7-9-2021

Using Modified Cover-Copy-Compare to Increase Math Fact Fluency and Promote Generalization

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USING MODIFIED COVER-COPY-COMPARE TO INCREASE MATH FACT FLUENCY AND PROMOTE GENERALIZATION

By

Juan Chen, Master of Art

Presented to the Faculty of the Graduate School of

Stephen F. Austin State University

In Partial Fulfillment

Of the Requirements

For the Degree of

Doctor of Philosophy

STEPHEN F. AUSTIN STATE UNIVERSITY

August, 2021

USING MODIFIED COVER-COPY-COMPARE TO INCREASE MATH FACT FLUENCY AND PROMOTE GENERALIZATION

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ABSTRACT

Many elementary school students struggle with basic math fact fluency in the United States (Stickney et al., 2012). Cover-Copy-Compare (CCC) is a widely used intervention strategy that helps students who experience math fact fluency delays. This study aimed to modify CCC to improve four students' math fact fluency. This study also aimed to modify CCC to generalize the target skill to more advanced skills. It was hypothesized that the intervention would increase participants' target item fluency. It also hypothesized that the intervention would facilitate generalization to untrained target items and more difficult items. However, due to the impact of COVID-19, the second hypothesis was discontinued and was approved by the dissertation committee. In addition, the fourth participant was not able to start the intervention session due to the impact of COVID-19. The fourth participant's data was removed prior to data collection. As a result, this study reported results based on three of the four participants and one guiding question with one hypothesis. A multiple baseline design was used to evaluate the modified CCC procedures. Results from the current study supported that accuracy and fluency level of prerequisite skills impact generalization. Results also demonstrated that once the procedural coaching was in place, the participant with higher fluency and accuracy prerequisite skills impact generalization. Results also demonstrated that once the procedural coaching was in place, the participant with higher fluency and accuracy prerequisite skills displayed a faster and steeper acquisition of generalized skills to the target problems than the participants with lower accuracy and fluency prerequisite skill levels. Overall, the first hypothesis was partially confirmed based on the fact that the modified CCC demonstrated the effectiveness of increasing math fact fluency and accuracy on target items on two of the three participants.

Keywords: math fact fluency, math fact generalization, learning disability, math intervention, cover-copy-compare

This study was impacted by COVID-19 (e.g., one participant had to be removed, all generalization measures could not be administered). The dissertation committee agreed to accept the dissertation given that the pandemic was outside the control of the doctoral candidate and she was still able to demonstrate the skills to conduct a study. This decision was also influenced by communications received from the university president and the dean of the James I. Perkins College of Education who advised faculty to accommodate students during the pandemic.

ACKNOWLEDGEMENTS

I want to thank several people for their support during the process of completing this dissertation. I am grateful to my committee members, Dr. Jaime Flowers, Dr. Glen McCuller, Dr. Lydia Richardson, and Dr. Elaine Turner. I also want to thank my previous committee member, Dr. Jillian Dawes. Thank you all for your support and guidance during the study. Also, I would especially like to thank Dr. Judy Abbott for providing me valuable feedback and detailed guidance on polishing the writing of this dissertation.

I would like to express my deepest appreciation to my dissertation chair and faculty advisor, Dr. Daniel McCleary for inspiring my interest in the area of mathematical intervention. In particular, thank you for the support, encouragement, and advice throughout this process. I could not have completed this dissertation without your support. He guided me through the right direction and devoted numerous hours helping it develop and mature.

In addition, I would like to thank my husband and my sweet girls. Their sympathetic hugs and company kept me moving forward.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I

INTRODUCTION

In the United States educational system (K-12), all children are required to take mathematics classes (Common Core State Standards Initiative, 2018). Unfortunately, many students experienced significant difficulty in mathematics, for example, only 41% of fourth graders and 34% of eighth graders achieved proficiency in the United States (National Assessment of Educational Progress, 2019). Compared to peers in other countries, students in the United States demonstrated poorer performance in math skills (Provasnik et al., 2016). In fact, fourth graders and eighth graders in the United States performed lower than students in at least 11 other countries according to the investigation from Trends in International Mathematics and Science Study (TIMSS) in 2019, including Singapore, Chinese Taipei, Korea, Japan, Hongkong China, Moscow City in Russia, Israel, Australia, and Hungary (TIMSS, 2019). USA students' low performance might be due to lack of curriculum exposure (Stigler et al., 1982), low motivation to work on mathematics (Stevenson et al., 1990), cultural beliefs (Hess et al., 1987), rigorous practices, and the teachers' pedagogical content knowledge of mathematics (An et al., 2004). In other words, the type of mathematics instruction used in the United States was often ineffective for students with and without learning disabilities (Ezbicki, 2008). One other major distinction between the U.S. and other countries, such as China and Japan, was that American families held different beliefs about academic performance than theirs. In the U.S., adults tended to provide unqualified praise to students. However, Chinese and Japanese families focus more on the amount of effort the student was putting forth to complete the work (Chen & Stevenson, 1995; Hess et al., 1987).

During the last couple of decades, researchers focused on math fact fluency interventions and identified strategies teachers and parents should use to improve students' math fluency skills (Jaspers et al., 2016; Poncy et al., 2007; Rhymer et al., 2002). However, most of the research only targeted one-digit problems, such as one digit addition, division, subtraction, and multiplication (McCleary et al., 2016). Furthermore, few studies examined the generalization ability of math fluency interventions (Codding et al., 2007; McCleary & Chen, 2018; Mong & Mong, 2010; Schutte, 2017; Stephens, 2016).

The current study examined the effectiveness of using a modified cover-copy-compare (MCCC) intervention to increase students' math fact fluency on two-digit minus two-digit problems with regrouping. In addition, the study also examined student's ability to generalize the targeted skills to novel problems.

CHAPTER II

LITERATURE REVIEW

Students' knowledge, including math knowledge is developed in a cumulative manner. The knowledge students learned in the early grades built the foundation for more complex calculations that were introduced later (Woodward, 2004). Math skills were commonly separated into three different stages: number sense, math fact fluency, and math problem solving (Jaspers et al., 2016). Each skill was necessary to successfully advance to the next stage (Wendling & Mather, 2008).

Number Sense

Number sense referred to students' ability to comprehend the basic meaning of numbers, the ordinality of numbers, and the ability to count (Von Aster & Shalev, 2007). It was considered a foundational skill of math learning, including math fact fluency and math problem solving (Griffin et al., 1994; Locuniak & Jordan, 2008; Woodward & Baxter, 1997). Most children have developed number sense by 4 to 5 years old (Griffin & Case, 1997). Instruction that encouraged students to use alternative mental calculation methods (e.g., computation estimation, number magnitude) were used to teach number sense (Markovits & Sowder, 1994; Rey et al., 1982). As early as kindergarten, number sense was used to predict a student's likelihood of experiencing math fluency difficulties in third grade (Locuniak & Jordan, 2008).

Math Fact Fluency

Math fact fluency referred to students' ability to recall basic math facts correctly without hesitation (Lee & Tingstrom, 1994; Wendling & Mather, 2008). Many factors might impede students from developing strong math fact fluency. For example, underdeveloped number sense and difficulty composing and decomposing numbers might impact students' ability to solve addition and subtraction problems automatically (Baroody, 1999; Von Aster & Shalev, 2007). Composing and decomposing referred to the ability to understand a large number could be comprised by two smaller numbers and vice versa, which could help students understand subtraction and addition (Baroody, 1999).

Math Problem Solving

Math problem solving was a higher and more complex math domain than number sense and math fact fluency. Number sense and math fact fluency were found to be necessary but insufficient skills for math problem solving (Wendling & Mather, 2008). Math problem solving could be affected not only by prior knowledge like number sense and math fact fluency, but also by many other factors, such as working memory, processing speed, and oral language abilities (Fuchs et al., 2008; Swanson & Beebe-Frankenberger, 2004; Woodward & Baxter, 1997).

Instructional Hierarchy

The National Mathematics Advisory Panel (2008) indicated that number sense, math fluency, and math problem solving are the foundations of higher-level math learning. Researchers also found that deficits in math fact fluency put elementary students at risk for having math difficulties that could persist throughout their academic life, and beyond (Rivera & Bryant, 1992; Woodward, 2006). As such, many interventions were developed to help students improve math fact fluency, such as repeated practice, computer-assisted instruction, self-correcting materials, board games, cover-copy-compare (CCC), interspersal, explicit timing, taped problems (TP), and error analysis (Aspiranti et al., 2011; Jaspers et al., 2016; Poncy et al., 2007; Rhymer et al., 2002). Haring et al. (1978) developed the theory of instructional hierarchy, which applies to mathematic instruction and learning. This theory included four stages: acquisition, fluency, generalization, and application.

The four stages of the instructional hierarchy were developed dependently on each other [i.e., each skill builds on the previous stage(s)]. In regard to mathematics, acquisition referred to the ability to solve math problems accurately. Math acquisition could be enhanced through prompting, modeling, and immediate feedback (Codding et al., 2016). After developing acquisition, students were ready to work on fluency, which referred to the ability to solve math fact problems with both speed and accuracy (Haring et al., 1978). Intervention strategies that helped build fluency included providing multiple opportunities to practice the target skills and providing immediate corrective feedback (Codding et al., 2016). Generalization referred to a student's ability to respond fluently in complex and unfamiliar situations. In the main, generalization did not automatically happen after students achieved fluency (Haring et al., 1978). Helpful intervention strategies at the generalization stage included providing prompts for generalization, introducing novel tasks that allowed the student to practice the target skills, and fading artificial supports (Codding et al., 2016). Application or adaption referred to the ability to modify learned skills to new problems or new situations. Intervention strategies at the adaptation stage included problem solving and simulations. Students that achieved mastery at each stage, in sequence, did not experience the same difficulty as students who failed to do so (Haring et al., 1978). For example, in order to be fluent in math fact problems, students had to first reach mastery at the acquisition stage (i.e., be accurate). Mastery at the acquisition stage prepared the student for success at the fluency stage, in which students had to be accurate and fast. Generalization occurred when students used the skill to solve novel problems accurately. Adaption referred to the ability to modify learned skills to solve new problems or respond to new situations (Haring et al., 1978). For example, once a student attained fluency of 20 two-digit minus two-digit problems, generalization was demonstrated if the student completed two-digit minus two-digit problems that were not included in the original 20 target problems.

Math Acquisition

Math acquisition is a term that has been used to refer to the ability to accurately solve a problem (Haring et al., 1978). Codding et al. (2016) recommended teachers use instructional strategies of prompting, modeling, immediate feedback, and motivation to help students improve math acquisition.

Math Fact Fluency

Many instructional strategies could be used to help students increase fluency in math calculation, such as drill, immediate feedback, goal setting, and reinforcement (Codding et al., 2016). Some of the most commonly used math fluency intervention methods included computer-assisted instruction; flashcards; explicit timing; TP; CCC; and detect, practice, and repair. Common elements among these interventions that helped students increase fluency included immediate corrective feedback, the opportunity to practice, and modeling (Poncy & Skinner, 2006; Rhymer et al., 2002; Wendling & Mather, 2008).

These mathematics intervention strategies adhered to the instructional hierarchy guidelines by incorporating the recommended instructional strategies in the intervention. Specifically, TP provided participants with immediate corrective feedback of the correct answer to each question (McCleary et al., 2011) and CCC provided the visual stimulus of the correct answers for the target skill problems (Skinner et al., 1989). CCC and TP provided performance feedback, multiple opportunities to practice, and reinforcement (Poncy et al., 2007; Skinner et al., 1989). Both verbal and visual feedback steps helped some students achieve fluency. In addition, frequent opportunities to respond allowed students to practice fluency (Poncy et al., 2007; Skinner & McCleary, 2011).

However, some instructional strategies used in schools aimed to help students develop basic math fact skills are considered developmentally immature and as a likely barrier for students to achieve fluency in the future (Wendling & Mather, 2008). For example, finger counting was a strategy often used to help students acquire number sense at an early age (Vandervert, 2017). However, researchers found that finger counting reflected an immature calculation strategy and related it to the development of math difficulties students developed as they became reliant on strategies that were not successful with more complex problems (Kaufmann et al., 2011).

Math Generalization

Generalization referred to behaviors that occur during untrained situations. Achieving generalization required the student to complete a task in a complex and unfamiliar situation (Haring et al., 1978). Instructional techniques found to develop generalization included providing novel stimuli and practicing the skill in novel situations (Stokes & Baer, 1977).

Practice and drill were often recommended strategies to help build math fact fluency and generalization (Poncy & Skinner, 2006; Poncy et al., 2007; Wendling & Mather, 2008). From a behavioral perspective, providing multiple opportunities to drill a specific behavior helped students develop generalization (Skinner & McCleary, 2011; Stokes & Baer, 1977). For example, repeated practice helped students develop math fact fluency, which was needed in order to advance to the next stage, generalization. The term drill was often incorrectly used synonymously with practice. Drill referred to the repetition of certain problems to learn the target skills; whereas, practice referred to the learned response with previously learned skills to solve novel problems. Thus, practice assisted in the development of fluency and generalization (Haring et al., 1978). In fact, the seminal article by Stokes and Baer (1977) recommended practitioners provide instructionally designed activities to plan for generalization rather than train and hope generalization occurs.

Specific Learning Disabilities

Students could be identified with two different types of math learning disabilities under the Individuals with Disabilities Education Act (IDEA, 2004), math calculation or math problem solving. Students with a specific learning disability demonstrated deficits in the skills of core number, memory, reasoning and visuospatial ability (Karagiannakis et al., 2014). Math calculation was a prerequisite skill for math problem solving (Fuchs et al., 2005). Furthermore, students with calculation deficits showed difficulties in retrieval skills (i.e., fluency; Fuchs et al., 2005; Geary et al., 2000). Math problem solving encompassed more cognitive skills than calculation and involved more requirements of contextual understanding, including the ability to integrate information, working memory, language-based memory, visuospatial ability and so on (Decker & Roberts, 2015).

Cover-Copy-Compare

CCC was a research-based intervention for helping students attain math fact fluency (Jaspers et al., 2016). It was often paired with goal setting, graphing, and/or reinforcement contingencies. Skinner and his colleges (1989) first demonstrated the effectiveness of CCC at enhancing accuracy and automaticity when solving math fact problems. Since then its efficacy on math fact fluency has been demonstrated through many research studies over the past few decades (McCleary et al., 2016). CCC yielded positive intervention outcomes with general education students (McCallum et al., 2004; Skinner et al., 1997; Mong & Mong, 2010); students at risk of emotional disturbance (Benson, 2013); students with intellectual disability (Carroll et al., 2006); and students with specific learning disabilities (Clark, 2013). However, students with autism spectrum disorder have not demonstrated benefits from CCC (Morton & Gadke, 2018). CCC was an inexpensive and simple intervention to implement (Poff et al., 2012) and could be used with individual students (Codding et al., 2007), small groups (Lee & Tingstrom, 1994), or class-wide (Poncy, McCallum, et al., 2010; Poncy & Skinner, 2011).

Most commonly, CCC contained five primary steps. During the intervention, students were provided with CCC training sheets. Each CCC sheet normally included five columns. The first column contained target problems and their corresponding answers (Carroll et al., 2006). The second to fifth columns were blank. The five steps to the intervention included: (1) studying the target problem and answer, (2) using an index card to cover the first column, (3) recording the target problem and the answer according to their memory in the second column, (4) removing the index card, and (5) comparing what they wrote in the second column to the answer in the first column. If the written problem and answer were correct, the student moved down to the next target problem (Skinner et al., 1989; Poncy, Skinner, et al., 2010). If the answer was incorrect, the student either repeated the previous five steps in the remaining empty columns (Mong & Mong, 2010) or copied the printed target item and answer three times into the remaining columns (Carroll et al., 2006).

By following all the steps in CCC, participants benefitted by having multiple opportunities to practice recalling math calculations and therefore building automaticity and accuracy (Skinner & McCleary, 2011; Wendling & Mather, 2008). CCC gave students immediate feedback, which also enhanced learning (Mong & Mong, 2010; Poncy, McCallum, et al., 2010). Furthermore, CCC was done privately at the student's desk, which allowed the student to work at their own pace and helped reduce the social desire to cheat (McLaughlin & Skinner, 1996).

CCC Modifications

Researchers modified CCC to improve its effectiveness with addition, subtraction, multiplication, and division, and/or to meet varied needs of diverse populations, such as combining CCC with feedback, reinforcement, and motivation coaching or goal setting (Benson, 2013; Codding et al., 2009; Piana, 2010). Combining CCC with performance feedback and/or rewards (Benson, 2013; Codding et al., 2007) was of the most widely used modifications. However, CCC modifications were not always effective. Benson (2013) compared the isolated effect of CCC, CCC paired with performance feedback, and CCC paired with rewards. The results demonstrated that CCC combined with feedback or rewards both failed to demonstrate significant gains in digits correct per minute (DCPM) compared to CCC alone (Benson, 2013). When comparing CCC alone, CCC and performance feedback on DCPM, and performance feedback on DCPM, Codding et al. found that there were no significant differences between the three conditions. However, Codding et al. also noted there were individual variances in response to CCC alone and CCC with these two different types of performance feedback, indicating certain conditions are more effective for specific individuals (Codding et al., 2007).

Motivation coaching and goal setting were other types of instructional strategies frequently paired with CCC (Codding et al., 2009; Piana, 2010). Different from the modifications above, Piana (2010) added motivation coaching to CCC with four 3rd-graders who were diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD). Motivation coaching was a self-regulation strategy used to increase academic motivation. This approach involved setting goals, learning progress monitoring, and then fading supervision. Participants in the CCC plus motivation coaching group greatly improved the math fluency scores compared to CCC alone. However, the effectiveness of motivation coaching was still uncertain because of treatment interference (i.e., CCC and motivation coaching were presented in the same order for every student; Piana, 2010). Similarly, Codding et al. (2009) examined the application of goal setting. They designed two types of goals in the research: one was based on the number of problems correct (GSC), and another was based on reducing problems incorrect (GSE). The group that used CCC with GSC exhibited significant improvement compared to the control group and CCC with GSE. In fact, CCC with GSC also demonstrated better performance on generalization tasks after the intervention.

The Generalization Ability of CCC

Although there was a strong research base demonstrating the effectiveness of CCC, few studies have either assessed or been able to generalize the target skill to novel problems and high-order skills (Codding et al., 2007; McCleary & Chen, 2018; Mong & Mong, 2010; Schutte, 2017; Stephens, 2016). It was important to note, CCC was only recommended for building acquisition and fluency of basic math facts (Codding et al., 2007). As previously noted, acquisition and fluency were necessary, but not sufficient for generalized responding. Additional instruction was necessary for generalization training. In addition, reinforcement and multiple opportunities to practice with multiple stimuli aided generalization (Poncy et al., 2015). Codding et al. (2007) examined the effectiveness of CCC at increasing math fact fluency and generalizing the skill to slightly more difficult math tasks. Despite the fact there was a slight increasing trend, all three participants demonstrated low fluency rates on generalization tasks.

More recently, Schutte (2017) conducted a study to evaluate combining programming common stimuli and prior sub-skill fluency with CCC to develop participants' generalization skills of subtraction from the target skill of single-digit addition. Schutte created fact triangle models with the problem answer at the top of the CCC intervention sheet. For example, the number six is on top of the triangle, then number two and number four are displayed at the two bottom corners. The students used this triangle as a number family to solve the problems. For example, if given the problem: 6 – 4 = ____, the student works on memorizing the addition problem of what number plus 4 equals 6, instead of using subtraction. Two more intervention probes were added, including the think-addition worksheet and the cloze worksheet. These two worksheets were added after the CCC sheet to assist participants in generalizing the procedures of addition to subtraction. Students whose fluency levels were in the mastery range were successfully able to generalize addition skills to subtraction problems.

CHAPTER III

METHOD

This study used a multiple-baseline design across participants to evaluate the effectiveness of a MCCC intervention. Multiple-baseline design allowed the researcher to collect data to show the effectiveness of the independent variable across different settings, behaviors, and participants during the intervention (Backman et al., 1997; Barger-Anderson et al., 2004) and allowed for examination of the research questions (i.e., does the intervention improve the fluency of target skill items and are the participants able to generalize the skills learned during intervention to novel and more difficult items). It was hypothesized that MCCC would improve participants' target item fluency and facilitate generalization to more complex problems.

Smilarly, McCleary and Chen (2018) used a modified version of CCC in China with a sixth grader with a reported IQ more than three standard deviations below the mean. During this pilot study, the researchers added a column targeting a prerequisite-skill of the target problems in the CCC intervention sheet. For example, for the problem of 54 – 6 = ____, they added a column displaying 14 – 6 = 8 directly before the problem of 54 – 6 = ____. Thus, the student practiced calculating the problem in the ones column before addressing the whole problem, to help her solve the target item in a sequential manner. The participant's fluency with two-digit minus one-digit problems requiring regrouping significantly improved. Also, the participant was able to transfer the skill to novel problems requiring the same skill.

Participants and Settings

Four participants were recruited from a public rural elementary school in Texas. The principal was asked to disseminate recruitment letters to parents/guardians and/or post information in the school. To be included in the study, students had to be in third, fourth, or fifth grade and be in the frustrational range (less than14 DCPM for second and third graders and less than 24 DCPM for fourth and fifth graders) when solving two-digit minus two-digit problems requiring regrouping (Burns et al., 2006). Informed consent was obtained from all participant's parents/guardians and assent was received from each participant. However, due to the special circumstances of COVID-19, the governor of Texas, Greg Abbott, announced that all the schools in Texas were required to be closed for the rest of the semester due to health and safety concerns (Executive Order No. GA- 16, 2020). Due to this, the fourth participant never had an opportunity to start the intervention phase. Therefore, the fourth participant's data was excluded from this study.

John was a 10-year-old African-American male in fourth grade. He was served as a student with a specific learning disability in oral expression, written expression, listening comprehension, reading, and math. Kate was a nine-year-old Caucasian female. She was in third grade and was served as a student with a specific learning disability in reading and math. Jane was an eleven-year-old African-American female. She was in fourth grade and was served as a student with a learning disability in listening comprehension, reading, and math at school. All three participants received special education services at school.

The intervention was implemented in an area free of distractions that did not interfere with the participants' normal academic instruction time. It typically occurred in the conference room, but sometimes occurred in the cafeteria during non-cafeteria time. It occurred during recess, gym, or music, based on the consent of the principal and the student's course schedule. The researcher served as the interventionist during the baseline, intervention, and generalization phases.

Materials

The material used during this intervention included a set of baseline sheets (Appendix B), a set of assessment sheets (Appendix C), intervention packages (Appendix D), a set of sprint sheets (Appendix E), and a set of generalization sheets (Appendix F). Other related materials included a procedural integrity checklist sheet (Appendix G) and a stopwatch.

Before the intervention, three different baseline sheets (see Appendix B) were used to assess the participants' mathematics performance on two-digit minus two-digit problems requiring regrouping (e.g., 43 - 25 = ____). Each baseline sheet contained 12 mutually exclusive problems. During the baseline probe, each participant was given a different baseline sheet each session (i.e., the three probes were rotated to prevent participants from memorizing the answers in order). Each participant had one minute to complete as many problems as possible. No feedback was provided to any participants during baseline.

The same 36 problems used during baseline comprised the target problems used during intervention. The intervention package included three sets and each set included three sheets: the assessment set [assessment sheet A, B, and C (see Appendix C), intervention set (intervention sheet A, B, and C; see Appendix D), and a sprint set (sprint sheet A, B, and C; see Appendix E]. Each sheet contained 12 mutually exclusive math problems. The format of the assessment sheets and sprint sheets were identical to baseline sheets. The sprint set included the same problems as the corresponding intervention sheet, but the problems appeared in a different order. For example, the participants were given intervention sheet A on the first day, then the problems on intervention sheet A appeared on assessment sheet A. This assessment sheet A was used at the beginning of the second intervention session, which was followed by intervention sheet B. At the end of the second intervention session, the participants completed sprint sheet B, which included the same problems as intervention sheet B, but in a different order. The purpose of the sprint sheet was to provide additional opportunities to practice solving the target problems of that session’s intervention sheet.

Three different generalization sets were created to test the intervention's ability to generalize to more advanced levels of problems (see Appendix F). Each generalization set contained three sheets. Each sheet included 12 mutually exclusive problems. The first generalization set (Level A) contained two-digit minus two-digit problems (i.e., 87 – 59 = ____) that differed from baseline sheet sets and intervention packages. The second generalization set (Level B) contained three-digit minus two-digit problems that required regrouping in the ones column (i.e., 364 – 46 = ____). The third generalization set (Level C) included three-digit minus two-digit problems that required regrouping in the ones and the tens column (i.e., 548 – 59 = ____). The level A generalization sheet set assessed the participants' ability to generalize the target skill to novel problems within the same level. The level B and C sheet sets were designed to test the participants' ability to generalize the target skill to more advanced types of problems.

Furthermore, the intervention used in this study was different than traditional CCC in two ways. First, an additional row was added before each target problem and included a prompt to complete the ones column before working on the tens column. For example, for the target problem 56 – 27 = ____, the additional row that was added is 16 – 7 = ____. As a result, even though there were 12 target problems on each intervention sheet, the actual number of problems presented on an intervention sheet was 24. Second, the traditional CCC sheet included five columns and started with the correct problem and answer to allow the participants to learn the problems first (Skinner et al., 1989). However, within this intervention sheet, an extra column was inserted first to encourage participants to solve the target problems by themselves first. If a participant was able to correctly solve the problem in the first column, then the participant moved down to the next row. At the end of each intervention session, the DCPM of items the participant correctly answered in the assessment sheet was calculated. Participants earned rewards if they got more DCPM right than the previous intervention session.

Dependent Measures and Scoring Procedure

The primary dependent variable in this study was the number of DCPM. A correct digit wass scored when the correct number wass written in the appropriate column (Deno & Mirkin, 1977). For example, for the problem 37 – 18 = ___ the correct answer is 19. So, there should be a 9 in the ones column and a 1 in the tens column. In this case, the participant would receive one point for having the correct number (9) in the ones column and one point for having the correct number (1) in the tens column. However, if the participant drew a 7 in the ones column and a 1 in the tens column, the participant would only earn one point for this problem. The participants had one minute to complete as many problems as possible on the baseline, assessment, and sprint sheets. The total number of digits correct on each participant's sheet was calculated as DCPM. The second dependent variable was the number of correct answers per min (CAPM). CAPM was scored when the whole answer was correct. The total number of answers correct on each participant's sheet was calculated as CAPM. For second- and third-grade students, 14 to 31 DCPM was considered within the instructional range. For fourth and fifth graders, 24 to 49 DCPM was considered within the instructional range. Thus, the frustrational range would be less than 14 DCPM for second and third graders and less than 24 DCPM for fourth and fifth graders. The mastery range would be 32 or more DCPM for second and third grade and 50 or more DCPM for fourth and fifth grade (Burns et al., 2006).

Intervention Procedure

During baseline, participants had one minute to complete each baseline assessment sheet. The baseline stability was determined with at least three data points within 10% of each other. After their performance became stable, the first participant began intervention. During this phase, the other two participants continued baseline until the first participant showed improvement. Then the second participant began intervention. The same procedure was also used for the third participant.

Intervention packets consisted of an assessment sheet, intervention sheets, and a sprint sheet. At the beginning of the intervention session, the participants had one minute to complete as many problems as possible on the assessment sheet. However, the first intervention session was different from the rest. Instead of using an assessment sheet, a baseline sheet was given to the participants. Then participants completed the MCCC procedures: (1) The participants covered the second through the sixth column with a blank page and then reviewed the target problem in the first column and tried to solve it by themselves within 10 seconds. (2) The participants removed the card and compared their answer to the model in the second column. (3) If the answer was correct, the participants moved to the next target problem in the row below. If the answer in the first column was incorrect, they engaged in traditional CCC procedures by studying the completed problem in the second column and then covering the first two columns and copying the target problem in the third column by memory. (4) If their answer was correct, they moved down a row to the next item. If the answer was incorrect, the participants compared their answer to the model in the second column and then copied the model in the last three columns. Third, the participants completed a one-minute sprint sheet for additional practice. After each intervention session, the DCPM and CAPM were calculated based on the participants' performance on the assessment sheet.

All three participants received oral guidance on how to solve two-digit subtraction problems with regrouping at the beginning of the first four intervention sessions. They also received immediate feedback from the interventionist if they did not correctly apply the procedures. The feedback procedure faded once the participant demonstrated procedural independence. There were two steps for the participants to learn to solve the target items. The first step involved calculating the ones column.

The second step was crossing out the number in the tens placement of subtrahend and writing the number that is one less than the original. The accuracy percentage was calculated by dividing the number of steps the participants correctly used to solve problems divided by the total number of required steps.

Reward Procedures

Due to the possibility of dropping out from this study and to increase participants' motivation, a reward procedure was added after intervention sessions. Jack started his reward session during the ninth intervention session and Kate started hers during the fifth intervention session. Jane's reward session was added during the third intervention session. Participants had two opportunities to earn rewards. The first reward was a sticker and the participants could earn it by working hard on the intervention sheets during the whole 15 minute intervention time period (i.e., for effort). This reward was meant to encourage students to work hard when completing the intervention sheets. The second reward was also a sticker and could be earned by attaining a higher number of DCPM attained than on the previous session's assessment sheet during the intervention phase. After earning five stickers the participant could access a tangible reward, which consisted of Playdoh, markers, pencils, and crayons. The reward options were selected based on participants' feedback.

Generalization Probe

The generalization probe was implemented in the same manner as the baseline probe. The generalization probes were also gathered during the first three baseline sessions and after the intervention phase. Like the baseline and intervention phases, the generalization phase contained at least 5 sessions. As soon as any participant achieved the mastery level, which was at least 32 DCPM for third graders and at least 50 DCPM for fourth and fifth graders (Burns et al., 2006), the intervention probe was discontinued and the generalization probe was implemented for at least three days. Each participant completed one of the level A generalization sheets, one of the level B generalization sheets, and one of the level C generalization sheets each day. For each level of generalization assessment (i.e., A, B, and C), participants had one minute to complete as many problems as possible. Thus, it took three minutes to complete the three levels of generalization probes. However, due to the impact of COVID-19, none of the three participants had the opportunity to finish the generalization sheets because they switched to virtual schooling for the rest of the semester. As a result, the second research question was not investigated within this study.

Procedural Integrity and Interscorer Agreement

An independent second observer assessed the procedural integrity for each participant separately by using a procedural integrity checklist (see Appendix F). The checklist included the intervention steps and the materials used in the intervention.

Specifically, 6% of Jack's intervention sessions were examined by using the procedural integrity checklist. For Kate, 8% of the intervention sessions were examined. For Jane, 13% of the intervention sessions were examined. The integrity checks were completed on fewer sessions than originally planned due to participants' being absent and the inability of the study to continue due to school closure caused by the pandemic. Procedural integrity was calculated by dividing the total number of agreements by the total number of agreements plus disagreements. Overall, the average interscorer agreement for Jack, Kate, and Jane was 100%.

Interscorer agreement was calculated on 25% of the assessment sheets by a second rater. The interscorer agreement was calculated by dividing the lowest score by the highest score and multiplying by 100. The interscorer agreement was calculated for DCPM and CAPM. For Jack, Kate, and Jane, the interscorer agreement was 100% for DCPM and 100% for CAPM.

Research Questions

The purpose of this study was to employ the MCCC used in a pilot study by McCleary and Chen (2018) with three students with a specific learning disability in math and establish the generalization ability of the MCCC procedures. A pre-requisite skill column was added directly before the target item column on the CCC sheet. This MCCC procedure was hypothesized to assist students in developing math fact skills for both the target probes (i.e., targeted two-digit minus two-digit problems with regrouping) and the generalization probes of untrained problems (i.e., untargeted two-digit minus two-digit problems with regrouping) as well as more advanced math problems (i.e., three-digit minus two-digit problems with regrouping in the ones column and three-digit minus two-digit problems with regrouping in the ones and tens columns).

The current study sought to answer the following research questions: 1) Could an MCCC intervention increase participant's math fluency of two-digit minus two-digit problems requiring regrouping and 2) Could the skills taught through the MCCC intervention generalize to untrained two-digit minus two-digit problems requiring regrouping, three-digit minus two-digit problems requiring regrouping in the ones column, and three-digit minus two-digit problems requiring regrouping in the ones and tens column?

Hypotheses

The hypothesis for the first research question was that MCCC would increase participant's math fluency of two-digit minus two-digit problems requiring regrouping. For the second research question, the hypothesis was that the skills taught through the MCCC intervention would transfer to untrained two-digit minus two-digit problems requiring regrouping, three-digit minus two-digit problems requiring regrouping in the ones column, and three-digit minus two-digit problems requiring regrouping in the ones and tens column.

CHAPTER IV

RESULTS

All three participants demonstrated extremely low performance on both math fact fluency and math fact accuracy during baseline (see Figure 1 and Figure 2). Correct responses increased after MCCC was implemented for two out of three participants, Jack and Kate. Jane did not appear to respond to the intervention, but she did not receive adequate time in the intervention phase due to the early school closure.

Math Fact Fluency Outcomes

MCCC was effective at increasing two of three participants' math fact fluency scores (see Figure 1). Specifically, Jack demonstrated a stable baseline performance after three baseline sessions. The mean number of DCPM during baseline was 0.6, ranging from 0 to 1. To address low motivation issues, a reward session (MCCC+R) was added to address low motivation issues. MCCC+R began on the 10th day of the intervention. During the intervention, Jack's mean number of DCPM increased to 2.6 (ranging from 0 to 5) during MCCC and then increased to 3.1 DCPM (ranging from 2 to 4) during MCCC+R. Overall, Jack demonstrated a slightly ascending trend in his fact math fluency performance after implementing the MCCC intervention. After adding rewards sessions to MCCC, Jack's DCPM performance slightly increased again. However, there appeared to be no significant difference between Jack's

DCPM performance during MCCC and MCCC+R. Kate received eight sessions of baseline, with a mean DCPM of 0.5 (ranging from 0 to 2). Her baseline performance was stable across sessions. Although Kate exhibited high motivation to participate in the study, MCCC+R was implemented during the fifth session of intervention to maintain conditions across participants. The mean number of DCPM increased to 7 (ranging from 0 to 12) during MCCC and then increased to 9.7 DCPM (ranging from 7 to 12) during MCCC+R. Beginning with the second intervention session, Kate demonstrated an increase in DCPM and a stable ascending trend for the remaining sessions. Compared to MCCC, MCCC+R slightly increased Kate's DCPM performance. However, similar to Jack's performance, there appeared to be no significant difference in DCPM for Kate between the two intervention conditions.

Jane received 14 sessions of baseline before starting the intervention phase. The mean number of DCPM during baseline was 0.7, ranging from 0 to 2. The mean number of DCPM increased to 1.5 (ranging from 1 to 2) during MCCC and then decreased to 0.4 DCPM (ranging from 0 to 2) during MCCC+R. Jane also demonstrated low motivation to attend the intervention during the first few sessions of the intervention. MCCC+R was implemented during the third intervention session. Jane's CAPM performance differed from Jack and Kate in that her performance was slightly lower during MCCC+R than during MCCC.

Math Fact Accuracy Outcomes

MCCC appeared to help two participants increase their math fact accuracy (see Figure 2). Math fact accuracy was examined by CAPM in the current study. For Jack, the mean number of CAPM during baseline was 0. The mean number of CAPM increased to 0.5 (ranging from 0 to 2) during MCCC and then increased to 0.7 CAPM (ranging from 0 to 3) during MCCC+R. Overall, Jack demonstrated a slightly ascending trend in his fact math accuracy performance after implementing the MCCC intervention. After MCCC+R began, Jack's CAPM performance slightly increased. However, there appeared to be no significant difference between Jack's CAPM performance when comparing MCCC to MCCC+R.

Kate was in the baseline phase for 8 sessions and had a mean CAPM of 0. The mean number of CAPM increased to 3.3 (ranging from 0 to 6) during MCCC and then increased to 4.7 CAPM (ranging from 4 to 6) during MCCC+R. Starting with the second intervention session, Kate demonstrated an immediate increase in CAPM on target items (Figure 2). Compared to MCCC, MCCC+R slightly increased Kate's CAPM performance. However, similar to Jack, there appeared to be no significant difference in CAPM between MCCC and MCCC+R conditions.

For Jane, the mean number of CAPM during her baseline was 0, ranging from 0 to 0. The mean number of CAPM remained 0 (ranging from 0 to 0) during MCCC and MCCC+R.

Practice Opportunities

Throughout the study, each participant received 15 min of intervention during each session. However, there was an emergency during one of Kate's intervention sessions which prevented her from completing the whole 15 min of intervention during that session. However, the number of items each participant completed in each session differed (see Figure 3). Overall, the number of items that Jack and Kate completed in 15 min was greater than the number Jane completed. Moreover, Jack attended 14 intervention sessions. The total number of items he finished from the beginning of the intervention to the end of the intervention was 320. The average number of items he finished each intervention session was 23 (ranging from 11 to 36). During the 13 intervention sessions Kate received, she completed 358 items. The mean number of items she completed each intervention session was 28 (ranging from 12 to 48). During the eight intervention sessions Jane received, she completed 94 items. On average, she completed 12 items (ranging from 6 to 16) per session.

Prerequisite skills' Accuracy Level and Procedure Applying Tracking

The prerequisite skills needed to complete the target items in this study were two-digit minus one-digit problems with regrouping with the answer limited to ten. The participants were asked to answer the prerequisite skill problems independently on the intervention sheets. Their prerequisite skills' accuracy level was calculated by adding the total number of questions the participants correctly answered throughout the intervention phases. All three participants exhibited a low accuracy level on prerequisite skills but showed steady improvement throughout the intervention phase (see Figure 4). Although Jack only completed one to two prerequisite items at the start of the intervention sessions, he was able to complete five to seven items by the end of the intervention phase. Kate also demonstrated improvement. At the start of the intervention, Kate was able to complete three prerequisite items compared to as many as 16 at the end of the intervention phase. Jane's abilities increased from one correct prerequisite item at the start of the intervention to five by the end of the intervention.

The increased accuracy level of prerequisite skills was consistent with the ascending trend of the target skills. For Jack, the average percentage of steps that he correctly applied when he solved the items in the assessment sheets after procedural coaching was 76%, ranging from 50% to 100%. Kate correctly applied the strategies 88% of the time on the second intervention, which was the session after receiving procedural coaching. She then remained at 100% accuracy during the rest of the intervention sessions. The average percentage of steps that Kate correctly applied procedures was 91% and ranged from 88% to 100%. For Jane, the average number of steps that she accurately used when she solved the items in the assessment sheets after procedural coaching was 74% and ranged from 50% to 100%.

Percentage of Non-Overlapping Data

The percentage of non-overlapping data (PND) could be used as a metric to measure the effectiveness of a single-subject research design study (Schlosser et al., 2008). PND was calculated by summing the number of data points in the intervention phase that does not overlap with the highest data point during baseline and dividing that number by the total number of data points and then multiplying by 100. According to Scruggs et al. (1986), PND of 90% and above could be considered highly effective, PND between 70% and 90% could be considered effective, PND between 50 and 70% could be considered questionably effective, and PND below 50% could be considered unreliable or ineffective. PND was calculated between baseline and intervention (MCCC and MCCC+R) for each participant.

For math fact fluency, Jack's PND was 86%, Kate's PND was 92%, and Jane's PND was 0%. For math fact accuracy, Jack's PND was 44%, Kate's PND was 92%, and Jane's PND was 0%. Overall, the PND indicates the current study was highly effective at improving Kate's math fact accuracy and fluency skills; effective at increasing Jack's math fact fluency, but ineffective at increasing his math fact accuracy; and ineffective at increasing Jane's math fact fluency or accuracy.

CHAPTER V

DISCUSSION

The current study aimed to examine the effectiveness of MCCC and MCCC+R at increasing math fact fluency on target items and its ability to generalize to untrained items. Due to COVID-19, the school district closed prematurely, which disrupted the completion of the intervention. As such, the generalization phase was not initiated or completed for any participant. Therefore, the second research question, and its corresponding hypothesis, could not be evaluated.

The Effectiveness of MCCC or MCCC+R to Target items

The first hypothesis of the current study was that adding prerequisite skills fluency training and procedural coaching could help students with specific learning disabilities increase their math fact fluency on two-digit minus two-digit problems with regrouping. The prerequisite skills fluency training was implemented by adding an extra row directly above the target items. Researchers demonstrated the efficacy of using CCC to build math fact accuracy and fluency on basic subtraction problems (Codding et al., 2007; Codding et al., 2009; Piana, 2011). The procedural coaching technique was added by orally instructing the participants with the procedures that they could use to solve target items. The procedure included two steps: adding the number one in front of the numbers in the ones place of the subtrahend and crossing out the number on the tens placement of the subtrahend writing down a number that was one less than the original number. Also, the prerequisite skill training row served as a prompt for procedural coaching of target items. Results from the current study partially supported the initial hypothesis as two of the three participants demonstrated improvement in DCPM and CAPM performance. Although the third participant, Jane, did not show any improvement during the intervention phase, the reason might be that she was only able to participate in eight intervention sessions before the school was closed due to the pandemic and she did not have a sufficient number of opportunities to respond to show progress with MCCC and MCCC+R.

Regarding the first hypothesis, Jack demonstrated a slight increase in DCPM on target problems from the fourth intervention session and stayed at a stable level for the rest of the intervention. For math fact accuracy, Jack demonstrated a temporary increase between intervention sessions seven and nine in CAPM and displayed another ascending trend during the last three intervention sessions. Kate demonstrated an immediate improvement in math fact fluency and accuracy after the first intervention session and continued to demonstrate accuracy and fluency improvements throughout the intervention phase. In sum, MCCC was effective at increasing math fact accuracy and fluency on two-digit subtraction problems requiring regrouping for both Kate and Jack.

However, the results of the effectiveness of MCCC and MCCC+R were mixed. MCCC+R was only found to be effective at surpassing MCCC performance for math fact accuracy for Jack. Although both Kate and Jack maintained the increased performance demonstrated with MCCC for fluency, their fluency levels with the addition of rewards never exceeded their performance under the MCCC condition. Furthermore, Jane demonstrated no changes in her accuracy level from baseline to MCCC or MCCC+R. Jane's fluency level slightly increased after implementing MCCC, but then decreased after implementing MCCC+R. The addition of rewards was a fairly common practice for academic interventions seeking to increase the accuracy and fluency levels of participants (Bolich et al., 1995; Piana, 2010). The inclusion of rewards had also been shown to increase participants' motivation to continue attending the invention sessions (Benson, 2013; Bolich et al., 1995; Piana, 2010). However, The MCCC+R results were similar to that of prior researchers (Benson, 2013; Bolich et al., 1995) who had not found a clinically significant difference between the efficiency of improving math fact accuracy and fluency between CCC and CCC with rewards. In fact, one participant in the current study showed a decline in accuracy levels after the implementation of CCC+R.

In addition, most CCC or modifications of CCC target basic addition, subtraction, multiplication, or division problems (Chen, 2020). There were only four studies that targeted multi-digit computations (Codding et al., 2007; Codding et al., 2009; Mong & Mong, 2012; Schutte, 2017). For the current study, MCCC and MCCC+R were used on two-digit minus two-digit problems with regrouping, which provided participants the opportunity to practice the prerequisite skills needed to correctly solve the target items by adding an extra row above the target items. Furthermore, the current study examined how prerequisite skills (two-digit minus one-digit problems with regrouping and the answer limited to ten) and procedural coaching affect math fact fluency. Results from the current study supported the effectiveness of MCCC at improving math fact accuracy and fluency on target problems for two of the three participants. However, the third participant only received eight intervention sessions before the study was ended due to the pandemic.

When investigating how the accuracy and fluency level of prerequisite skills and procedural coaching affect generalization, the current study found similar conclusions as previous researchers (Codding et al., 2007; Schutte, 2017). The results of the study supported the conclusion of prior researchers that the accuracy and fluency level of prerequisite skills impact generalization. Also, once the procedural coaching was in place, the participant with higher fluency and accuracy prerequisite skills before the intervention phase began demonstrated a faster and steeper acquisition of generalized skills to the target problems than the participants with lower accuracy and fluency prerequisite skill levels during baseline. Similarly, Schutte (2017) examined the effectiveness of prerequisite skills training and procedural coaching on generalizing basic addition problems to basic subtraction problems. Within Schutte's study, he combined fact family triangles with CCC as prerequisite skills training to help participants increase math fact fluency on basic addition problems. The procedural coaching included two worksheets (think-addition and cloze sheets) that were used to help participants learn and practice the strategies to solve subtraction problems based on the knowledge of addition.

The results from the current study were also similar to Schutte's (2017) study. As soon as the procedural training was implemented with Kate, who had the highest prerequisite skill accuracy and fluency levels, demonstrated an immediate increase in targeted generalization items. Once Kate's prerequisite skills improved, the immediate increase in target skills was also displayed. Compared to Kate, Jack demonstrated slower growth on target skills, presumably because the accuracy and fluency level of his prerequisite skills were not developed enough to demonstrate immediate growth on the target items. This also indicated that the target skill was not appropriate and should have been a lower-level item, such as two-digit minus one-digit problems with the answer limited to ten. However, during the intervention, Jack increased prerequisite skills and target skills simultaneously. Specifically, Jack displayed an increasing trend after the fifth intervention session on his prerequisite skills and demonstrated improvement on the target skills after the fourth intervention session. For Jane, like Jack, the fluency and accuracy level of her prerequisite skills were not high enough to generalize her prerequisite skills to target skills, presumably. In addition, because of the pandemic (COVID-19), Jane did not have the opportunity to continue her intervention sessions to show improvement even though she demonstrated 100% procedural accuracy. After all, both the accuracy and fluency of prerequisite skills and procedural coaching were essential for generalization (Schutte, 2017).

The Generalization Ability of MCCC to Untrained Items

Because of the school closure caused by the pandemic, the interventionist was not able to give any of the participants generalization sheets to test for the generalization ability of MCCC to untrained items. Thus, this research question and its hypothesis could not be addressed by the study.

Limitation and Future Research

Despite the positive results from two of the three participants demonstrated within this research, several limitations should be mentioned. First, due to the impact of COVID-19, the third participant did not have the chance to attend enough intervention sessions to demonstrate the possible effectiveness of MCCC. The incomplete data collection on all three participants impacted the second research question and hypothesis as well. Second, the examination of prerequisite skills could be set up in a more formal way, such as creating a series of prerequisite skills sheets that give participants one minute to finish as many problems as they can. In this way, the same measure can be obtained and then compared with the intervention results. In addition, some statistical analyses can be used to test the relationship between the growth of prerequisite skills and generalization skills. Third, the arrangement of assessing the generalization probe sheets cannot accurately reflect the development of the participants' generalization skills. To track how and when the participants generalize the learned strategy to the untrained items, the generalization probes can be administrated to the participants after each intervention session.

Future research should focus on investigating the relationship between procedural coaching and the development of generalization skills on untrained problems. For instance, after the participants achieve fluency on two-digit minus two-digit problems with regrouping and its prerequisite skills, researchers can test whether or not participants can apply the learned skills and procedural coaching to untrained skills (e.g., three-digit minus two-digit problems with regrouping and/or two-digit minus three-digit problems with regrouping). In this way, researchers can investigate whether or not procedural coaching skills are generalized to untrained skills.

The aforementioned two limitations were related to the research design; another important factor that impacted data collection and reduced the number of participants in the study was the pandemic caused by COVID-19. For the current study, the interventionist had to prematurely terminate the intervention with all three participants. This was especially problematic for the third participant who only received eight intervention sessions. As a result, this participant did not have a sufficient opportunity to develop her skills and demonstrate improvement. Also, the generalization probe sheets were unable to be implemented due to the school closure because this procedure was designed to occur at the end of the study. The study was impeded from resuming as schools remained closed for six months and instituted a number of additional safety precautions upon reopening to prevent the spread of COVID-19, which prevented the study from continuing. Because many schools are providing the option for distance learning, future research should investigate the efficacy of CCC and MCCC via distance education in both synchronous and asynchronous modalities.

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APPENDICES

Appendix A

Figure 1:

The Fluency Level of Participants' Target Items

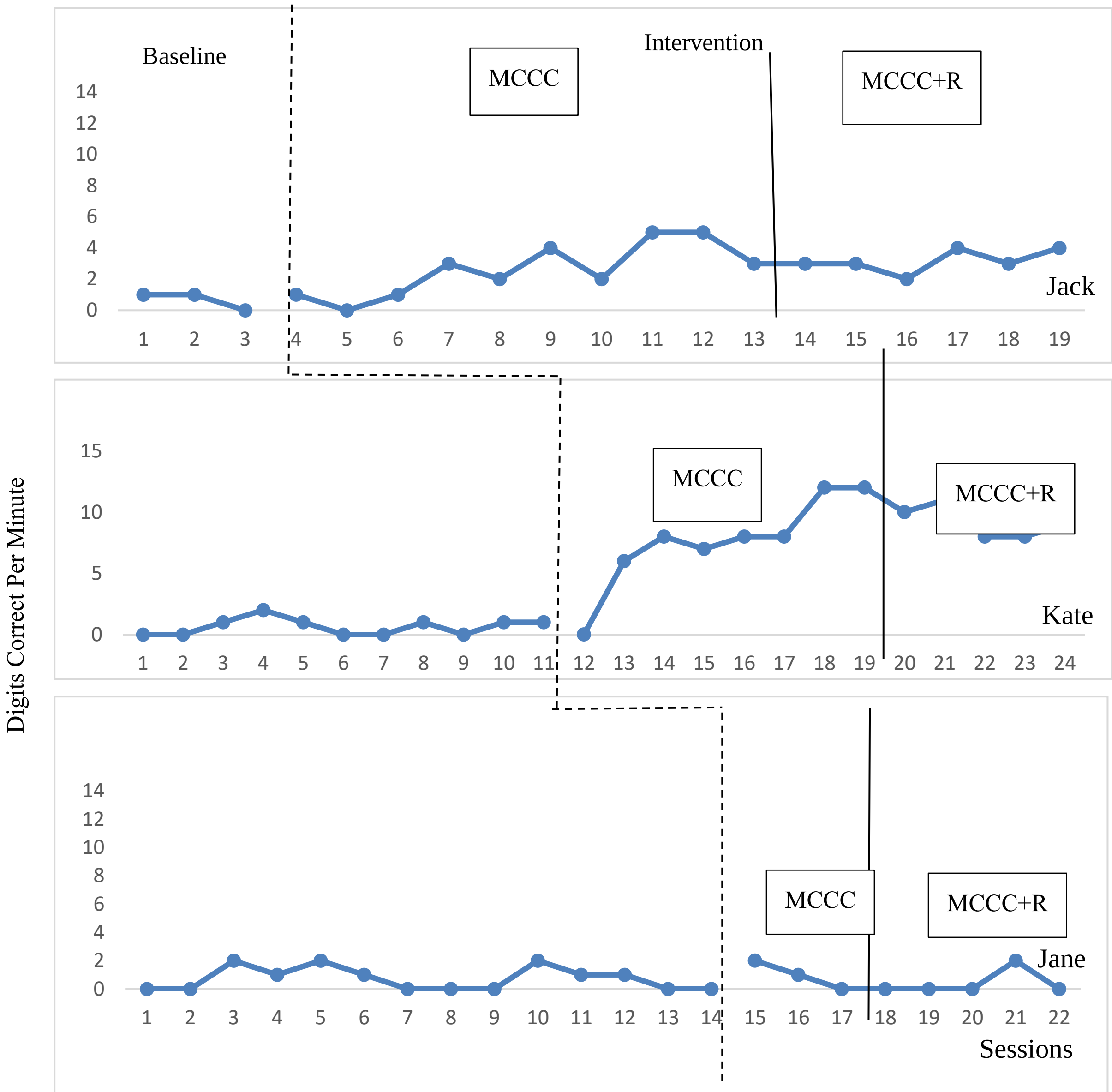


Figure 2:

The Accuracy Level of Participants' Target Items

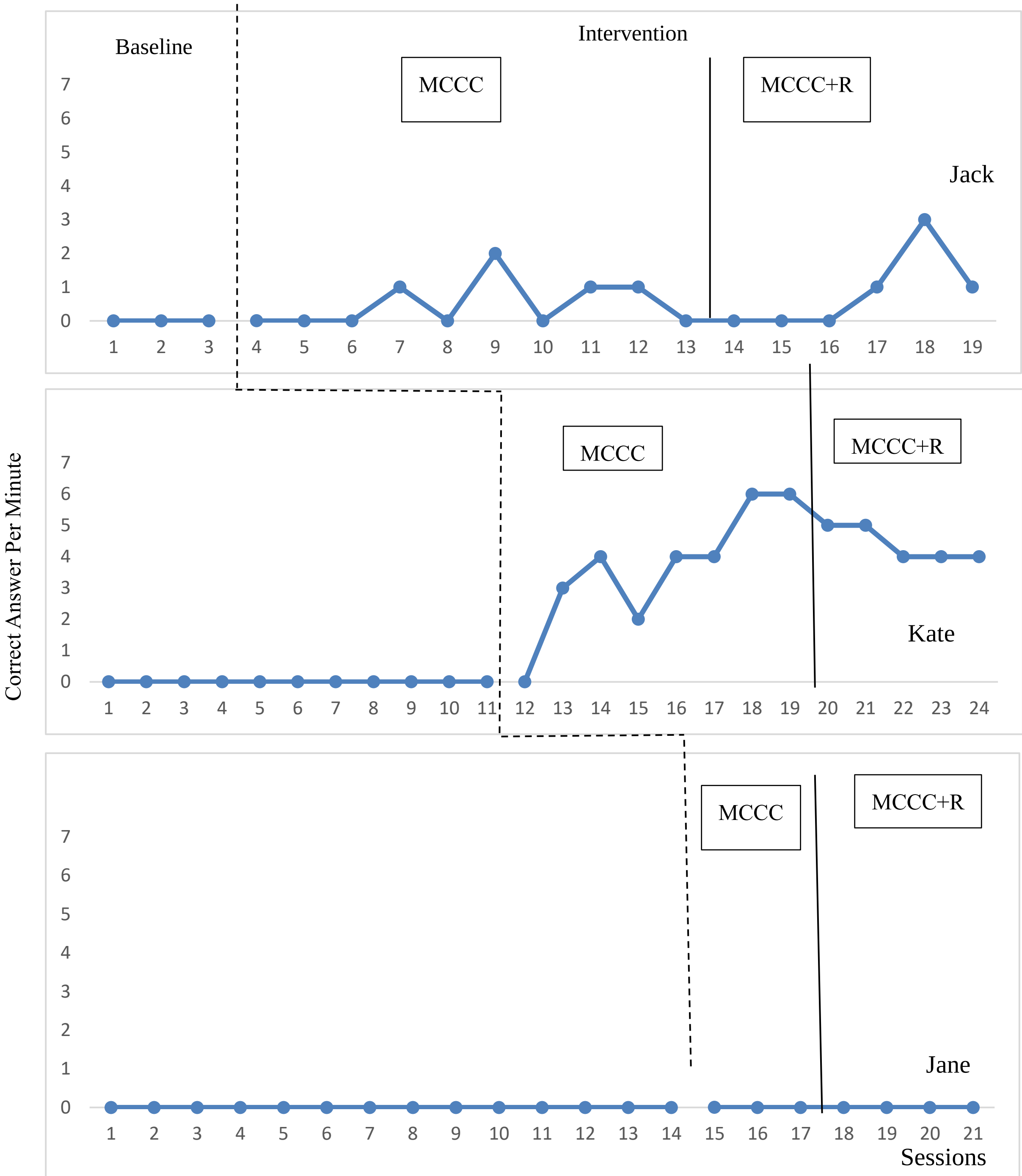


Figure 3:

The Frequency of Practice on Each Intervention Session

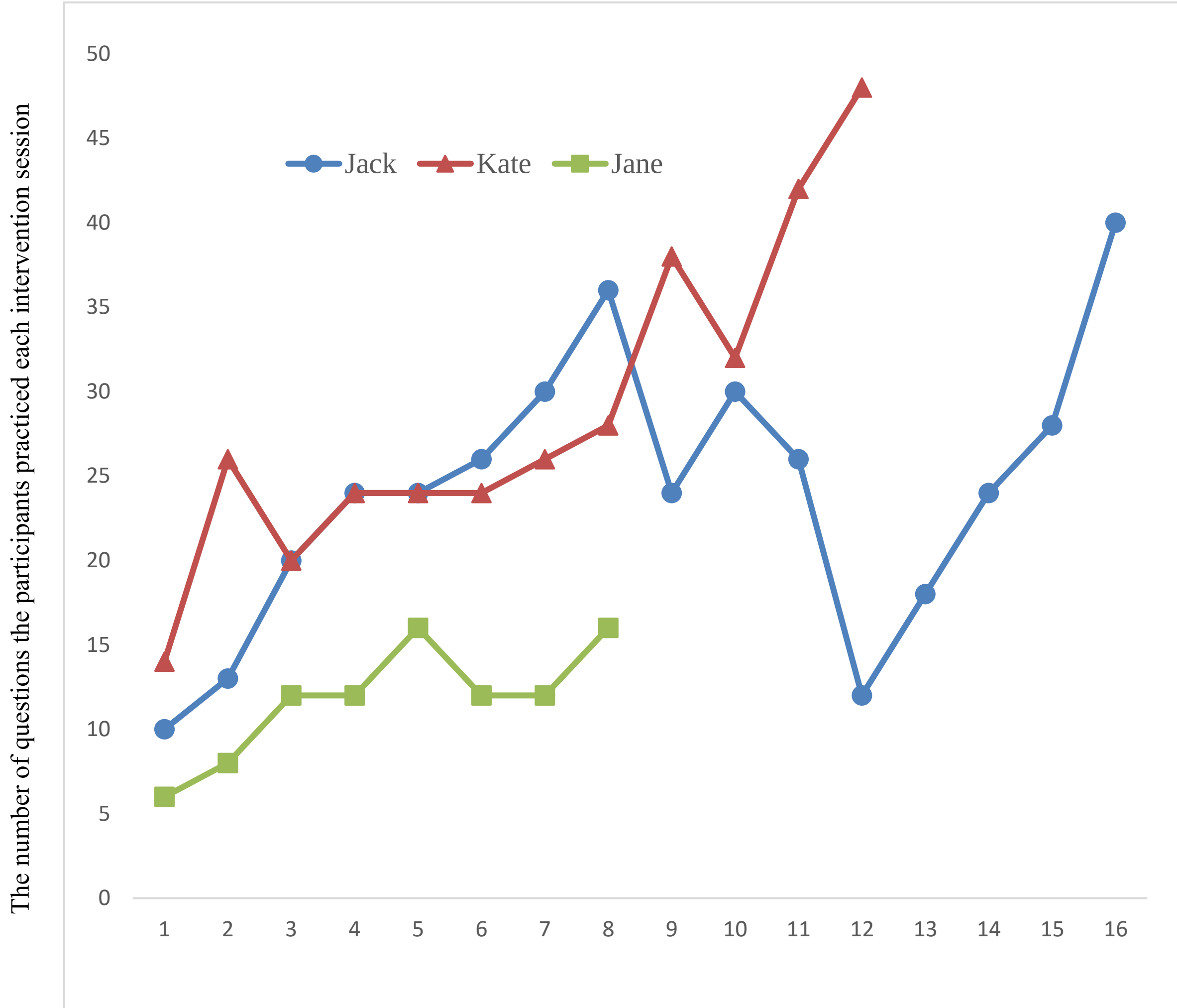
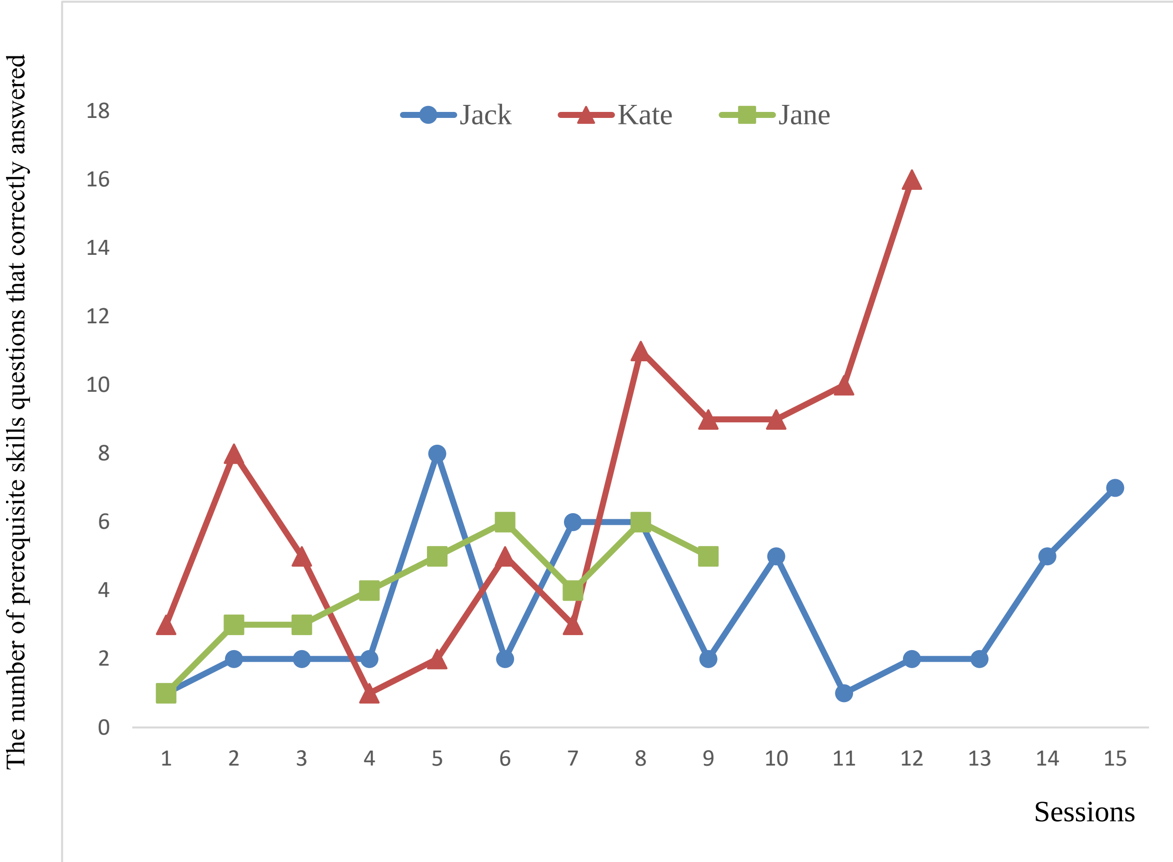


Figure 4:

The Level of Prerequisite skills for Each Participant



Appendix B

Baseline Sheet A:

Name: _______ Date: _________

6 4 −2 9	8 3 −7 7	9 2 − 4 6
7 3 −5 4	4 3 − 2 5	8 1 − 4 2
6 3 − 3 8	9 5 − 1 6	6 8 − 1 9
9 2 −2 5	4 5 − 3 7	3 7 − 1 8

Baseline Sheet B:

Name: _______ Date: _________

8 6 − 5 9 ____	5 2 − 3 7 ____	7 2 − 1 9 ____
2 4 − 1 6 ____	8 6 − 6 8 ____	5 5 − 3 9 ____
7 6 − 2 7 ____	4 2 − 1 8 ____	7 1 − 1 6 ____
9 4 − 3 5 ____	9 1 − 8 5 ____	5 1 − 2 7 ____

Baseline Sheet C:

Name: _______ Date: _________

34 − 27	72 − 44	81 − 39
51 − 48	94 − 58	97 − 79
53 − 16	31 − 23	85 − 28
91 − 64	83 − 29	62 − 43

Appendix C

Assessment Sheet A:

Name: _______ Date: ___

9 2 − 2 5	8 1 − 3 9	2 4 − 1 6
3 4 − 2 7	6 8 − 1 9	8 3 − 7 7
7 1 − 1 6	6 4 − 2 9	8 5 − 2 8
9 5 − 1 6	7 2 − 1 9	8 6 − 6 8

Assessment Sheet B

Name: _______ Date: _________

51 − 48	83 − 29	76 − 27
42 − 18	94 − 58	43 − 25
91 − 64	37 − 18	62 − 43
97 − 79	72 − 44	52 − 37

Assessment Sheet C:

Name: _______ Date: _________

3 1 − 2 3 ———	5 5 − 3 9 ———	5 3 − 1 6 ———
7 3 − 5 4 ———	9 1 −8 5 ———	4 5 − 3 7 ———
5 1 − 2 7 ———	8 1 − 4 2 ———	8 6 − 5 9 ———
9 4 − 3 5 ———	9 2 − 4 6 ———	6 3 − 3 8 ———

Appendix D

Intervention Sheet A

Name: ______ Date: ________

1 4 − 7	1 4 − 7 7				
3 4 − 2 7	· 3 4 − 2 7 7				
1 1 − 6	1 1 − 6 5				
7 1 − 1 6	· 7 1 − 1 6 5 5				
1 8 − 9	1 8 − 9 9				
6 8 − 1 9	· 6 8 − 1 9 4 9				
1 5 − 6	1 5 − 6 9				
9 5 − 1 6	· 9 5 − 1 6 7 9				

1 3 − 7	1 3 − 7 5				
8 3 − 7 7	· 8 3 − 7 7 5				
1 4 − 9	1 4 − 9 5				
6 4 − 2 9	· 6 4 − 2 9 3 5				
1 4 − 6	1 4 − 6 8				
2 4 − 1 6	· 2 4 − 1 6 8				
1 5 − 8	1 5 − 8 7				
8 5 − 2 8	· 8 5 − 2 8 5 7				

1 1 − 9	1 1 − 9 2				
8 1 − 3 9	· 8 1 − 3 9 4 2				
1 6 − 8	1 6 − 8 8				
8 6 − 6 8	· 8 6 − 6 8 1 8				
1 2 − 5	1 2 − 5 7				
9 2 − 2 5	· 9 2 − 2 5 6 7				
1 2 − 9	1 2 − 9 3				
7 2 − 1 9	· 7 2 − 1 9 5 3				

Intervention Sheet B

Name: ______ Date: ________

1 2 − 7	1 2 − 7 5				
5 2 − 3 7	· 5 2 − 3 7 1 5				
1 2 − 3	1 2 − 3 9				
6 2 − 4 3	· 6 2 − 4 3 1 9				
1 2 − 8	1 2 − 8 4				
4 2 − 1 8	· 4 2 − 1 8 2 4				
1 1 − 8	1 1 − 8 3				
5 1 − 4 8	· 5 1 − 4 8 3				

1 2 − 4	1 2 − 4 8				
7 2 − 4 4	· 7 2 − 4 4 2 8				
1 7 − 8	1 7 − 8 9				
3 7 − 1 8	· 3 7 − 1 8 1 9				
1 7 − 9	1 7 − 9 8				
9 7 − 7 9	· 9 7 − 7 9 1 8				
1 1 − 4	1 1 − 4 7				
9 1 − 6 4	· 9 1 − 6 4 2 7				

1 4 − 8	1 4 − 8 6				
9 4 − 5 8	· 9 4 − 5 8 3 6				
1 6 − 7	1 6 − 7 9				
7 6 − 2 7	· 7 6 − 2 7 4 9				
1 3 − 5	1 3 − 5 8				
4 3 − 2 5	· 4 3 − 2 5 1 8				
1 3 − 9	1 3 − 9 4				
8 3 − 2 9	· 8 3 − 2 9 5 4				

Intervention Sheet C

Name: ______ Date: ________

1 3 − 6	1 3 − 6 7				
5 3 − 1 6	· 5 3 − 1 6 2 7 3				
1 6 − 9	1 6 − 9 7				
8 6 − 5 9	· 8 6 − 5 9 2 7				
1 3 − 8	1 3 − 8 5				
6 3 − 3 8	· 6 3 − 3 8 2 5				
1 1 − 3	1 1 − 3 8				
3 1 − 2 3	· 3 1 − 2 3 8				

1 4 − 5	1 4 − 5 9				
9 4 − 3 5	· 9 4 − 3 5 5 9				
1 1 − 5	1 1 − 5 6				
9 1 − 8 5	· 9 1 − 8 5 6				
1 3 − 4	1 3 − 4 9				
7 3 − 5 4	· 7 3 − 5 4 1 9				
1 1 − 2	1 1 − 2 9				
8 1 − 4 2	· 8 1 − 4 2 3 9				

1 5 − 9	1 5 − 9 6				
5 5 − 3 9	˙5 5 − 3 9 1 6				
1 5 − 7	1 5 − 7 8				
4 5 − 3 7	˙4 5 − 3 7 8				
1 2 − 6	1 2 − 6 6				
9 2 − 4 6	˙9 2 − 4 6 4 6				
1 1 − 7	1 1 − 7 4				
5 1 − 2 7	˙5 1 − 2 7 2 4				

Appendix D

Sprint Sheet A:

Name: _______ Date: _________

6 4 − 2 9	7 1 −1 6	9 2 −2 5
8 6 −6 8	9 5 − 1 6	2 4 − 1 6
8 5 − 2 8	3 4 −2 7	7 2 − 1 9
8 1 − 3 9	8 3 −7 7	6 8 − 1 9

Sprint Sheet B:

Name: _______ Date: _________

43 − 25	37 − 18	52 − 37
72 − 44	91 − 64	83 − 29
62 − 43	51 − 48	97 − 79
42 − 18	76 − 27	94 − 58

Sprint Sheet C:

Name: _______ Date: _________

94 − 35	92 − 46	81 − 42
51 − 27	86 − 59	73 − 54
91 − 85	31 − 23	53 − 16
55 − 39	45 − 37	63 − 38

Appendix F:

Generalization Level I Sheet A:

Name: _______ Date: _________

52 − 37 ____	81 − 44 ____	32 − 15 ____
82 − 59 ____	83 − 68 ____	63 − 26 ____
94 − 85 ____	74 − 39 ____	65 − 17 ____
57 − 49 ____	41 − 12 ____	46 − 27 ____

Generalization Level I Sheet B:

Name: _______ Date: _________

$\begin{array}{r} 82 \\ -\ 38 \\ \hline \end{array}$	$\begin{array}{r} 91 \\ -\ 68 \\ \hline \end{array}$	$\begin{array}{r} 42 \\ -\ 33 \\ \hline \end{array}$
$\begin{array}{r} 78 \\ -\ 29 \\ \hline \end{array}$	$\begin{array}{r} 44 \\ -\ 27 \\ \hline \end{array}$	$\begin{array}{r} 85 \\ -\ 76 \\ \hline \end{array}$
$\begin{array}{r} 56 \\ -\ 39 \\ \hline \end{array}$	$\begin{array}{r} 52 \\ -\ 24 \\ \hline \end{array}$	$\begin{array}{r} 73 \\ -\ 49 \\ \hline \end{array}$
$\begin{array}{r} 21 \\ -\ 17 \\ \hline \end{array}$	$\begin{array}{r} 93 \\ -\ 54 \\ \hline \end{array}$	$\begin{array}{r} 81 \\ -\ 26 \\ \hline \end{array}$

Generalization Level I Sheet C:

Name: _______ Date: _________

8 3 − 2 5 _____	6 2 − 5 6 _____	5 4 − 1 8 _____
6 1 − 3 9 _____	9 3 − 4 7 _____	8 1 − 2 3 _____
9 5 − 3 8 _____	7 7 − 6 8 _____	9 1 − 2 5 _____
9 5 − 1 9 _____	7 6 − 5 8 _____	6 4 − 4 6 _____

Generalization Level II Sheet A:

Name: _______ Date: _________

8 8 3 − 2 5 ______	7 6 2 − 5 6 ______	2 5 4 − 1 8 ______
1 6 1 − 3 9 ______	9 9 3 − 4 7 ______	4 8 1 − 2 3 ______
3 9 5 − 3 8 ______	6 7 7 − 6 8 ______	7 9 1 − 2 5 ______
5 9 5 ______ − 1 9	3 7 6 − 5 ______	7 6 4 ______ − 4

Generalization Level II Sheet B:

Name: _______ Date: _________

7 5 2 − 3 7	2 8 1 − 4 4	5 3 2 − 1 5
6 8 2 − 5 9	8 8 3 − 6 8	5 6 3 − 2 6
2 9 4 − 8 5	5 7 4 − 3 9	7 6 5 − 1 7
3 5 7 − 4	1 4 1 − 1	4 4 6 − 2

Generalization Level II Sheet C:

Name: _______ Date: _________

4 8 2 — 3 8	3 9 1 — 6 8	8 4 2 — 3 3
6 7 8 — 2 9	5 4 1 — 1 6	8 8 5 — 7 6
4 5 6 — 3 9	2 5 2 — 2 4	6 7 3 — 4 9
1 2 1 — 1 7	7 9 3 — 5 4	9 8 4 — 2 7

Generalization Level III Sheet A:

Name: _______ Date: _________

6 3 2 − 5 7	3 4 1 − 8 4	7 1 2 − 3 5
5 5 2 − 8 9	6 6 3 − 8 8	8 2 3 − 6 6
3 8 4 − 9 5	7 3 4 − 7 9	5 2 5 − 3 7
1 4 7 − 5 9	3 1 1 − 4 2	3 2 6 − 4 7

Generalization Level III Sheet B:

Name: _______ Date: _________

482 − 98	361 − 98	842 − 53
678 − 89	544 − 67	885 − 96
456 − 79	252 − 64	673 − 79
121 − 47	753 − 94	981 − 96

Generalization Level III Sheet C:

Name: _______ Date: _________

8 2 3 — 2 5	7 6 2 — 9 6	2 5 4 — 7 8
1 3 1 — 6 9	9 4 3 — 7 7	4 3 1 — 5 3
3 3 5 — 9 8	6 4 7 — 6 8	7 2 1 — 7 5
5 2 5 — 3 9	3 7 6 — 9 8	7 4 4 — 7 6

Appendix G

Cover-Copy-Compare Procedural Integrity Checklist

Correctly Implemented?		Step	
Yes	No	1	Establish goal for the participant to earn blue rewards.
Yes	No	2	Instruct the participants to complete the assessment sheet.
Yes	No	3	Provide instructions about the steps used in this experiment for the intervention sheet to the student in the first three sessions.
Yes	No	4	Show the student a problem and give him/her approximately 10 seconds to respond to the problem in the first row. Wait up to 10 seconds and then prompt them to move to the next step.
Yes	No	5	Instruct the student to compare his/her answer to the problem solved correctly.
Yes	No	6	If s/he is correct, student moves to the next item. [Skip to step #12]
Yes	No	7	If s/he is incorrect, instruct student to look at the written problem and answer and read it aloud.
Yes	No	8	Instruct student to cover his/her written problem and answer.
Yes	No	9	Instruct student to copy the problem and answer from memory.
Yes	No	10	Instruct student to compare his/her result to the answer.
Yes	No	11	If s/he is correct, student moves on to next item, if s/he is incorrect, student copies the question and answer three times.
Yes	No	12	Finish all of the problems on the intervention sheet.
Yes	No	13	Guide the participants to complete the sprint sheet in one minute.
Yes	No	14	Calculating the DCPM on the assessment sheet with the participants.

VITA

Juan Chen entered Soochow University in China in 2003. She received the degree of Bachelor of Education in May 2007. During the following five years, she was employed as an elementary teacher at a public school in Shanghai, China. In August 2012, she entered the Graduate School of Stephen F. Austin State University and received the degree of Master of Education in December of 2014. Following graduation, she entered the Graduate School of Stephen F. Austin State University and received the degree of Master of Art in May of 2020. Currently, Chen is doing her predoctoral internship at Dallas Children's Advocacy Center.

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