.3	10.3	+/-0	96.8	100.0	+3.2
F	6.6	13.3	+6.7	95.0	97.5	+2.5
I	8.6	9.0	+0.4	72.2	100.0	+27.8
J	6.3	7.3	+1.0	86.3	84.5	-1.8
L	18.0	24.0	+6.0	98.1	100.0	+1.9
M	6.0	12.0	+6.0	90.0	80.0	-10.0
O	3.6	8.3	+4.7	78.0	100.0	+22.0
Q	8.6	11.3	+2.7	89.6	80.9	-8.7
R	13.6	16.3	+2.7	97.6	100.0	+2.4
T	8.6	17.0	+8.4	92.8	98.0	+5.2
Mean	**9.3**	**14.0**	**+4.7**	**90.5%**	**98.8%**	**+4.3%**

In the area of accuracy, three students actually decreased in percentage correct from the initial assessment to the final assessment. The largest increase in accuracy was by student O moving from only 78% correct to 100% correct. It is important to note that three of the 12 students in the peer learning group were absent more than three times during this intervention, which may contribute to less growth among those students.

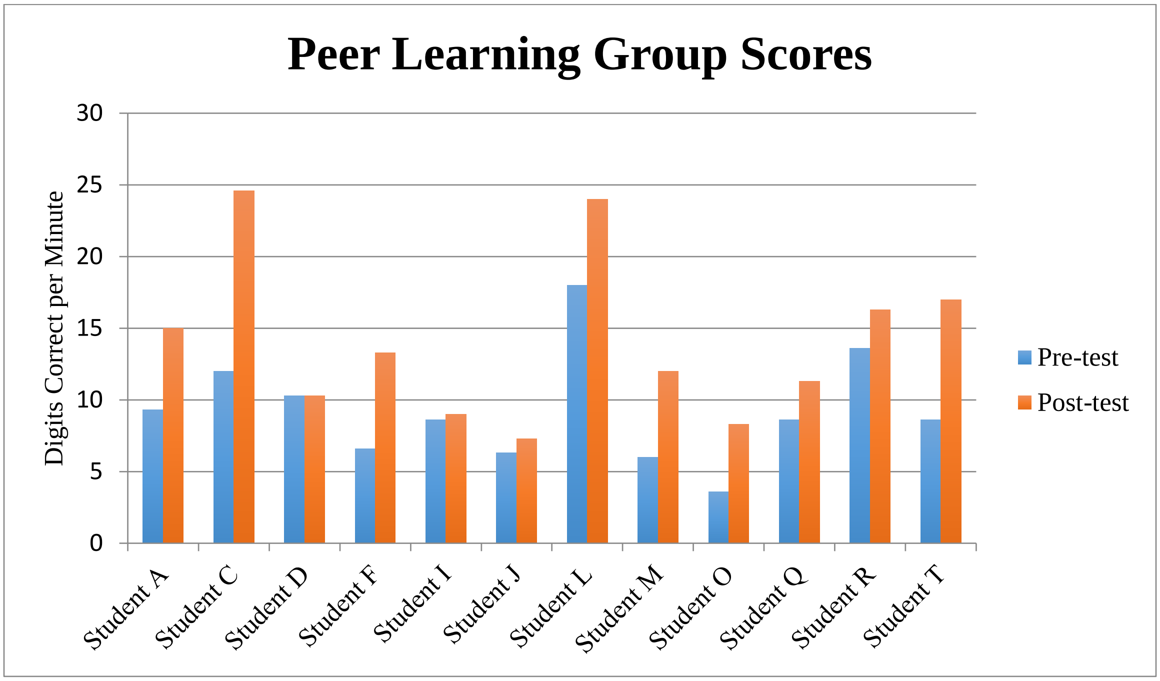

Figure 2. Peer Learning Group Pre- and Post-test Scores for Digits Correct per Minute.

Table 3 examines the pre- and post-test scores of the computer-based learning group. Overall, this group increased by more digits correct per minute, with a mean of 6.4 digits per minute.

Table 3

Computer-based Group Assessment Scores

	Digits Correct per Minute			Accuracy		
Student	Pre-test	Post-test	Increase	Pre-test	Post-test	Increase
B	11.6	19.6	+8.0	100.0	98.0	-2.0
E	8.6	15.3	+6.7	89.6	93.8	+4.2
G	13.6	17.3	+3.7	82.0	88.0	+6.0
H	10.0	23.6	+13.6	100.0	98.6	-1.4

K	9.6	15.6	+6.0	96.6	97.9	+1.3
N	13.3	18.3	+5.0	100.0	100.0	+/-0.0
P	8.0	9.0	+1.0	96.0	100.0	+4.0
S	9.3	17.6	+8.3	93.3	98.0	+4.7
U	13.0	13.6	+0.6	97.5	97.6	+0.1
V	2.6	14.3	+11.7	80.0	97.7	+17.7
Average	**10.4**	**16.4**	**+6.4**	**93.5%**	**96.9%**	**+3.8%**

Increases in accuracy were not as great as the peer-learning group, however their initial accuracy scores were greater. The highest digits correct per minute increase came from student H, with an increase in 13.6 digits; however, accuracy of this student decreased slightly on the post-test. The lowest increase in digits correct per minute was from student U, with just 0.6 digits growth. The largest percentage of increase in accuracy came from student V with 17.7 percent raise in post-test score. Two of the students in the computer-based learning group were absent for more than 5 days at a time, also affecting fidelity of their intervention.

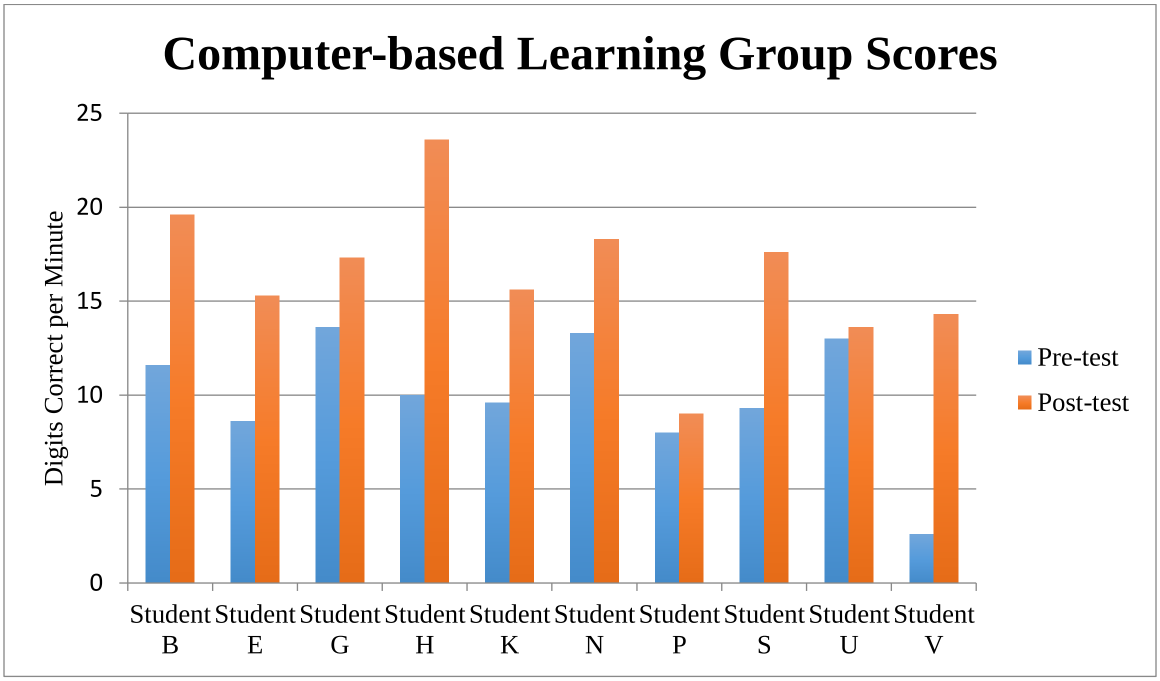

Figure 3. Computer-based Group Pre- and Post-test Scores for Digits Correct per Minute.

Discussion

Summary of Major Findings

Using computer-based learning games and peer learning groups are both successful ways to practice subtraction fact fluency with second grade students. While both groups showed similar scores before the intervention began, the computer-based learning group showed a greater increase in digits correct per minute by only 1.3 digits per minute. This increase of the computer-based group is not significant, indicating that both methods of fact practice were successful for students and increased their fact fluency skills in the area of subtraction.

The data of this study is consistent with research in the field, indicating any method of practice is beneficial to young students in improving fact speed and accuracy. The peer-learning group followed the pace of the students, and allowed for the use of manipulatives such as blocks and game pieces that could be used to count. These strategies are consistent with Piaget's stages of cognitive development, utilizing counting strategies for learning. The group used forms of cover copy compare and the hiding assessment as procedures for their interventions. The idea of using peer as coach was successful for some groups of students, but not all, suggesting forming the correct pairing of students is crucial to the success of peer learning groups.

The group using the computer-based program experienced more fidelity of practice, as the program involves computer timing and follows the same systematic approach each day, following successful practices of repetition and timely feedback for intervention. The program moved right to an automatic recall stage of development, making it difficult for students to stop and solve problems with concrete objects or counting. Students were engaged with the fast pace of the program and interesting graphics, and appeared to be motivated to beat their previous score while utilizing goal setting and explicit timing. The program also focused on only a few study facts to achieve mastery, rather than all facts, which was not consistent with the pre- and post-test that included all facts.

Limitations of the Study

This study does hold some limitations in its research. This research only took place in one grade level, limiting the ability to generalize results across other grade levels. The classroom was comprised of a homogeneous population, making it unclear if these strategies would work for diverse groups of students. Because only one - second grade classroom was used, the sample size is small. The research involved splitting the class into even smaller groups of ten to twelve students, reducing sample size further. These small sample sizes make it difficult to generalize results across similar groups of students in other areas, and could reduce validity and reliability of research.

Another limitation is teacher as researcher, which could pose potential bias among students or strategies used, as compared to an outside researcher. The teacher researcher also acted as trouble-shooter for the computer based program, and had to assist all students with any questions or difficulties in the process, leaving the potential for some students to become off task, limiting amount of practice time. The idea of using discussions among students to strengthen fact understanding was minimal as well with the peer groups, which could have aided in conceptual understanding towards reaching fluency. A final limitation is time on task of students within the peer-learning group. Some pairings of students did not work as productively as others, reducing the quality of their intervention and validity of results.

Further Study

Due to the small nature of this study, further research in the area of best practices for increasing student fluency of subtraction facts at the elementary level is warranted. Student engagement during the activities could be studied as well, which directly affects student performance. The computer-based fact program used in this study is just one of many. Research in the area of which computer-based program is most effective would be helpful to many elementary classroom teachers wishing to promote fact fluency among students. More research in regards to which type of non-computer based intervention is most effective with this age group would also be beneficial for elementary educators wishing to enhance fact fluency instruction.

Conclusion

As research in the field of education shows, learning basic mathematic facts is important in the development and future success of mathematical concepts and problem solving for all students. Research pointed to the need for more emphasis on fact practice and acquisition at younger ages to become fluent, though types of practices varied. This study questioned the effectiveness of peer learning strategies versus computer-based fact programs at increasing subtraction fact fluency of second grade students. The results of this research confirm the idea that any type of fact practice is beneficial to increasing speed and accuracy for young students. Both the peer-learning group and the computer-based group showed growth in digits correct per minute and accuracy. The difference between the two groups in growth was minimal, making it inconclusive that one way to practice math fact fluency is better than another in this study. However, the growth in this short time period justify the need for continued fact practice among elementary students to achieve fact fluency and mastery.

The benefits of both groups throughout the study were student engagement. Participants from both groups showed excitement in their method of practice. The peer-learning group did show more signs of becoming less engaged toward the end of the intervention, indicating a need for either a change in partner or activities and games. The computer-based group seemed to enjoy the pace of the program and rewards when mastering facts. The aspect of motivation was more present with this group as well as they tried to beat their previous score every day with the program, an aspect not part of the peer-learning group.

Playing games and using technology are both effective ways to increase student learning and engagement in the classroom. In the future, the teacher-researcher plans to incorporate both methods of practice within the math instructional block throughout the year for both addition and subtraction fact practice. When used effectively, these methods can positively increase student performance and motivation while working toward fact fluency.

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Appendix A: Pre- and Post-test Assessments

Pre A. Date: ______

Name________________________________ **Subtraction Facts:** 0 to 18

A.	2 − 0	17 − 8	9 − 8	7 − 0	16 − 9	10 − 6	4 − 4	12 − 6	8 − 6	6 − 2
B.	9 − 1	5 − 4	8 − 2	1 − 1	11 − 5	6 − 6	13 − 4	7 − 7	3 − 0	9 − 4
C.	11 − 7	18 − 9	6 − 1	14 − 5	7 − 2	4 − 0	17 − 9	10 − 1	9 − 7	5 − 1
D.	5 − 0	10 − 2	4 − 2	10 − 5	9 − 0	5 − 3	9 − 3	8 − 8	7 − 4	11 − 9
E.	8 − 3	3 − 1	10 − 7	9 − 6	6 − 5	13 − 6	12 − 5	1 − 0	12 − 9	11 − 2
F.	9 − 9	8 − 7	7 − 6	11 − 4	13 − 8	8 − 5	3 − 3	15 − 6	8 − 1	2 − 2
G.	7 − 1	9 − 2	14 − 7	0 − 0	12 − 8	10 − 4	6 − 0	11 − 8	10 − 9	6 − 4
H.	11 − 6	7 − 5	5 − 2	13 − 7	16 − 8	8 − 0	15 − 8	4 − 3	14 − 9	12 − 3
I.	3 − 2	15 − 9	12 − 4	15 − 7	7 − 3	2 − 1	16 − 7	13 − 9	14 − 6	10 − 8
J.	10 − 3	5 − 5	12 − 7	8 − 4	4 − 1	11 − 3	9 − 5	14 − 8	6 − 3	13 − 5

Minutes 1 | 2 | 3 | 4 | 5 **Score** ____

 14

Appendix B: Weekly Progress Monitoring Assessments

Subtraction Facts: Differences 0-18
Test 1 –

Name ______________________________

Minutes 1 | 2 | 3 | 4 | 5

Score [ ]

A	10 − 5	9 − 6	15 − 6	7 − 2	11 − 5	3 − 2	13 − 7	6 − 6	12 − 3	14 − 7
B	4 − 3	13 − 4	5 − 2	10 − 6	6 − 4	18 − 9	8 − 8	9 − 7	12 − 8	9 − 1
C	8 − 3	12 − 4	17 − 9	5 − 5	13 − 8	7 − 3	10 − 3	11 − 2	15 − 7	6 − 2
D	14 − 6	9 − 0	7 − 7	11 − 8	2 − 0	9 − 2	14 − 8	4 − 1	8 − 4	12 − 5
E	4 − 4	16 − 7	6 − 5	10 − 9	12 − 9	9 − 8	1 − 0	13 − 9	5 − 0	16 − 8
F	9 − 5	10 − 4	11 − 7	15 − 8	5 − 3	11 − 3	13 − 5	8 − 1	9 − 9	7 − 0
G	14 − 9	7 − 4	6 − 0	12 − 6	3 − 3	9 − 3	17 − 8	2 − 1	10 − 7	11 − 6
H	8 − 0	13 − 6	7 − 1	8 − 7	3 − 1	14 − 5	7 − 5	1 − 1	10 − 1	3 − 0
I	8 − 6	16 − 9	2 − 2	4 − 2	10 − 8	8 − 2	5 − 4	11 − 9	0 − 0	6 − 1
J	11 − 4	4 − 0	9 − 4	5 − 1	12 − 7	6 − 3	10 − 2	8 − 5	15 − 9	7 − 6

Subtraction Facts: Differences 0-18
Test 2 –

Name ____________________________________

Minutes				
1	2	3	4	5

Score [ ]

A	8 − 1	4 − 2	16 − 7	7 − 1	9 − 3	13 − 4	10 − 2	5 − 4	7 − 7	2 − 2
B	9 − 8	5 − 5	10 − 7	13 − 8	6 − 4	1 − 0	9 − 0	14 − 9	11 − 6	9 − 1
C	12 − 9	8 − 0	0 − 0	13 − 6	7 − 6	12 − 4	8 − 5	4 − 1	11 − 9	6 − 1
D	5 − 0	14 − 6	8 − 8	10 − 3	3 − 0	12 − 7	7 − 0	10 − 1	2 − 1	9 − 7
E	11 − 7	6 − 0	9 − 4	4 − 0	10 − 6	5 − 3	15 − 8	4 − 4	10 − 9	8 − 4
F	7 − 5	2 − 0	12 − 3	6 − 3	9 − 2	11 − 5	8 − 3	14 − 5	7 − 3	12 − 6
G	10 − 8	6 − 6	14 − 8	11 − 2	3 − 2	13 − 5	9 − 6	1 − 1	16 − 9	11 − 3
H	4 − 3	13 − 7	7 − 2	15 − 6	10 − 5	18 − 9	6 − 2	17 − 8	11 − 8	5 − 1
I	16 − 8	8 − 2	10 − 4	15 − 9	5 − 2	8 − 6	13 − 9	9 − 9	14 − 7	12 − 8
J	3 − 1	15 − 7	9 − 5	6 − 5	17 − 9	7 − 4	11 − 4	3 − 3	12 − 5	8 − 7

Name ______________________________

Subtraction Facts: Differences 0-18
Test 3 –

Minutes

1	2	3	4	5

Score [ ]

A	2 − 0	17 − 8	9 − 8	7 − 0	16 − 9	10 − 6	4 − 4	12 − 6	8 − 6	6 − 2
B	9 − 1	5 − 4	8 − 2	1 − 1	11 − 5	6 − 6	13 − 4	7 − 7	3 − 0	9 − 4
C	11 − 7	18 − 9	6 − 1	14 − 5	7 − 2	4 − 0	17 − 9	10 − 1	9 − 7	5 − 1
D	5 − 0	10 − 2	4 − 2	10 − 5	9 − 0	5 − 3	9 − 3	8 − 8	7 − 4	11 − 9
E	8 − 3	3 − 1	10 − 7	9 − 6	6 − 5	13 − 6	12 − 5	1 − 0	12 − 9	11 − 2
F	9 − 9	8 − 7	7 − 6	11 − 4	13 − 8	8 − 5	3 − 3	15 − 6	8 − 1	2 − 2
G	7 − 1	9 − 2	14 − 7	0 − 0	12 − 8	10 − 4	6 − 0	11 − 8	10 − 9	6 − 4
H	11 − 6	7 − 5	5 − 2	13 − 7	16 − 8	8 − 0	15 − 8	4 − 3	14 − 9	12 − 3
I	3 − 2	15 − 9	12 − 4	15 − 7	7 − 3	2 − 1	16 − 7	13 − 9	14 − 6	10 − 8
J	10 − 3	5 − 5	12 − 7	8 − 4	4 − 1	11 − 3	9 − 5	14 − 8	6 − 3	13 − 5

Name ____________________

Subtraction Facts: Differences 0-18
Test 4 –

Minutes

1	2	3	4	5

Score [ ]

A	8 − 3	11 − 8	9 − 5	5 − 1	10 − 2	13 − 7	9 − 0	2 − 2	12 − 8	4 − 0
B	13 − 4	3 − 2	18 − 9	6 − 5	15 − 8	5 − 5	12 − 6	8 − 0	10 − 4	7 − 4
C	14 − 8	10 − 8	7 − 7	11 − 7	1 − 0	8 − 8	8 − 5	6 − 1	16 − 8	2 − 0
D	6 − 6	12 − 9	4 − 2	11 − 3	5 − 0	10 − 1	9 − 4	11 − 5	3 − 3	5 − 3
E	8 − 4	2 − 1	9 − 6	7 − 3	13 − 6	3 − 1	12 − 5	7 − 0	8 − 2	10 − 6
F	5 − 2	10 − 3	6 − 0	12 − 3	9 − 9	16 − 7	6 − 3	15 − 6	0 − 0	14 − 5
G	9 − 1	7 − 6	10 − 7	16 − 9	4 − 4	13 − 9	8 − 7	4 − 1	11 − 2	9 − 3
H	11 − 9	1 − 1	14 − 7	9 − 8	15 − 9	7 − 2	14 − 9	13 − 5	8 − 1	17 − 8
I	9 − 7	7 − 1	12 − 7	6 − 4	11 − 6	10 − 5	7 − 5	14 − 6	5 − 4	15 − 7
J	11 − 4	4 − 3	8 − 6	13 − 8	6 − 2	17 − 9	3 − 0	10 − 9	9 − 2	12 − 4

Appendix C: Math Games