Winter 12-16-2022

Comparing the Effectiveness of Traditional Taped-Problems Intervention with a Remote Delivery Version for Increasing Math Fact Fluency

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COMPARING THE EFFECTIVENESS OF TRADITIONAL TAPED-PROBLEMS INTERVENTION WITH A REMOTE DELIVERY VERSION FOR INCREASING MATH FACT FLUENCY

A Dissertation

Submitted to the School of Education

Duquesne University

In partial fulfillment of the requirements for

the degree of Doctor of Philosophy

By

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December 2022

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ABSTRACT

COMPARING THE EFFECTIVENESS OF TRADITIONAL TAPED-PROBLEMS INTERVENTION WITH A REMOTE DELIVERY VERSION FOR INCREASING MATH FACT FLUENCY

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December 2022

Dissertation supervised by Elizabeth McCallum, Ph.D.

The knowledge of math fact fluency skills is crucial for children to develop both related and subsequent necessary math skills. Students require fluency in basic math facts in order to successfully understand and perform more complicated math problems. Research has shown that students demonstrating math skill deficits are likely to have limited cognitive capacity to devote to higher math tasks, and also suffer from math-related anxiety, a lack of engagement, and limited vocational and career opportunities (Delli Sante et al., 2001; Gersten & Chard, 1999; Parkhurst et al., 2010; Poncy et al., 2007; Riconscente, 2013). During the COVID-19 pandemic, all U.S. public schools, approximately 124,000 schools, shut down their buildings in some capacity by March 26^{th}, 2020 (Ballotpedia, 2020). The majority of these schools continue to provide remote-learning instruction to students. Examining the effects of time spent on learning, academic losses over summer vacation, absenteeism, and home-schooling outcomes, students' academic progress is jeopardized (Garcia & Weiss, 2020). However, empirically-based research for delivery of math fact fluency interventions remotely is narrow provided the lack of previous need on such a massive scale. With the unknown timeline of when educational practices will resume in person, and the need for individualized student intervention, it is important to demonstrate the effectiveness of established math fact fluency interventions in a remote setting. Using an alternating treatments design, the current study compared the effectiveness of an *adapted* remote-delivery version of Taped Problems Intervention (VTPI) with the traditional methodology of TPI, provided in a virtual environment. Both interventions were delivered via one-on-one video conference. Effectiveness was measured by graphing the participants' DCPM and calculating percentage of nonoverlapping data between the two intervention conditions. Participants were assessed with 2-minute math fact assessment probes following the delivery of each intervention. After the intervention phase was complete, participants completed acceptability questionnaires for both VTPI and TPI conditions. Results indicated multiplication fact fluency gains for all participants, regardless of baseline performance level. The VTPI procedures yielded greater DCPM gains than traditional TPI procedures delivered remotely for four of the five participants. The TPI procedures increased DCPM, but to a lesser degree. Of the four participants for whom VPTI led to greater DCPM scores, PND ranged from 60% to 100%. Follow-up phase data showed that VTPI was more effective in maintaining or leading to continued gains in the maintenance phase than was TPI. Generalization effects were revealed across both intervention conditions as well as the control condition, but results were inconclusive in distinguishing which intervention led to more pronounced generalization effects. Results indicated that participants endorsed higher acceptability ratings for VTPI procedures compared to TPI procedures. Discussion focused on implications for providing academic interventions in virtual learning environments, the importance of direct instruction of multiplication fact fluency, as well as future considerations for researchers.

DEDICATION

This dissertation is dedicated to my mother, Mary, for being the most inspirational person in my life. Mom, you have demonstrated the ultimate example of perseverance and strength. By having you as a role model, I know it is possible to overcome and conquer any obstacle life may throw my way. Thank you for continuously encouraging me to pursue my dreams and for giving all of the opportunities in life to succeed. This dissertation is a tribute to the sacrifices you have made for our family.

I would also like to dedicate this dissertation to my partner, Jordan, for going on this journey with me. Thank you for believing in me during the times that I did not believe in myself, always pushing me to achieve my goals, and making sure that I was cared for during the busy days and nights. This path might not have been smooth, but your love and support was unwavering.

ACKNOWLEDGEMENT

First, I would like to acknowledge and thank my advisor and committee chair, Dr. Elizabeth McCallum, for the guidance and support throughout my graduate career. Thank you for assisting me in the process of changing my dissertation topic rapidly after the barriers brought on by the global pandemic. Also, thank you for being patient with me, for making yourself available to meet/talk without hesitation, and for inspiring me to enhance my research skills. I would also like to thank my other committee members, Dr. McGoey and Dr. Schmitt. Dr. McGoey, thank you for going out of your way to offer me support with writing and motivating me to push forward. Dr. Schmitt, thank you for your guidance with my research topic and challenging me to improve throughout the process. Without any of you, I would not have been able to finish my dissertation and I will be forever grateful.

I would like to thank Dr. Elizabeth Pask and Dr. Larry Sutton for transcending the role of supervisor into professional mentorship that I will cherish forever. Thank you for helping me with strengthening my clinical, research, and professional abilities.

I must also acknowledge and thank Dr. Kaylee Amend for volunteering her time to help throughout the data collection process of this research study.

Acknowledgement is also owed to my family and friends. Without the love and support from all of you, I would not have had the strength it took to overcome the challenges throughout my graduate career. Thank you for always believing in me.

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CHAPTER I

Introduction

Math fact fluency is one of the fundamental components to successful math achievement. The International Association for the Evaluation of Educational Achievement (IEA), a global group of national research institutions, governmental research agencies, scholars, and analysts, steers the Trends in International Mathematics and Science Study (TIMSS). The TIMSS is a study conducted every four years to compare the trends of mathematics and science achievement scores for fourth and eighth grades students across a total of 64 countries worldwide. According to the most recent TIMSS results in 2019, mathematics scores for fourth-grade U.S. students were ranked 15th among 64 participating education systems and eighth-grade U.S. students' scores were ranked 11th among 46 education systems (Mullis et al., 2020). Biannually, the National Center for Educational Statistics (NCES) in the U.S. Department of Education releases results of the National Achievement of Educational Progress (NAEP) assessment in the form of the Nation's Report card. In the Nation's Report card from 2019, it was reported that 41% of fourth-grade and 34% of eighth-grade students performed at or above the Proficient level in mathematics. Students performing at the Proficient level demonstrate grade-level competence in the subject matter, whereas students performing at the Basic level demonstrate a need for extra support to meet grade-level content and students in the Advanced level demonstrate a superior ability. This performance represented a 1% increase for fourth-grade students and no change for eighth-grade students from the previous Nation's Report Card in 2017. Accordingly, in the 2019 Nation's Report Card, 59% of fourth-grade and 66% of eighth-grade students were described as requiring extra practice or intervention to order to meet the benchmark for their grade levels. Overall, data suggest there is an immense need for effective interventions to increase mathematics skills at a national level in the United States.

A math fact is the term used to define one-digit addition and multiplication problems and their subtraction and division counterparts (Poncy et al., 2010). Math fact fluency can be defined as the ability to recall the answers to basic math facts automatically. The National Council of Teachers of Mathematics (NCTM) indicate that students who cannot easily recall the answers to basic math facts struggle with solving more complicated math problems, such as algebra or long division. Also, students who struggle with math fact fluency may experience math-related anxiety, receive fewer opportunities to respond, and have limited cognitive abilities when performing complex math problems (Parkhurst et al. 2010; Poncy et al., 2007, 2010).

Researchers have established a number of effective interventions to increase students' math fact fluency as measured by digits correct per minute (DCPM). Of these interventions, some of the most empirically-supported are Cover-Copy-Compare (CCC), Taped Problems Intervention (TPI), Detect-Practice-Repair (DPR), and Incremental Rehearsal (IR; Musti-Rao & Plati, 2015; Poncy et al., 2010; Poncy et al., 2012). These interventions have been supported for use individually and at a class-wide level to increase math fact fluency (Poncy et al., 2012; Skinner & McCallum, 2012). However, to date, these interventions have not been delivered remotely.

Significance of the Problem

Math fact fluency skills are critical for children to develop both related and subsequent necessary math skills. Students require fluency in basic math facts in order to successfully understand and perform more complicated math problems. Research has shown that students demonstrating math skill deficits are likely to have limited cognitive capacity to perform more advanced math tasks, and also suffer from math-related anxiety, a lack of engagement, and limited vocational and career opportunities (Delli Sante et al., 2001; Gersten & Chard, 1999; Parkhurst et al., 2010; Poncy et al., 2007; Riconscente, 2013).

The NCTM reported that students struggling with math facts often experience difficulty in solving more complicated math problems. Automatic recall of math facts it thought to "free up" mental resources, or improve the cognitive capacity needed to complete complex mathematics operations that require more attention and working memory (Gersten & Chard, 1999; Parkhurst et al., 2010). Additionally, students who struggle with recalling math facts may experience increased anxiety related to math class (Parkhurst et al., 2010; Poncy et al., 2007). This math-related anxiety may prevent students from volunteering to participate in math tasks, thus affecting their opportunities to respond and skill development (Poncy et al., 2007, 2010). Furthermore, students with low confidence in their mathematics ability may lack the motivation to participate in math class (Riconscente, 2013). Without the necessary engagement to initiate and complete math tasks, students often suffer from lower mathematics performance. Finally, deficits in mathematics performance may limit vocational or career opportunities (Delli Sante et al., 2001). Consequently, improving math fact fluency will provide students with a foundation of math skills and the confidence needed to improve their performance in a variety of domains.

Theoretical Basis for the Study

The behaviorist learning theory underlies the evidence-base for effective math fact fluency intervention development. Behaviorism, or the behavioral approach to mathematics intervention, requires explicit instruction with an emphasis upon accurate responding (Haring & Eaton, 1978). Behaviorism components found in conventional interventions for math fact fluency include: opportunities to respond (OTR), error-correction, immediate feedback, reinforcement, and self-monitoring.

Student engagement is created by providing numerous opportunities for students to respond to math facts (Grafman & Cates, 2010). Automaticity to recall math facts may increase when students are given opportunities to practice those math skills with speed and accuracy (i.e., fluency; Skinner, Pappas, & Davis, 2005). Behaviorism focuses on opportunities to actively, accurately, and academically (AAA) respond to stimuli in the environment (Bliss et al., 2010). Additionally, engagement in math tasks is only effective if students are provided with the correct responses to math problems (Grafman & Cates, 2010). An error-correction component built in to the intervention is important to increase students' accurate responding and response rates (Bliss et al., 2010). The use of immediate feedback provides students with the correct response whether or not their response was correct or incorrect. In the instance of when the student provides a correct response, this immediate feedback may serve as reinforcement for students (Poncy et al., 2010). This positive reinforcement of math fact knowledge will promote student motivation and persistence on math tasks. Lastly, the self-monitoring is important for students to increase their math fact fluency. Students observe their own behaviors (or responses) and evaluate their own performance (Bishop et al., 2015). With this component, students self-correct and provide themselves with immediate feedback, which promotes self-efficacy and AAA responding.

Relevant Literature

Several evidence-based interventions are rooted in behavioral learning theory and have been found to be effective in increasing math fact fluency in students. Some of these interventions include: Cover-Copy-Compare (CCC), Taped Problems Intervention (TPI), Detect-Practice-Repair (DPR), and incremental rehearsal (IR). Researchers have demonstrated the use of these interventions individually and class-wide, as well as for students from diverse backgrounds and disability categories, such as ADHD, Autism Spectrum Disorder, Emotional Disturbance, ID/DD, and Learning Disabilities (Joseph et al., 2012; Lee & Tingstrom, 1994; Poncy & Skinner, 2011; Skinner & McCallum, 2012).

While research has supported the use of the aforementioned interventions, the COVID-19 pandemic abruptly interrupted educational practices worldwide. By March 25, 2020, all U.S. public schools, approximately 124,000 schools, shut down their buildings to varying degrees, many with no plans of reopening for the 2019-2020 school year (Ballotpedia, 2020). Conversely, in 2017-2018, approximately 19,000 public schools offered classes or curriculum entirely online (NCES, 2020). Without appropriate trainings, tools, or knowledge of remote learning strategies, educators were forced to adapt and provide remote instruction and interventions to their students.

To date, one study has been conducted to measure the effects of an adapted remote-delivery of an academic intervention, specifically the Taped Problems Intervention procedure (McCallum et al. 2022). This study adapted the evidenced-based TPI procedures into a completely remote delivery of the intervention targeting subtraction fact fluency, designated as the Virtual Adaptation of Taped Problems Intervention (VTPI). The VTPI procedures eliminated the written response requirement of TPI procedures and asked participants to provide verbal responses to the math fact problems after they were presented on audio/visual screen/share presentations. This study yielded positive gains for three elementary students which supports the notion that math fact fluency interventions can be successfully adapted for use in a virtual setting.

Given the immediacy of the recent school closures that came without educator preparedness, one can expect there to be consequences to the education students are receiving during this unprecedented time. Currently researchers are studying previous literature regarding time spent on learning, academic losses over summer vacation, absenteeism, and home-schooling outcomes in order to predict future potential educational consequences of the pandemic school shutdowns (Garcia & Weiss, 2020). The emerging evidence suggests that students in the U.S. are more at-risk for deficits in academic achievement in the near future than they were prior to the pandemic. This finding, combined with the already present need to improve the math skills of students with math fact fluency deficits points to an urgent need for safe and effective interventions. The time to develop evidence-based math fact fluency intervention that can be delivered remotely has hastily arrived.

The purpose of the current study is to compare the effectiveness of the adapted remote-delivery version of the Taped Problems Intervention (VTPI) with the traditional methodology of TPI, which is an evidence-based in-person math fact fluency intervention. With the growing need for remote-delivery of math interventions due to the uncertainty given the COVID-19 pandemic, it is important to demonstrate the effectiveness of remote-delivery of a newly established intervention that focuses on math fact fluency. This area of research is within its infancy stage with one published research study exploring math fact interventions in the remote setting. Consequently, the purpose of the current research study is to compare the effectiveness of VTPI procedures created by McCallum et al. (2022) with the traditional TPI procedures delivered remotely, in increasing math fact fluency in students in order to add to the emerging literature base.

Research Questions and Hypotheses

Research Question 1: Will VTPI increase DCPM of students struggling with multiplication math fact fluency?

a) Hypothesis 1: It is hypothesized that VTPI will increase DCPM of the participants.

Research Question 2: Will traditional TPI delivered remotely increase DCPM of students struggling with multiplication math fact fluency?

b) Hypothesis 2: It is hypothesized that traditional TPI delivered remotely will increase DCPM of the participants.

Research Question 3: Which intervention (i.e. VTPI or traditional TPI delivered remotely) will result in greater DCPM gains?

c) Hypothesis 3: It is hypothesized that VTPI will result in greater DCPM gains than traditional TPI delivered remotely.

Research Question 4: Will participants rate VTPI as highly acceptable?

d) Hypothesis 4: It is hypothesized that participants will rate VTPI as highly acceptable.

Research Question 5: Will participants rate traditional TPI delivered remotely as highly acceptable?

e) Hypothesis 5: It is hypothesized that participants will rate traditional TPI delivered remotely as highly acceptable.

CHAPTER II

Literature Review

Background/History

The International Association for the Evaluation of Educational Achievement (IEA) is a global group of national research institutions, governmental research agencies, scholars, and analysts that work together to conduct research in order to improve the education system worldwide. The IEA leads the Trends in International Mathematics and Science Study (TIMSS), which is a quadrennial study that compares the trends of mathematics and sciences achievement measurements for fourth and eighth grade students across a total of 64 countries worldwide. In 2019, mathematics scores for fourth-grade U.S. students were ranked 15th among 64 participating countries and eighth-grade U.S. students' scores were ranked 11th among 46 education systems (Mullis et al., 2020).

Every other year, the National Center for Educational Statistics (NCES) in the U.S. Department of Education releases results of the National Achievement of Educational Progress (NAEP) assessment in the form of the Nation's Report Card. The NAEP is a nationwide measure of student subject matter achievement using a common metric. Students performing at or above the Proficient level on NAEP assessments demonstrate adequate academic performance and competency over grade level subject matter. In 2019, approximately 149,500 fourth-grade and 147,400 eighth-grade students took the NAEP assessment in mathematics electronically for the second time in the assessment's history. Previous assessments were taken with paper and pencil, while students since 2017 have been administered the mathematics assessment on tablet computers supplied by the NAEP. Forty-one percent of fourth-grade and 34% of eighth-grade students performed at or above the Proficient level in mathematics. Correspondingly, students performing at the Basic level have developed partial mastery of prerequisite knowledge and skills and students at the Advanced level have exhibited superior performance. These findings represent a 1% increase for fourth-grade students and no change from the previous measure in 2017 for eighth-grade students. The findings suggest that 59% of fourth-grade and 66% of eighth-grade students require extra practice or intervention to succeed in mathematics in the United States.

Reading and Math Wars

Controversy over educational practices is not a new development. As far back as 100 years ago, debate over reading education has been occurring (Kim, 2008). The argument over whether to use phonics or whole word language to teach reading began a political debate. This conflict, also known as the Reading Wars, gained momentum in the 1980s (Pearson, 2004). Similar to the debate of the Reading Wars, the widespread use and distribution of mathematics textbooks in the 1990s sparked the era referred to as the Math Wars (Klein, 2003). Critics argued that U.S. textbooks lacked basic math skills and content (Klein, 2003). This “war” was portrayed by journalists as a disagreement between individuals who wanted to teach basic math skills versus those who favored teaching a more conceptual understanding of mathematics (Klein, 2003).

However, it is inaccurate to presume that the Math Wars only began in the 1990s. Dating back to the early 1900s, the topic of math education sparked debates amongst educators, politicians, and decision-makers. The National Education Association’s Commission on the Reorganization of Secondary Education (NEACRSE) committee, which was missing representation of mathematicians, released a report that lessened the importance of high school mathematics in 1915. According to Klein (2003), the report stated that mathematics in high school should be taught only to a select few and only taught if it presented value, which created debate from mathematicians.

The National Council of Teachers of Mathematics (NCTM) was formed in 1920 to promote the values and interests of the educational world by conducting studies and adjustments from teachers, rather than reformers (Klein, 2003). However, progressivism, a child-centered teaching approach that focused on the interests of children, became popular in the 1930s (Thompson, 2001), analogous to the teaching of reading through the whole language approach. This approach places an emphasis on the meaning of the text through a literature-rich environment (Connor, Morrison, & Katch, 2004; Reyhner, 2008). The theory behind teaching reading using whole language is to create a natural learning process through the combination of speaking, listening, reading, and writing in a less structured approach (Reyhner, 2008).

By the 1940s, however, the progressive educational techniques for teaching of mathematics were scrutinized by the army. Many army recruits reportedly did not have arithmetic skills needed for the basic bookkeeping and gunnery required by the army (Klein, 2003; Schoenfeld, 2004). As a result, the formation of a new movement, the Life Adjustment Movement, was created to develop a program to teach 60% of the estimated public-school students skills needed for everyday life (Klein, 2003). Math courses in this program included the topics of taxation, budgeting, insurance, buying, and other important life skills.

A new era emerged in the 1950s and 1960s as “New Math” was introduced. This small movement was responsible for disseminating a report with curriculum recommendations to prepare students for college mathematics (Davison & Mitchell, 2008; Klein, 2003; Schmittau, 2004). This era relied heavily on utilizing evidenced-based decision-making through research review. In the 1970s, the National Science Foundation (NSF) attempted to redirect mathematics back to focusing on the basics, while progressivism also made a return during this time (Klein, 2003; Schoenfeld, 2004).

The decline of math and science education gained recognition in the early 1980s when a presidential report targeted the low enrollment in advanced science and math course as well as the lowered expectations (Klein, 2003). This report initiated the U.S. Secretary of Education to act by releasing *A Nation at Risk*, an educational reform report, addressing the issues in education that were a result of the Open Education Movement, the importance of assessment, teacher training, and textbooks content (Epstein & Miller, 2011; Klein, 2003). In 1986, the NCTM established the Commission on the Standards for School Mathematics (Schoenfeld, 2004). These standards reverted to previously-held progressive education views, which used the term of "constructivism," focused on discovery learning and learning at one's own pace (Epstein & Miller, 2011; Klein, 2003).

In 1991, grants were designated to encourage state education agencies to align mathematics standards with NCTM Standards (Klein, 2003). These efforts resulted in compliance to create consistent standards at the state level. Despite teacher and principal support of the standards, they failed to teach procedures for addition, subtraction, multiplication, and division problems, and opposed the "back to basics" approach (Epstein & Miller, 2011; Jacobs et al., 2006; Klein, 2003). Consequently, this setback sparked the Math Wars of the 1990s (Epstein & Miller, 2011).

In 2006, President Bush appointed the National Mathematics Advisory Panel (NMAP) to reinstate instruction in math facts, fractions, and algebra into elementary, middle, and high school math curricula (Hechinger, 2008). The development of the NMAP was similar to the development of the National Reading Panel (NRP), which was formed in 1997 by the US Congress to "synthesize the best research on the effectiveness of different approaches to teaching reading" (Kim, 2008, p. 101). The NRP gathered evidence demonstrating that explicit, code-based instructional approach develops stronger reading skills in students than those approaches with meaning-based instruction (Connor, Morrison, & Katch, 2004).

The NRP released a comprehensive report in 2000 stating that teaching of "phonemic awareness, phonics, and guided oral reading fluency improved children's ability to read words, to read connected text with speed and accuracy, and to comprehend text" (Kim, 2008, p. 103). However, the use of this approach to teaching should not be used as a single curriculum. The NRP supported the use of a balanced curriculum of phonics related instruction with other instruction which may include both meaning-based and code-based instruction (Conor, Morrison, & Katch, 2004; Kim, 2008). Current textbook publishers provide curriculum to teachers for a "balanced approach" to teaching to encompass the interests of students (Reyhner, 2008).

In 2008, the National Mathematics Advisory Panel (NMAP) was given the task of reviewing research on the instructional practices that impact parents, teachers, and educators of mathematics. These findings addressed the main topics of curricular content, learning processes, teachers and teacher education, instructional practices, instructional materials, assessment, research policies and mechanisms (NMAP Final Report, 2008).

This included the clarification of concepts and learning objectives, development of classroom assessments, and adopted research policies and mechanisms. Consequently, the NMAP played a role in making recommendations of criteria for students to master at each grade level regardless of teaching approach in order to call a truce and put an end to the Math Wars (Epstein & Miller, 2011).

Comparable to the NRP's report, the NMAP Final Report produced standards at a governmental level that put to rest much of the previous debate within mathematics education. The report remained neutral on the conflicting teaching methods but provided evidence-based results that were disseminated as recommendations for educators, researchers, and mathematicians to continue to improve educational techniques and practices of mathematics courses (Epstein & Miller, 2011; NMAP Final Report, 2008).

Importance of Math Fact Fluency

Math fact is the term used to define one-digit addition and multiplication problems and their subtraction and division counterpart problems (Poncy et al., 2010). Math fact fluency can be defined as the ability to recall the answers to basic math facts automatically. The NCTM stated that students who cannot easily recall the answers to basic math facts struggle with more complicated math problems, such as algebra or long division. Employers in the 1980s filed complaints about the costs to teaching entry level workers basic math skills (Klein, 2003). Political leaders were driven by these complaints and the low standing of U.S. students when compared to students from foreign countries, to act towards implementing academic reform to stress the importance of building basic math fact fluency (Klein, 2003). Indeed, research has shown that students demonstrating basic math skill deficits are likely to have limited vocational and career opportunities (Delli Sante et al., 2001).

Math fact fluency is also important from a cognitive processing model standpoint (Gersten & Chard, 1999). When students are fluent with math facts, they have more cognitive capacity to attend to more difficult mathematics tasks that require more attention and use of their working memory (Gersten & Chard, 1999; Parkhurst et al., 2010). Working memory is where information is entered, maintained, and mentally manipulated consciously, which requires attention and concentration (Baddeley, 1983). Students fluent in math facts will require less strain on their working memory when completing more difficult math tasks (Parkhurst et al., 2010). The theory that individuals have a limited cognitive capacity derives from cognitive processing learning theories (Gersten & Chard, 1999).

Students who demonstrate math fact fluency may have lower math-related anxiety, considering that it requires less of an effort to arrive at math solutions (Parkhurst et al. 2010; Poncy et al., 2007). Math anxiety has a predictive relationship with math performance if general test anxiety is statistically controlled (Foley et al., 2017). Math anxiety is specific to math and not related to other anxiety in other academic subject areas, as evidenced by greater brain activity in areas associated with threat detection and pain in students with high math anxiety (Foley et al., 2017; Lyons & Beilock, 2012). Researchers have hypothesized that math anxiety uses up the cognitive resources, such as executive function and working memory, necessary for learning math facts, thus resulting in limited cognitive capacity, as previously discussed (Ashcraft & Kirk, 2001; Lyons & Beilock, 2011, 2012; Maloney & Beilock, 2012; Park et al., 2014; Young et al., 2012).

Students with poor math fact fluency may experience anxiety in math classes and may be unwilling to participate in math tasks, thus reducing their opportunities to respond (fewer learning opportunities; Poncy et al., 2007, 2010). If students are unwilling to respond, they are less likely to progress in their skill development (Poncy et al., 2007). For students to increase in their math skills, they must be actively engaged in the learning process (Bliss et al., 2010; Christle & Schuster, 2003). Students who know they are going to fail, due to lack of engagement, may experience and demonstrate negative reactions and behaviors in math class (Skinner et al., 2005).

Lastly, motivation is another factor that influences students' mathematics performance, which may impact their engagement. Students with low confidence in their own ability may be less motivated to complete mathematics tasks (Riconscente, 2013). Moreover, children are more likely to engage with material that they understand, which may develop into a long-term interest (Hidi & Renninger, 2006; Riconscente, 2010). Improving students' knowledge in mathematics will yield more positive attitudes towards the material, thus affecting student engagement in math over a longer period of time (Riconscente, 2013).

Components of Math Fact Fluency Interventions

Effective interventions for math fact fluency consist of components rooted in behaviorism. Poncy et al. (2010) provided support for behavioral methods of intervention and instruction in increasing rates of math fact learning. The study found that Cover, Copy, and Compare (CCC, an intervention founded on behavioral learning principles) produced an immediate and sustained increase of subtraction fact fluency in students when compared to Facts That Last (FTL, an intervention founded on constructivist learning principles). The FTL intervention yielded results similar to the control condition in which students did not receive intervention (Poncy et al., 2010). Behaviorism or the behavioral approach to mathematics intervention, requires explicit instruction with an emphasis on accurate responding (Haring & Eaton, 1978). Indeed, the NMAP Final Report (2008) yielded positive results of explicit instruction for students with learning disabilities and other low performing students. Students are provided repeated practice, more opportunities for accurate responding, immediate feedback, and goal setting to increase their speed and accuracy of responses (Musti-Rao & Plati, 2015; Poncy et al., 2010; Shapiro, 201).

Opportunities to Respond. Creating opportunities for students to respond to math facts is necessary for students to practice and build their knowledge. Increasing student responding to increase student engagement is important within a behavioral approach (Grafman & Cates, 2010). This component applied to mathematics intervention can be seen in the focus on opportunities to actively, accurately, and academically (AAA) respond (Bliss et al., 2010). By increasing the opportunities to respond, the accuracy of responses increases as well (Skinner et al., 1997). However, performance will only increase if students are practicing accurate responses (Skinner et al., 1997). Providing adequate practice for students will also increase students' fluency of accurate responses (Parkhurst et al., 2010; Skinner et al., 1997).

Immediate Feedback. Simple engagement will not promote learning if the engagement consists of inaccurate responding, thus, underscoring the importance of immediate feedback on learning (Grafman, & Cates, 2010). Once the skills are acquired, students are to practice to completion the tasks with speed and accuracy. Students may exhibit “can’t do” or “won’t do” behaviors when presented with math problems. To differentiate, “can’t do” behaviors occur when a student does not have the materials necessary to complete a task, understand the assignment, have enough time to respond, and/or the prerequisite skills to respond correctly, while “won’t do” behaviors are a choice (Skinner et al., 2005). “When students respond correctly, this immediate feedback presumably serves as positive reinforcement, increasing the likelihood of future correct responses” (Poncy et al., 2010, p. 919).

Error Correction. In order for students to learn new concepts, they must be learning and studying accurate material. Authors of previous studies have implemented an error correction component of intervention (Poncy et al., 2007). By having students correct errors in their responding, an intervention promotes accurate responding, an increase in accurate response rates, and the likelihood that the last response provided will be correct (Bliss et al., 2010).

Reinforcement. B.F. Skinner’s behaviorist views of reinforcement explain the success of AAA. For example, positive reinforcement strengthens a behavior by providing a reward following that behavior (McLeod, 2015). Students experience continuous reinforcement during math fact interventions after receiving the immediate feedback, thus promoting students’ persistence throughout the task.

Self-monitoring. Another behaviorist component important for learning is self-monitoring. Self-monitoring is described as a student’s observation of one’s own specific behavior, recording and evaluating that behavior regarding performance (Bishop et al., 2015). Mathematics interventions include this component in the form of self-correction and immediate feedback for the student to promote their own active accurate academic responding. Benefits of self-monitoring interventions include being self-managed by students, fewer resources required, teaching students independence, less teacher involvement, the opportunity for self-pacing, and the promotion of motivation (Joseph et al., 2012; Skinner et al., 1997).

Self-managed interventions allow for students to be responsible for their own learning, thus promoting independent work at their own rate (Skinner et al., 1997). Students can aim their learning at different skills that require more attention. The independence gained by students relieves teacher involvement needed for intervention. Teachers can attend to a classroom of students engaging in independent intervention tasks targeting each student's academic need as well as provide students with increased opportunities to respond (Grafman & Cates, 2009; Skinner et al., 1997).

Self-monitored interventions may also increase students' motivation (Skinner et al., 1997). Students may develop an internal locus of control for their learning, rather than the external rewards and benefits to learning produced by teachers. Such internal motivation may result in a student's gained independence for their own learning. Lastly, self-monitored interventions may be more enjoyable for students which would appeal to teachers and students alike (Grafman & Cates, 2009).

Evidence based interventions for math facts fluency

There are several evidence-based interventions that have been found to be effective in increasing a student's math fact fluency, such as Taped Problems Intervention (TPI), Cover-Copy-Compare (CCC), Detect-Practice-Repair (DPR), and incremental rehearsal (IR). Researchers have compared the interventions in order to determine the rates of increasing math fact fluency of students (Poncy et al., 2007, 2012).

Researchers have also found support for the use of these interventions on both an individual and class-wide level (Lee & Tingstrom, 1994; Skinner & McCallum, 2012; Poncy & Skinner, 2011). Researchers have established the measure of digits correct per minute (DCPM or DCM) as a reliable and sensitive measure of students' math fact fluency (Musti-Rao & Plati, 2015).

Taped Problems Intervention. The Taped Problems Intervention (TPI) is an evidence-based intervention that is effective in increasing student digits correct per minute (DCPM) (McCallum et al., 2004, 2006; Poncy et al., 2007). This intervention requires students to listen to recordings of math fact problems, followed by delays for students to write their answers, and then the correct answers are provided by the recording (Bliss et al., 2010). Students are encouraged to write their answers down quickly, before the recording provides them.

Poncy et al. (2007) compared Taped Problems Intervention (TPI) with the traditional cover, copy, compare (CCC) intervention. Both interventions were effective in increasing student math facts fluency; however, when compared to CCC, TPI resulted in higher effectiveness due to the decrease of time needed for implementation. The Taped Problems Intervention has been demonstrated to be effective in previous studies by taking about 30% less time than CCC intervention sessions (Poncy et al., 2012).

McCallum et al. (2004) implemented TPI with progressive time delay procedures. The initial response time students were provided was 1-second. This response time was increased progressively as each problem was presented during the session, and then it was reduced. This procedure resulted in increases of division fact fluency that were maintained. In another study, McCallum et al. (2006) varied the time delay procedures at a class-wide level of implementation when presenting students with multiplication facts. The results yielded increases of multiplication fact fluency that were maintained. These researchers also implemented an assessment probe immediately following TPI to assess the immediate effects of the intervention and provide students with an additional opportunity to respond. The immediate assessment results indicated an immediate increase in DCPM with an upward trend in subsequent TPI sessions.

Bliss et al. (2010) expanded upon the McCallum et al. (2006) study to determine whether additional post assessment of TPI would increase fluency. Participants included three boys and three girls from a fifth-grade class using an alternating treatments design (TPI and additional immediate assessment). Bliss et al. (2010) found positive support for TPI as an effective intervention to increase DCPM. However, regarding the additional immediate assessment (AIA) as a component to increase DCPM, the students presented variable results. The AIA boosted DCPM in two students, showed no effect on three students, and appeared to hinder fluency on one student.

A meta-analysis examined the effectiveness of TPI across effect sizes, the maintenance of TPI, the single-case design standards met, and potential moderator variables (Kleinert et al., 2017). Kleinert et al. (2017) compared parametric and nonparametric effect sizes amongst TPI studies, which resulted in positive effects for TPI producing math computation fluency. Analyses were conducted to determine the maintenance effect of TPI as well. Results of case- or study-level effect sizes yielded moderate to very large effects, suggesting that TPI has a maintained effect on computation fluency over time (Kleinert et al., 2017). Klenert et al. (2017) analyzed single-case design standards according to What Works Clearinghouse recommendations and were measured through Kratochwill et al. (2013) guidelines of *Met*, *Met with Reservations*, or *Did Not Meet* evidence standards. Of the studies examined, three *Met*, nine *Met with Reservations*, and zero *Did Not Meet* WWC evidence standards. Kleinert et al. (2017) noted that only two research groups evaluated TPI and more research of comparing TPI to other interventions is needed. Lastly, potential moderation variables were explored through the analysis of intervention target skills, delivery method, and study design (Kleinert et al., 2017). Results indicated moderate to very large effect sizes for targeted addition and non-addition skills, class-wide and individual delivery methods, and across multiple baseline, alternating treatments, and multiple-probe designs.

Another meta-analysis study by Aspiranti et al. (2018) examined the components of TPI in order to determine which were most influential in increasing math fact fluency. Analysis of the study validated the positive effects of TPI on math fact fluency. The overall effect size of TPI presented a weak effect (Tau-U = 0.62), with effect sizes ranging from 0.31 to 1.00 across studies (Aspiranti et al., 2018). However, the effect of TPI persisted through the maintenance phase of studies. The specific components of time and reinforcement were found to be significant in producing higher effects for TPI. The component of positive reinforcement created higher performance gains when compared to students that received TPI without any rewards (Aspiranti et al., 2018). Each student that engaged in TPI was also exposed to increased opportunities to respond, immediate feedback, and error correction which suggest that these are essential components to TPI as a successful intervention for increased math fact fluency.

Cover-Copy-Compare. Cover-copy-compare (CCC) is an established academic intervention that has been effective in increasing math fact fluency (Grafman & Cates, 2010; Poncy et al., 2007, 2010, 2012; Stading et al., 1996). This procedure requires students to look at a math fact problem and its correct answer, cover the problem, write the problem and answer, and then check for accuracy. If the student wrote the problem and answer correctly, the student moves on to the next problem. If the response is incorrect, the student must write the problem with the correct answer multiple times before moving on.

Behaviorist components of CCC include immediate feedback, reinforcement, error correction, and repeated practice with increased opportunities to respond. Students are provided with immediate feedback during CCC when they check their responses with the model. This immediate feedback and error correction ensure that students are not practicing incorrect responses (Skinner & Smith, 1992). Students are positively reinforced when they correctly respond during the immediate feedback (Poncy et al., 2010). Lastly, students are given repeated stimulus-response trials throughout the CCC intervention session (Poncy et al., 2010). The exposure to the stimulus-response trials provides students who struggle with additional practice, as they are required to write the correct problem and answer before moving on to the next problem, which increases their opportunities to respond.

When implemented as a class-wide intervention, CCC has been effective in increasing DCPM (Lee & Tingstrom, 1994; Poncy & Skinner, 2011; Skinner & McCallum, 2012). As stated above, Poncy et al. (2010) compared the effectiveness of CCC, a behaviorist approach, with FTL, a constructivism based approach, using an alternating treatments design as class-wide interventions. Comparing the two theoretically distinct interventions of CCC and FTL provided support for the behaviorist approach (Poncy et al., 2010). The study resulted in immediate and sustained subtraction fact fluency for students receiving the CCC intervention. In the CCC approach, students were presented with accurate models, high opportunities to respond, and immediate feedback (Poncy et al., 2010).

Morton and Gadke (2017) compared the effectiveness of CCC with a variation of cover-copy-compare (MCCC), both with students diagnosed with an Autism Spectrum Disorder. The MCCC intervention involved an additional step beyond traditional CCC. Students initially covered the math problem and answer presented, then wrote the problem and answer. Next, they uncovered the problem and answer to compare them to what problem and answer they had written. Students moved on if their answer was correct or completed the problem again if their answer was incorrect (Morton & Gadke, 2017). The study did not result in a significant difference between the interventions, however, both interventions were effective in increasing students' DCPM (Morton & Gadke, 2017).

Joseph et al. (2012) examined the effectiveness of CCC across types of participants, settings, designs, and dependent measures, as well as academic outcomes. Analyses included 184 participants across 12 studies of math skills; 167 participants were without disabilities, nine were diagnosed with an Emotional Disturbance, five were diagnosed with a Specific Learning Disability, two were diagnosed with ADHD, and one was diagnosed with MR/DD. The studies examined accuracy, fluency, maintenance, and social validity (Joseph et al., 2012). CCC yielded improved math performance for all students, without or with disabilities. Also, results were more effective when CCC was coupled with other evidence-based interventions (Joseph et al., 2012).

Detect-Practice-Repair. Detect-Practice-Repair (DPR) has been effective in increasing math fact fluency in subtraction, multiplication, and division when presented to students in small groups and at the class-wide level (Musti-Rao & Plati, 2015). The first phase of the three-phase intervention approach is *Detect*. Students must respond to a set of math facts that are administered at a fixed interval (Poncy et al., 2006). After the problems are presented, students transition to the practice phase. In the *Practice* phase, students identify the problems they answered incorrectly or left blank. Then, they practice those problems using the CCC technique (Musti-Rao & Plati, 2015). Lastly, students enter the *Repair* phase of the intervention. Students are administered a timed assessment of all the math problems from the first phase as well as additional problems not previously presented. After this, students score their own assessments and graph their performance (Musti-Rao & Plati, 2015).

Poncy et al. (2006) explored the effects of DPR on subtraction fluency of 14 students. The students were assessed on digits correct per 2 minutes (DCP2M). After six weeks of receiving the class wide DPR intervention, students produced significant increases of digits correct per 2 minutes, increasing from an average of 21.7 DCP2M to 41.0 DCP2M (Poncy et al., 2006). This study produced results for the use of DPR as a class-wide intervention to increase math fact fluency in students.

Musti-Rao and Plati (2015) compared the use of DPR with an iPad intervention, in which both interventions resulted in the increase of multiplication fact fluency in students. The Math Drills app, available in the iTunes App store for $1.99, was used for the iPad intervention in the study. An individual profile was created for each student on the Math Drills app. Student profiles were created with a set of 12 math facts customassigned for each student. Trials were set to 20 problems for each phase of the app: review, practice, and test which provided students with 60 opportunities to respond per use. The Math Drills app provided immediate feedback to incorrect responses, only allowing students to move on after providing a correct response (Musti-Rao & Plati, 2015). The iPad intervention yielded higher increases from baseline to intervention DCPM than the DPR condition (Musti-Rao & Plati, 2015).

Incremental Rehearsal. Incremental rehearsal (IR) refers to the method of presenting flash cards of known math facts and unknown math facts (Burns, 2005). This intervention technique increases retention of new math facts in students. This intervention is a drill and repeat task that presents each math fact individually (Codding et al., 2010). Through IR, math facts are presented at a known to unknown ratio of 90% to 10% and increased gradually (Burns, 2005). This method is repeated until the unknown math fact cards are learned through repeated practice. Students are provided with more opportunities to respond with IR than other drill tasks (Burns, 2005).

Burns (2005) implemented IR to three students with identified Learning Disabilities (LD) in mathematics computation. This study resulted in a positive trend for each student in increasing mathematics computation skills. Codding and colleagues (2010) replicated the Burns (2005) study; using DCPM and percent of digits correct on targeted problems. Target problems were probed prior to each treatment session. Results indicated that fluency was maintained, and skills were generalized to subskill mastery, fraction, and word problems.

Burns et al. (2016) expanded upon the previous work with IR to increase math fact fluency by pairing the intervention with the individual student's acquisition rate.

Acquisition rate is defined as the amount of information an individual can rehearse and later recall during one intervention session (Burns et al., 2016). They discovered that IR was an effective intervention as students retained 75% of the math facts. Researchers found it to be more effective in stopping the intervention after the student had met their acquisition rate than to continue with further math facts.

Intervention Acceptability

Intervention or treatment acceptability was first introduced under the scope of social validity. The construct of social validity was introduced to provide evidence to society in regard to applied behavior analysis interventions on three levels: social significance of the goal, social appropriateness of the procedures, and social importance of the effects (Wolf, 1978). Wolf's article influenced a number of researchers to develop a standard for treatment acceptability measures. The Treatment Evaluation Inventory (TEI; Kazdin, 1980) and the Intervention Rating Profile (IRP; Witt & Martens, 1983) were among the first measures developed to measure the acceptability of interventions.

The CIRP was chosen as the measure for participants' acceptability of the remote interventions for the current study. A study conducted by Riconscente (2013) produced results of student acceptability of educational iPad apps as a way to practice skills. The CIRP has been used extensively as a measure of students' acceptability of interventions (Turco & Elliot, 1985; Waas & Anderson, 1991). The CIRP is a modification of the IRP to target the feedback of students. It is a 7-item questionnaire using a 6-point Likert-type scale to measure the fairness and effectiveness of an intervention using a 5th grade reading level (Wilczynski, 2017).

Technology-Based Learning

Technology-based learning can include the use of interactive whiteboards, computers, laptops, iPads/tablets, and mobile phones. In 1999, most teachers reported having at least one computer in their classroom with over half having access to the internet (NCES, 2000). Less than a decade later, it was estimated that 100% of public-school classrooms had one or more computers in their classrooms with internet access, per the Educational Technology in U.S. Public Schools: Fall 2008 report (Gray et al., 2010). Of those computers in the classroom setting, it was also reported that 91% of them were used for instructional purposes (Gray et al., 2010). By 2018, the accessibility of technology had grown within the homes of U.S. citizens, with reportedly 94% of 3- to 18-year-olds having access to the internet in at home (NCES, 2019).

Technology provides students, teachers, and parents with resources at their fingertips that were not previously available. Ling (2016) tested 8th grade students using a desktop computer, an iPad, and an iPad with an attached keyboard. The student participants reported preferring the iPad or desktop computer. Neither assessment modality resulted in significant score differences, thus suggesting no disadvantage or advantage to using a desktop computer or iPad for assessments (Ling, 2016). Despite the lack of advantage noted, students in the present study enjoyed the use of technology, making the use of technology appealing to students.

Shift in Education Practices During Pandemic

On February 27th, 2020, the first school in the United States shut down due to the COVID-19 pandemic after an employee's relative tested positive for the novel coronavirus (Decker et al., 2020). Bothell High School in Washington state was the first of many to close their doors to students as the virus reached across the borders of the U.S.

As cases of COVID-19 begin to rise, the shift to distance learning became more prevalent across the nation. On March 5th, 2020, Northshore school district in Washington state was the first to shift the entire student body to distance learning for what they anticipated would be 14 days (Decker,et al., 2020).

Next, Ohio became the first state in the U.S. to close public schools statewide in a precautionary move to reduce the potential spread of the coronavirus. Fifteen other states followed suit on March 13th, 2020, after President Donald Trump declared the coronavirus pandemic a national public health emergency. By March 16th, 2020, nearly 27 states and territories had closed their school buildings for face-to-face instruction (Decker et al., 2020). Nearly all U.S. public schools were closed by March 25, 2020, with plans of remaining closed through the remainder of the 2019-2020 school year (Ballotpedia, 2020).

In order to provide education to students, teachers and districts abruptly transitioned to remote learning practices, despite their overwhelming unfamiliarity with the platform. According to the National Center for Education Statistics within the U.S. Department of Education (NCES, 2020), 21% of all public schools and 13% of all private schools offered any courses entirely online during the 2017-2018 school year. Astonishingly, the number of public schools that offered entirely online learning increased from 19,000 to at least 124,000 following the onset of the COVID-19 pandemic. Educators were forced to become experts in technology at the drop of a hat once schools were closed for the remainder of the school year with a return to face-to-face instruction undetermined.

Garcia and Weiss (2020) explored the educational consequences caused by the shift to remote learning for students of all ages and abilities. Primarily, academic losses during the pandemic have been attributed to the decrease in time spent on learning. Previous research on summer learning losses, absenteeism, and home-schooling indicate correlations between learning time and poor academic performance (Garcia & Weiss, 2020). Based on this prior literature, the lack of teacher training and expertise in online education, as well as the ongoing stressors impacting students, families, and teachers, academic growth for students is at at-risk for all students.

In order to meet students' academic needs during the pandemic, remote learning must provide opportunities for individual student needs. Research has not explored the use of remote delivery of academic interventions. Given the unknown timeline of when schools will be permitted to return to full time, in person instruction again, along with the possible effects the pandemic is having on student academic growth, it is essential to begin to explore the effectiveness of remote academic interventions. Specifically, interventions in the area of math fact fluency are important to investigate in the remote setting due to the possible long-term effects that students may experience if they continue to struggle with math fact fluency. There are a number of highly effective, evidence-based math fact fluency interventions that could easily be delivered in a remote environment. These interventions require examination to determine and compare their effectiveness when delivered remotely.

In response to the restrictions on visitors within school buildings during the COVID-19 pandemic, McCallum et al. (2022) conducted a study to measure the effects of an adapted remote-delivery version of the Taped Problems Intervention procedure. The

Virtual Adaptation of Taped Problems Intervention (VTPI) was implemented to increase subtraction fact fluency for three elementary students. The VTPI procedures were delivered absolutely remotely by eliminating the written response requirement of TPI procedures and asked participants to provide verbal responses to the math fact problems after they were presented on audio/visual screen/share presentations. Both visual and quantitative analyses determined that VTPI procedures were effective in increasing math fact fluency for the three participants. The findings of this study indicate that math fact fluency intervention can be successfully adapted for use in a virtual setting.

Summary

Students struggling with math fact fluency may experience long-term negative effects, such as problems with more complicated math problems, limited cognitive capacities to perform tasks, math-related anxiety, limited vocational or career opportunities, and low engagement in mathematics instruction. Traditional math fact fluency interventions (e.g., CCC, TPI, DPR, IR) have been effective for increasing math fact fluency skills by increasing opportunities to respond, providing immediate feedback, promoting error-correction, delivering reinforcement, and applying self-monitoring techniques. Despite the evidence base supporting these interventions, they have never been delivered in a remote setting, which has become ever more essential given the COVID-19 pandemic. The purpose of the current study is to compare the effectiveness of the *adapted* remote-delivery version of the Taped Problems Intervention (VTPI) with the traditional methodology of TPI, which is an evidence-based in-person math fact fluency intervention.

CHAPTER III

Method

Participants

Participants included five students from a local approved private school in the Pittsburgh, PA area. After obtaining necessary Institutional Review Board (IRB) permission, initial contact for the study was made via email or phone call through ongoing professional relationships of the researchers with local school personnel. Participants were recommended by teachers to researchers as students who were struggling in the area of math fact fluency, specifically multiplication fact fluency. Parents and guardians of potential participants were contacted via phone call informing them of the opportunity for their child to participate in this study. Interested parents and guardians were provided with a combined informed consent/parent permission form approved by the university institutional review board. A combined form was created because, in addition to parents/guardians being asked to grant permission for their children to participate in the study, they were also asked to conduct some minor duties themselves, namely to facilitate their children's remote meetings and return math fact probes to researchers. Parent/guardian involvement in the study characterized them as participants as well as their children, thus informed consent was necessary.

All participants were provided with Individual Education Programs (IEP) for full-time emotional support as students identified with an emotional disturbance as their primary disability category. Participants included four boys and one girl, ranging in age from 10 to 13 years, with a mean age of 11.8. Participants included one fourth-grade, one fifth-grade, one sixth-grade, and two seventh-grade students. Regarding racial background, the participants included two White students, one Biracial student, and two Black students. Pseudonyms were used in place of the participants' real names.

Tommy was 12-years-old at the time of the study and is identified as a White male. A records review indicated that his full-scale IQ was found to be 99 on the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV). Tommy has received his education in a partial hospitalization placement since April 2019, which provides therapeutic classroom support, psychiatric services, and weekly individual, group, and family therapy services. Records indicated mental health diagnoses of Disruptive Mood Dysregulation Disorder, Attention-Deficit/Hyperactivity Disorder, Combined Presentation, and Unspecified Depressive Disorder.

Brittany was 13-years-old at the time of the study and is identified as a White female. A review of her educational records revealed that Brittany's full-scale IQ was found to be 121 on the Wechsler Intelligence Scale for Children, Fifth Edition (WISC-V). She has been placed in her current alternative education setting since fourth grade, initially placed for acute partial hospitalization services. Brittany was transitioned to partial hospitalization services during her fourth-grade school year. After making treatment progress, she was transitioned to therapeutic support services within the school environment for her fifth-grade year, which is her current educational placement. Brittany is currently diagnosed with Unspecified Bipolar Disorder, for which she receives medication management and other therapeutic services within the community.

Anthony was 13-years-old at the time of the study and is identified as a Black male. His full-scale IQ score was found to be 70 on the Wechsler Intelligence Scale for Children, Fifth Edition (WISC-V). However, Anthony's performance across measures of cognitive functioning varied from Extremely Low to Average ability, which may indicate that his full-scale IQ might not be an accurate measure of his overall cognitive functioning. He currently receives full-time emotional support services with outpatient services for therapy and medication management. Anthony's IEP included a math-related goal as well as provision of discrete steps for math problems in the specially designed instruction section. His records reported diagnoses of Posttraumatic Stress Disorder, Reactive Attachment Disorder, and Attention-Deficit/Hyperactivity Disorder, Combined Presentation. Anthony has been receiving full-time emotional support since his fifth-grade school year following his discharge from a residential treatment facility. At the time of this intervention delivery, Anthony participated in remote-learning due to transportation issues with his home school district.

Nick was 10-years-old at the time of the study and is identified as a Black male. A records review indicated that his measured cognitive abilities were not valid due to variability across measures on the Differential Ability Scales-2. His demonstrated scores for specific skills ranged from the Extremely Low range to the Average range with an overall General Cognitive Ability score of 79, which lies in the Low range. Nick was initially placed in the acute hospitalization program in the fall of his first-grade year. Following his discharge from acute hospitalization program services, Nick transitioned to the partial hospitalization classroom to continue to receive therapeutic classroom support, psychiatric services, and weekly individual, group, and family therapy services. He was discharged from the partial hospitalization program in the spring of 2020 and received therapeutic supports within the outpatient setting. At the time of the intervention delivery, Nick was re-referred to the partial hospitalization program due to treatment regression.

Records indicated mental health diagnoses of Posttraumatic Stress Disorder, Unspecified Anxiety Disorder, Attention-Deficit/Hyperactivity Disorder, Combined Presentation, and Unspecified Depressive Disorder in which he is identified as a student with an Emotional Disturbance and Other Health Impairment.

Noah was 11-years-old at the time of the study and identified as a Biracial male on records. His overall full-scale IQ was reported to be 88 on the Kaufman Brief Intelligence Test, Second Edition (KBIT-2). He was placed in full-time emotional support through an approved private school since February of his kindergarten school year when he was referred to the acute partial hospitalization program. Noah transitioned to the partial hospitalization program and received services in this classroom until February 2021 when he transitioned to outpatient services. Noah's records indicated current mental health diagnoses of Unspecified Anxiety Disorder, Attention-Deficit/Hyperactivity Disorder, Combined Presentation, and Tourette's Disorder.

Setting

Due to the COVID-19 pandemic, the current study was implemented remotely via the Zoom platform in a one-on-one video conference format. Participants received the intervention in the school and/or home settings, dependent on their individual education plan. Anthony and Noah were receiving solely remote-instruction, while the other three participants were provided a hybrid/in-person/remote delivery schedule. Of this hybrid intervention delivery, Tommy and Brittany participated remotely for one of the five intervention sessions due to a scheduled remote-learning day for the entire school. Nick participated remotely during three of five intervention sessions due to his individual hybrid schedule that was developed to transition him to the brick-and-mortar education setting slowly.

When in the home setting, participants were provided the aid of their parent/guardian in facilitating the use of a home computer in a quiet location in the home, as well as returning the data collection materials (i.e., math fact probes) electronically. When in the school setting, participants were transitioned to a separate room from their classroom that was quiet and free from distraction. They used their individual laptop computer to access the Zoom meeting to join the session. The remote intervention sessions were delivered by the researcher or a school psychology pre-doctoral intern who was trained to use the administration procedures of the interventions. Both VTPI and TPI interventions were provided for approximately 6 minutes each per session (Poncy et al., 2010).

Measures

Assessment Probes. Student's DCPM was measured using assessment probes developed for this study similar to those used in Musti-Rao and Plati (2015). Problem sets created by Poncy & Duhon (2017) were adapted into assessment probes. The assessment probes consisted of three congruent problems sets that were developed with twelve 1-digit by 1-digit math facts (factors 2-9). The level of difficulty was counterbalanced across the three sets by factors (see Appendix A). For example, factor six appears in each problem set two times. The problem sets were repeated ten times randomly for each probe, consisting of 120 problems total. Two assessment probes were created using this method of randomization for each problem set. Students were given two minutes to complete the assessment probe.

Generalization Probes. Generalization probes were created to measure participants' ability to generalize their knowledge to non-intervention multiplication facts. The generalization problem sets were created by providing the inverse multiplication facts presented on the assessment probes, such as the multiplication fact 5 x 7 = 35 was transposed to 7 x 5 = 35 in the generalization problem set. For more details on the generalization problem set, see Appendix A.

Research Design

In the current study, an alternating treatments design was utilized to compare and evaluate the effects of VTPI and traditional TPI delivered remotely (VTPI and TPI). The alternating treatments design has been used in other studies of math fact fluency (Bliss et al., 2010; Musti-Rao & Plati, 2015; Poncy et al., 2010). Alternating treatment designs allow a researcher to determine intervention effectiveness and to compare multiple interventions with one another directly. Also, presenting stable baseline data prior to intervention is not required for this design, thus allowing the researcher to quickly determine the effectiveness of the interventions both independently and comparatively (Richards et al., 2014).

Participants were assessed with probes prior to the delivery of each intervention. Problem set A was used for the VTPI condition, problem set B was used for the TPI condition, and problem set C was assigned to a third problem set for a control condition. For example, students were probed for all three conditions, then provided one intervention followed by the other intervention. The order of probes and intervention delivery was counterbalanced across sessions. Counterbalancing the administration of assessment probes and implementation of interventions is important to avoid order or sequencing effects. The assessment probes provided the DCPM data used for the primary dependent variable. This design allowed for the display of treatment effects on student DCPM of math facts as well as internal validity demonstrated using within-subject replications of treatment (Poncy & Skinner, 2011). Secondary problem sets (generalization probes) were used during the maintenance phase to determine whether the students learning generalized to problems not directly intervened upon during the intervention conditions.

Both assessment and intervention procedures were implemented via one-on-one Zoom video conference. Parents/guardians were responsible for providing a room in the home that was free of distractions. Participants that were provided the intervention within the school setting were transitioned to a separate, quiet room with their individual computer (e.g. empty office, conference room, etc.). Both treatments were applied across 5 consecutive sessions, spread over two school weeks, and maintenance and generalization data were collected one week after the final intervention session. The VTPI and TPI procedures were implemented daily with the intervention order selected at random, as well as the order counterbalanced so that one intervention was not delivered first for more than two consecutive days (Musti-Rao & Plati, 2015). Time was held relatively constant for the implementation of VTPI and TPI conditions; each intervention was delivered for approximately six minutes per session, as demonstrated in Poncy et al. (2010). Each procedure encourages students to try to "beat the recording" by providing an answer to each problem before they are presented with the correct answer.

Virtual Adaptation of Taped Problems Intervention. The Virtual Adaptation of Taped Problems Intervention (VTPI) procedures from McCallum et al. (2022)

included an adaptation of the traditional TPI that uses an exclusively virtual format. The effectiveness of the VTPI intervention was measured independently and compared to the traditional TPI procedures during this study. Instead of writing their responses on paper follow-along worksheets, participants verbally or subvocally speak the responses before they are presented on audio/visual screen/share presentations. Participants were presented with a multiplication fact vertically on a light pink screen in black font. The multiplication problem was presented, then the answer was presented without animation effects. Two versions of the VTPI procedures were created with the same problem set presented in two different orders. The presentation of the two VTPI procedures were counterbalanced throughout the sessions by not presenting one version of VTPI more than twice in a row across sessions. Counterbalanced details can be viewed in Table 1.

Taped Problems Intervention. The effectiveness of the traditional TPI procedures was measured independently and compared to the VTPI intervention in this study with both interventions being delivered remotely. The traditional delivery of TPI required participants to listen to an audio-recording of math fact problems with a delay after each problem for participants to write down their answer to the problem on provided follow-along worksheets, then the recording provided the correct answer to the problem (Bliss et al., 2010). Two versions of the TPI procedures were also created similarly to the VTPI procedures. The TPI problem set was presented in two different orders and were counterbalanced throughout the sessions by not presenting one version of TPI more than twice in a row across sessions (see Table 1).

Dependent Variable. The dependent variable measured in the current study was digits correct per minute (DCPM). The scoring procedure developed by Deno and Mirkin

(1977) was used to calculate DCPM. For each assessment probe, participants were timed for two minutes and prompted to complete as many multiplication facts as they could. Each correct digit provided for a multiplication problem completed was calculated towards DCPM. To be scored correct, the correct digit has to be in the correct place. For example, for the problem 5 x 5, if the student responded 27, one digit would be counted correct for the 2 in the tens place. If the student responded 10, the answer would be counted as no digits correct. Unanswered problems and responses given after the allotted time did not count towards DCPM.

Procedures

Baseline Phase. The baseline session occurred over Zoom one-on-one with the researcher and lasted approximately 10 minutes. During the initial session with each participant, the researcher discussed the procedures that would be used during the study and obtained participant assent to participate in the study. Participants were provided with the necessary training to ensure that they were comfortable using the required Zoom features. Additionally, baseline data was collected for each of the three problem sets (control, TPI, and VTPI) during the baseline session. Participants were administered paper-and-pencil math fact probes that were clearly labeled and mailed to parents/guardians prior to the initial session.

Participants were provided the instruction as follows: “We’re going to take a 2-minute math fact probes test. I want you to write your answer to these multiplication problems. Look at each problem carefully before you answer it. When I say ‘BEGIN,’ write your answer to the FIRST problem and work across the page. Then go to the next row. Try to work each problem. If you come to one you really don’t know how to do, put an ‘X’ through it and go to the next one. If you finish the first side, turn it over and continue working and continue onto the next page. Do you have any questions? Begin.” The experimenter used a stopwatch to time for two minutes for each assessment probe and prompted participants when time was up. During the baseline data collection, no feedback was provided to students. After each probe was completed, the researcher asked the student to put it away to give to their parent for later. At the end of each session, the parent texted photos or scanned images using a scanning app to the researcher. The Zoom call ended when the researcher confirmed receipt of images.

Intervention Phase. After the first baseline assessment probes were administered, participants were introduced to the intervention phase. Each intervention session occurred over Zoom one-on-one with the researcher and lasted approximately 20 minutes. Participants were involved in five total intervention sessions and were provided 6 minutes to engage in each math fact intervention (VTPI and TPI).

Each intervention phase session began with participants being administered the three assessment probes in random order, with the control problem set being delivered to assess for potential carryover effects. For example, a session might commence with assessment probe set B, followed by assessment probe set A, and then probe set C. See Table 1 for the assessment probe schedule by session of baseline, intervention, and assessment activities.

After assessment probes were administered, participants were delivered either the VTPI or TPI procedures (see Table 1 for details). For VTPI, the researcher administered an adapted version of the evidence-based Taped Problems intervention by screen-share (McCallum et al., 2022). Participants were provided the instruction as follows: “I’m going to be showing you some math problems on your screen and I want you to try to answer the problems out loud before you see and hear the answers."

For TPI, the traditional delivery of TPI procedures were used by share-screen which only provided an audio-recording of the problem set, as well as a follow-along paper worksheet. Participants were provided the following instructions for TPI implementation: "You're going to listen to problems and there will be a little bit of time after you hear each problem for you to write down the answer. Try to write down the correct answer before you hear it. If you write the wrong answer or you don't write anything, go ahead and write the correct answer when you hear in on the recording. Try to stay with recording and don't skip around on the page." Both intervention instructions included the following script: "Remember to pay attention to the (recording or screen), and when you're finished, I'm going to show you something really fun! Ready? Let's get started."

During both interventions, each problem set was presented in random order three times through, for total of 36 problems. After each problem, there was a delay for participants to provide their response to the problem either verbally or written on the follow-along worksheet. During the first presentation of the problem set, participants were provided a two-second delay. Next, the delay was one-second and the last time through, there was no delay after each problem was presented. This pattern of time delays was chosen to allow students more time to respond early on during each intervention session, and then to encourage automatic responding (McCallum et al., 2006). Each procedure encouraged participants to try to "beat the recording" by providing an answer to each problem before they were delivered the correct answer.

Follow-Up Phase. The follow-up phase occurred one week following the final intervention session for each participant in order to collect maintenance and generalization data. During the follow-up phase, probe procedures similar to those conducted during the baseline phase, with the added measurement of the generalization probes for each of the three problem sets, were implemented.

Reinforcement procedure. The current study implemented a positive reinforcement procedure in order to boost participant motivation during the intervention sessions. Each participant was asked about their interests during the baseline session and was provided with a 30 to 60-second video reinforcement based on their interests, similarly McCallum et al. (2022). The video reinforcement was presented via the shared screen by the researcher at the end of each session during the intervention and follow-up phases. Participant interests' ranged from puppies, pranks, and superhero videos. Previous research findings found the use of positive reinforcement strategies encourage persistence throughout a task, specifically foster higher performance gains of students that received the TPI intervention (Aspiranti et al., 2018; McLeod, 2015).

Data Analysis

The purpose of the current study was to compare the effectiveness of an *adapted* remote-delivery version of Taped Problems Intervention (VTPI) with the traditional methodology of TPI, provided in a virtual environment. Both interventions were delivered via Zoom video conference. Effectiveness was measured by visual analysis and calculating percentage of nonoverlapping data between the two intervention conditions. Visual analysis of time-series graphs was used to evaluate the effectiveness of each intervention by comparing the individuals' digits correct per minute (DCPM) within and across baseline, intervention, and follow-up phases, as well as with generalization probes. Findings were also contextualized using the math fact fluency performance ranges identified by Burns et al. (2006; frustrational level: 0 – 23 DCPM, instructional level: 24 –49 DCPM, mastery level: 50 DCPM and higher).

Percentage of Nonoverlapping Data. Percentage of Nonoverlapping Data (PND) was calculated in order to determine which intervention was more effective in increasing DCPM for each participant. The PND was calculated by comparing the first data point of VTPI condition with the first data point of the TPI condition, then comparing the second data point of the VTPI condition with the second data point of the TPI condition, etc.

Interscorer Agreement. Interscorer agreement was collected for 20% of the assessment probes. An independent scorer separately scored the assessment probes to determine agreement on DCPM. Interscorer agreement was calculated by dividing the number of agreements on DCPM by the number of possible agreements and multiplying by 100.

Procedural Integrity. The current study accounted for the procedural integrity of the intervention sessions by providing an integrity checklist for an observer to complete during 20% of the intervention sessions. Procedural integrity checklists were created for both VTPI and TPI conditions. See Appendixes B and C for the full procedural checklists for each intervention phase derived from McCallum et al. (2006).

Student Acceptability. In order to assess the student acceptability of VTPI and TPI, the participants were asked to complete a student acceptability questionnaire. Participants completed an adapted version of the Children's Intervention Rating Profile

(CIRP) for each intervention on the final day of the study. The CIRP consisted of six items measured with a 6-point Likert scale (1- I agree to 6- I do not agree) to assess students' perceptions of VTPI and TPI (see Appendices D and E). The items asked questions about use of the audio recording and worksheet, the use of the audio-recording and presentation, if the procedures were helpful, if they would help other kids, and if the participant liked the intervention. The CIRP has reported internal consistency ranges from 0.75 to 0.89, less than adult measures, however, still falling in the moderate to high range (Carter, 2007). The minor modifications made to the wording of items, such as replacing "the program" with "the audio recording practice," have been utilized in previous research using the CIRP and has not affected the reliability of the measure (Fiala & Sheridan, 2003; McQuillan et al., 1996; Radley et al., 2016).

Research Questions and Hypotheses

Research Question 1: Will VTPI increase DCPM of students struggling with multiplication math fact fluency?

a) Hypothesis 1: It is hypothesized that VTPI will increase DCPM of the participants.

Research Question 2: Will traditional TPI delivered remotely increase DCPM of students struggling with multiplication math fact fluency?

b) Hypothesis 2: It is hypothesized that traditional TPI delivered remotely will increase DCPM of the participants.

Research Question 3: Which intervention (i.e. VTPI or traditional TPI delivered remotely) will result in greater DCPM gains?

c) Hypothesis 3: It is hypothesized that VTPI will result in greater DCPM gains than traditional TPI delivered remotely.

Research Question 4: Will participants rate VTPI as highly acceptable?

d) Hypothesis 4: It is hypothesized that participants will rate VTPI as highly acceptable.

Research Question 5: Will participants rate traditional TPI delivered remotely as highly acceptable?

e) Hypothesis 5: It is hypothesized that participants will rate traditional TPI delivered remotely as highly acceptable.

CHAPTER IV

Results

This study utilized an alternating treatments design to compare and evaluate the effects of traditional TPI with an adapted version of Taped Problems Intervention delivered virtually (VTPI). The participants were exposed to both treatments (TPI and VTPI) during each intervention session in order to determine whether the interventions alone would increase math fact fluency, as well as which of the two interventions would be most effective in increasing math fact fluency skills measured by digits correct per minute (DCPM). In addition, a control condition was included by assessing DCPM of a control problem set of multiplication facts that were not delivered via formal intervention. The control condition was measured each time the dependent variable math probes were administered.

Research Question 1

Will VTPI increase DCPM of students struggling with multiplication math fact fluency?

a) Hypothesis 1: It is hypothesized that VTPI will increase DCPM of the participants.

Baseline measures of DCPM were obtained during session one for all participants on the VTPI problem set. Participants' baseline DCPM ranged from 0 to 38 for the VTPI problem set. On the final session of the VTPI intervention phase (prior to the follow-up phase), the participants' DCPM ranged from 11 to 53.5. Furthermore, visual analysis reveals that VTPI led to an increase in DCPM for each participant when compared to their individual baseline DCPM performance.

Research Question 2

Will traditional TPI delivered remotely increase DCPM of students struggling with multiplication math fact fluency?

b) Hypothesis 2: It is hypothesized that traditional TPI delivered remotely will increase DCPM of the participants.

Baseline measures of DCPM on the TPI problem set were also obtained during session one for all participants. The baseline measure of participants' DCPM from the TPI problem set ranged from 2 to 30.5. On the final session of the intervention phase, participants' DCPM on the TPI problems set ranged from 9 to 58. Visual analysis indicated that TPI led to an increase of DCPM for each participant for multiplication fact fluency when compared to their baseline DCPM performance.

Research Question 3

Which intervention (i.e. VTPI or traditional TPI delivered remotely) will result in greater DCPM gains?

a) Hypothesis 3: It is hypothesized that VTPI will result in greater DCPM gains than traditional TPI delivered remotely.

Tommy, Nick, Anthony, and Noah made greater DCPM gains during VTPI, while Brittany made greater gains during TPI (see Table 2 for individual DCPM averages across conditions and participants). Additionally, when further considering effect size and follow-up phase data, the VTPI procedure was more effective than TPI in increasing DCPM for four of the five participants. However, the extent to which each student met a "mastery" level of performance during the study varied. Using the framework established by Burns et al. (2006; frustrational level: 0 – 23 DCPM, instructional level: 24 –49

DCPM, mastery level: 50 DCPM and higher), Tommy, Nick, Anthony, and Noah's baseline performances across conditions were within the frustrational level, while Brittany's performance across all three conditions were in the instructional level. Nick and Noah's performance maintained within the frustrational level across the intervention and follow-up phases for all conditions.

Tommy's performance remained within the frustrational level throughout the intervention phase for the TPI and control conditions, while his VTPI performance hit the instructional level of performance during one intervention measure (session 4). In the follow-up phase, Tommy's performance on the VTPI problem sets were within the instructional level of functioning while his TPI performance remained in the frustrational level. His control performance stayed in the frustrational level on the maintenance probe while his generalization probe just hit the instructional level of functioning. Overall, Tommy's performance gains were maintained or continued to grow following the cessation of the intervention only for the VTPI condition.

Brittany's performance was the only one within the instructional level during baseline. Her performance during the intervention phase gradually improved across all three conditions, climbing to the mastery level by the last intervention session. However, in the follow-up phase, Brittany's performance hovered between the instructional and mastery levels for the VTPI and control problem sets while her TPI performance maintained within the instructional level. Although Brittany demonstrated slightly higher scores in the TPI condition than the VTPI condition, her mastery level performance was maintained with the VTPI condition.

Anthony's performance throughout the intervention phase was variable. He climbed from the frustrational level to the instruction level on the first intervention session across all problem set conditions. Anthony's performance on the control problem set descended into the frustrational level after the second intervention session and maintained throughout the follow-up phase. Conversely, his performance on the VTPI and TPI conditions hovered within the instructional and frustrational level throughout the intervention phase. He maintained his instructional level of performance across both VTPI and TPI conditions in the follow-up, but did not demonstrate the ability to generalize those skills

Individual DCPM Results

Tommy. Tommy's results are graphed in Figure 1. Visual analysis reveals that Tommy's DCPM performance increased across the study in both VTPI and TPI conditions. While his baseline performance in both intervention conditions was similar (VTPI = 5.5 DCPM; TPI = 5.0 DCPM), he made greater gains in the VTPI condition than in the TPI condition across time (VTPI intervention phase mean = 20.2 DCPM; TPI intervention phase mean = 13.8 DCPM). He continued to make gains in both conditions following the removal of the interventions (VTPI maintenance = 29.0 DCPM; TPI maintenance = 20.0 DCPM) and appeared to generalize his performance gains for both intervention conditions (VTPI generalization = 27.0 DCPM; TPI generalization = 22.0 DCPM).

Tommy's control condition performance remained stable across the study (baseline = 20.5 DCPM; intervention mean = 18.9 DCPM; maintenance = 19.0 DCPM) and his performance generalized (24.5 DCPM). Although Tommy began the study with a higher level of DCPM performance in the control condition (compared to the two intervention conditions), his performance on the control problem set remained relatively stable across the intervention phase while his DCPM performance within the two intervention conditions improved.

Tommy made significant gains on both the VTPI and TPI problem sets during the intervention phase, with VTPI resulting in a greater increase in DCPM. His DCPM performance on the VTPI problem set was consistently higher than his performance on the TPI problem set across the intervention and follow-up phases with no overlap between the VTPI and TPI conditions. Percent of non-overlapping data (PND) was calculated in order to estimate effect size. PNDs are reported in Table 3. Tommy's PND comparing VTPI with TPI was 100%, indicating that VTPI was a very effective treatment procedure when compared to TPI.

Brittany. Brittany's results are graphed in Figure 2. During the intervention phase, Brittany scored similarly across VTPI and control problem sets, and somewhat lower on the TPI problem set. When considering her initial baseline performance was lowest in the TPI condition, she made the greatest relative gains in this condition (VTPI baseline mean = 38.0 DCPM; TPI baseline mean = 30.5 DCPM). Brittany's DCPM performance slightly increased across the study for both VTPI and TPI conditions, as well as the control condition (VTPI intervention phase mean = 48.5 DCPM; TPI intervention phase mean = 48.6 DCPM; control intervention phase mean = 49.0 DCPM). She maintained her DCPM gains across all conditions following the removal of the interventions (VTPI maintenance = 47.5 DCPM; TPI maintenance = 43.5 DCPM; control maintenance = 56.5). Brittany appeared to generalize the gains she made in the VTPI and

TPI conditions (VTPI generalization = 52.5 DCPM; TPI generalization = 41.0 DCPM), but not those in the control condition (40.0 DCPM).

Brittany demonstrated slightly higher scores in the TPI condition than the VTPI condition during four out of five sessions. Despite this, Brittany's DCPM during the follow-up phase was higher in the VTPI condition (47.5 DCPM) than the TPI condition (43.5 DCPM). Percent of non-overlapping data (PND) was calculated in order to estimate effect size (Table 3). Brittany's PND for comparing VTPI with TPI was 80%, indicating a TPI as an effective procedure for Brittany.

Anthony. Anthony's results are demonstrated in Figure 3. His baseline performance across the three conditions was as follows: VTPI = 18.5 DCPM, TPI = 22.5 DCPM, and control = 20.0 DCPM. He made immediate and large DCPM gains in the VTPI condition during the first intervention session, followed by a significant decrease during the second intervention session, and increases during the following two intervention sessions and a decline during the final session. The variability in Anthony's performance during this phase contributed to a mean VTPI intervention phase performance of 26.9 DCPM. In the TPI condition, Anthony's DCPM performance increased during the first session and remained stable and relatively high (but less so than his peak VTPI performance; TPI intervention phase mean = 29.1 DCPM). When comparing his VTPI and TPI performances during the intervention phase, Anthony demonstrated higher VTPI performance than TPI performance on three out of five intervention sessions.

Anthony's DCPM performance during the follow-up phase were similar to his performance during the baseline phase across all conditions, indicating that his performance did not necessarily maintain following the removal of the interventions (24.5 DCPM, 25.5 DCPM, and 14.0 DCPM for VTPI, TPI, and control, respectively). Similarly, with the exception of a slight generalization effect for VTPI (DCPM = 21.0), Anthony's gains did not seem to generalize as his scores on these probes were similar to his baseline scores (TPI generalization DCPM = 23.5; control generalization DCPM = 16.0). Percent of non-overlapping data (PND) was calculated in order to estimate effect size (see Table 3). Anthony's PND for comparing VTPI with TPI was 60%, indicating questionable effectiveness of the VTPI treatment for Anthony.

Nick. Nick's results are demonstrated in Figure 4. Nick's DCPM performance during baseline was slightly higher in VTPI than TPI and the control condition (VTPI = 6.5 DCPM; TPI = 2.0 DCPM, and control = 5.0 DCPM, respectively). His performance was observed to increase during the intervention phase between both VTPI and TPI conditions to a mean of 12.8 and 8.3 DCPM, respectively. He maintained these gains or continued to make gains in these conditions following the removal of the interventions (VTPI maintenance performance = 15.0 DCPM; TPI maintenance performance = 9.5 DCPM), as well as generalized his performance gains for both intervention conditions, as evidenced by high performances on the VTPI and TPI generalization probes (VTPI generalization performance = 15.0 DCPM; TPI generalization performance = 15.5 DCPM). Although Nick's control intervention phase mean performance (12.8 DCPM) was higher than his control baseline data point (5.0 DCPM), his performance on the control problem set remained stable throughout the intervention phase, ranging from 11 to 14.5 DCPM.

Nick consistently scored higher on the VTPI problem set when compared to the TPI problem set during the intervention phase. He demonstrated superior scores on the VTPI problem set on all five sessions, resulting in 100% PND indicating VTPI as a very effective treatment procedure for Nick.

Noah. Noah's results are demonstrated in Figure 5. Noah demonstrated the lowest DCPM performance compared to the other four participants (baseline DCPM performance of 0.0, 2.0, and 1.5 for VTPI, TPI, and control conditions, respectively). Despite this, he made DCPM gains across both VTPI and TPI conditions, as well as the control condition (intervention means = 5.6, 4.4, and 3.8 for VTPI, TPI, and control conditions, respectively). Furthermore, these gains were observed to be continuing to improve after the removal of the interventions during the maintenance phase, particularly for the VTPI condition (maintenance VPTI = 9.0 DCPM; TPI = 5.5 DCPM). Noah also appeared to generalize performance improvements for both intervention conditions following the termination of the interventions (VTPI generalization = 11.0 DCPM; TPI generalization = 6.0 DCPM). Noah's control DCPM performance increased across the study's intervention phase, but to a markedly lesser degree than the two intervention conditions, and his control maintenance and generalization probes decreased. Noah's PND for comparing VTPI with TPI was 80%, indicating VTPI as an effective treatment for increasing DCPM for Noah.

Percentage of Non-Overlapping Data (PND)

Percentage of Non-overlapping Data (PND) was calculated in order to determine which intervention, VTPI or TPI, was more effective in increasing DCPM for each participant. Across the study, on average, VTPI DCPM gains exceeded those of TPI for four of the five participants. Of the four participants for whom VPTI led to greater DCPM gains, PND ranged from 60% to 100% (see Table 3). The PND standard established by Scruggs et al. (1987) was used for interpretation of PND values. This standard determined PND values over 90% to interpret the treatment as very effective, 70% to 89% as effective, 51% to 69% as questionable effectiveness, and below 50% as ineffective treatments (Rakap et al., 2014; Richards et al., 2014).

Two participants, Tommy and Nick, demonstrated five out of five (100%) VTPI data points that exceeded TPI DCPM data points within their intervention phase. Noah exhibited 80% VTPI data points that exceeded his TPI data points. Lastly, Anthony demonstrated 60% VTPI data points that exceeded his TPI data points. Brittany demonstrated four out of five (80%) TPI data points that exceeded her VTPI data points, indicating TPI as the effective treatment procedure for her over VTPI. Please see Table 3 for PND results.

Overall, for four out of five participants, PND scores suggested VTPI to be more effective than TPI, with treatment effects ranging from questionable to very effective. One participant (Brittany) demonstrated higher DCPM performance in TPI than in VTPI (effective treatment results). However, Brittany demonstrated higher DCPM in the VTPI condition during the follow-up phase than she did in TPI. Please see Table 2 for maintenance and generalization data.

Student Acceptability

Research Question 4

Will participants rate VTPI as highly acceptable?

c) Hypothesis 4: It is hypothesized that participants will rate VTPI as highly acceptable.

Participant acceptability data for VTPI was collected following the intervention phase to assess student perceptions of VTPI procedures (see Table 4). Each participant completed an adapted version of the Children's Intervention Rating Profile (CIRP; Witt & Elliott, 1985) that consisted of six items measured with a 6-point Likert scale (1 = *Strongly Agree* to 6 = *Strongly Disagree*).

The CIRP ratings for VTPI indicated four of the five participants liked VTPI procedures for practicing math by endorsing *Strongly Agree* to *Agree* on the item "I liked the way we used audio-recording and presentation for math." These participants also favored VTPI procedures over other ways they practice math. Overall, all five participants supported VTPI procedures for helping them in school, being helpful for other children, and being easy to use.

Research Question 5

Will participants rate traditional TPI delivered remotely as highly acceptable? Hypothesis 5: It is hypothesized that participants will rate traditional TPI delivered remotely as highly acceptable.

Participant acceptability data for TPI was also collected following the intervention phase to assess each participants' perception of TPI procedures (see Table 5). Participants completed an adapted version of the Children's Intervention Rating Profile (CIRP; Witt & Elliott, 1985) that consisted of six items measured with a 6-point Likert scale (1 = *Strongly Agree* to 6 = *Strongly Disagree*).

The CIRP ratings for TPI indicated that three of the five participants liked TPI procedures for practicing math by endorsing *Agree* on the item “I liked the way we used the audio recording for math.” Two participants indicated *Strongly Agree* and two other participants indicated *Agree* for liking the TPI procedures more than other ways they practice math. However, regardless of whether participants enjoyed the TPI procedures, all participants reported that TPI procedures could help other kids and had helped them do better in school. Additionally, all participants reported that TPI procedures were easy to use and two participants reported procedures to also be hard.

CHAPTER V

Discussion

There are various evidence-based interventions that have been effective in increasing math fact fluency in students, including Cover-Copy-Compare (CCC), Taped Problems Intervention (TPI), Detect-Practice-Repair (DPR), and incremental rehearsal (IR). These interventions have demonstrated positive outcomes in increasing math skills when implemented individually or class-wide to students of diverse backgrounds and disability categories (Joseph et al., 2012; Lee & Tingstrom, 1994; Poncy & Skinner, 2011; Skinner & McCallum, 2012). However, until recently, there has not been application of these procedures through a remote learning platform (McCallum et al., 2022). With the COVID-19 pandemic disrupting educational practices and forcing educators to adopt increasing remote learning instructional practices, a demand for empirically-based research on the delivery of math fact fluency interventions remotely has emerged.

The current study utilized an alternating treatments design to compare and evaluate the effects of the remote delivery of the traditional version of the evidence-based math fact fluency intervention Taped Problems Intervention (TPI) and an adapted version of Taped Problems Intervention delivered entirely virtually (VTPI), by evaluating and comparing their effectiveness for increasing multiplication fact fluency in a group of students diagnosed with emotional disturbances attending an Approved Private School. The participants were exposed to both treatments (TPI and VTPI) on each intervention day in order to determine each intervention's independent effects as well as which of the two would be most effective in increasing math fact fluency skills measured by digits correct per minute (DCPM). In addition, a control condition was included by assessing DCPM of a control problem set of multiplication facts that were not delivered via formal intervention. The control condition was measured each time the dependent variable math probes were administered.

Conclusions

The current study revealed further support for VTPI procedures for increasing multiplication fact fluency. Moreover, VTPI procedures yielded greater DCPM gains than traditional TPI procedures delivered remotely for four of the five participants. In terms of VTPI alone, four participants demonstrated performance increases across the study (Tommy, Anthony, Nick, and Noah). Similarly, TPI alone led to fluency increases for four of the five participants across the study (Tommy, Brittany, Nick, and Noah), but to a markedly less degree for some. The current study was the first to adapt traditional TPI procedures for remote delivery.

When comparing the interventions, four participants made greater DCPM gains in the VTPI intervention (Tommy, Anthony, Nick, and Noah), while one participant made greater gains in the TPI intervention (Brittany). Consequently, VTPI procedures were more effective overall in increasing DCPM in this study. Of the four participants for whom VPTI led to greater DCPM scores, PND ranged from 60% to 100% (see Table 3).

Contrarily, intervention data for one participant (Brittany) determined TPI as the more effective intervention for increasing multiplication fact fluency. Brittany demonstrated the highest DCPM across the five participants, which is unsurprising given her measured full-scale IQ within the superior range (FSIQ = 121). At baseline, Brittany was performing well within the instructional level and she reached the mastery level of

50 DCPM (for fifth-grade students) within the follow-up phase (Burns et al., 2006). Brittany's high DCPM baseline performance suggests that a ceiling effect may have interfered with the ability to distinguish treatment effects between the two intervention conditions.

While analyzing follow-up phase data, VTPI was more effective in maintaining or leading to continued gains in the maintenance phase than was TPI. In fact, while Anthony and Brittany maintained their VTPI gains, the other three participants continued to make significant gains following the removal of the VTPI intervention. The same pattern was not seen in TPI. In the TPI condition, two students maintained their DCPM gains (Nick and Noah), one continued to make gains following the removal of the intervention (Tommy), and two students decreased their performance following the removal of the intervention (Brittany and Anthony). Given the upward DCPM trend across all participants, an increased number of intervention sessions might allow participants to reach mastery level. Future research is necessary to determine whether this might be the case.

Another purpose of this study was to measure whether gains made during intervention procedures would generalize to non-intervention math fact problems. Indeed, generalization effects were revealed across both intervention conditions as well as the control condition. However, results were inconclusive regarding the extent to which the two interventions led to more pronounced generalization effects. Previous research has found that with subtraction fact fluency, direct instruction on specific items is necessary in order for learning to occur. For instance, there was no generalization of learning from the math fact 9 – 2 = 7 to 9 – 7 = 2; students seemed to need direct instruction and practice with both items (McCallum et al., 2022). The current results provide at least preliminary evidence that this may not be the case for multiplication fact fluency. This study demonstrated that learning the math fact 5 x 7 = 35 can be generalized to 7 x 5 = 35. Four of the five participants generalized their multiplication fact fluency gains to inverse multiplication facts that were never explicitly taught. This finding has implications for math fact intervention and instruction practice. Future research is needed to determine generalization effects regarding addition and division facts using the TPI and VTPI procedures.

The CIRP ratings for the VTPI and TPI indicated that four of the five participants liked both procedures more than other ways they have practiced math. However, of those four participants, two endorsed a rating of *Strongly Agree* and two endorsed a rating of *Slightly Agree* for TPI procedures on the same item. Four of the five participants endorsed liking the VTPI procedures for math. Of these four participants, two indicated *Strongly Agree* and two indicated *Agree* ratings for the item "I liked the way we used audio-recording and presentation for math." Furthermore, three of these four participants indicated *Agree* for the item "I liked the way we used the audio recording for math" when asked about the TPI procedures.

Overall, four of five participants indicated positive ratings for acceptability of both VTPI and TPI procedures, supporting this researcher's hypotheses. When looking closely at the ratings, results indicated that participants endorsed higher acceptability ratings for VTPI procedures compared to TPI procedures. Additionally, all five participants indicated that both VTPI and TPI procedures were easy to follow, could help other children, and helped them do better in school.

Additionally, the VTPI procedures require less facilitator time and resources for delivery than traditional TPI procedures, even when those TPI procedures are delivered remotely. Students only require a computer, tablet, or device that can access the VTPI presentation to receive the intervention, thus demanding minimal facilitator involvement. However, TPI procedures require facilitator involvement throughout intervention delivery to provide paper-and-pencil materials, begin the audio recording, and monitor students' progress on the follow-along worksheets to ensure students are following along with the recording. Facilitators must supervise students closely when administering TPI procedures to keep them on track, while VTPI naturally keeps students on track and reduces required time and resources by not requiring paper-and-pencil materials. This reduced need for materials and facilitator attention allows for flexibility for educators when implementing VTPI procedures to address students' needs. Educators can address individual student needs while delivering VTPI to the classroom due to the independent nature of VTPI as a self-monitoring intervention.

Another advantage of VTPI is the ability to remotely delivery the intervention to students. Remote interventions have become an urgent need after the COVID-19 pandemic abruptly closed schools in March 2020, but remote interventions are beneficial beyond pandemic-related issues. Educators can reach students that were previously inaccessible, such as students in rural areas, districts with limited resources, and schools with limited interventionists that can provide individual attention.

While both VTPI and TPI procedures offer self-monitoring components, VTPI procedures also offers a self-managing element which gives students responsibility for their own learning. Self-monitored interventions may increase students' motivation and strengthen their internal locus of control for their own learning (Skinner et al., 1997). Since VTPI characteristically requires students to become responsible for their own learning, students are more independent during intervention delivery. This independence and motivation may have contributed to students' increased learning and greater acceptability of the VTPI procedures over TPI procedures.

Study Limitations

Only five students (4 males and 1 female) participated in this study, thus limiting the external validity of the results to other populations. The participants ranged in age from ten-years-old to thirteen-years-old and grades fourth to seventh. Each participant qualified for special education services under the primary category of Emotional Disturbance and received full-time emotional support. The broad spectrum of mental health diagnoses of the participants in the present study may have influenced intervention effectiveness. Each participant presented with unique diagnostic profiles and were within variable stages of their mental health treatment programs. Given the range of presenting behaviors and possible psychotropic medication interactions, participants' performance was incomparable to one another.

Additionally, students who were diagnosed with a specific learning disability in mathematics, had comorbid speech or language impairments, and students with other disability types (i.e., autism, emotional disturbance, etc.) were not included in the study. Due to the participant selection, this was the first time these participants had received individual academic intervention support. Therefore, effectiveness of the interventions may have been either exaggerated or weakened due to the lack of formal intervention for math fact fluency prior to participating in the study. Unknown are the extent to which these interventions would impact different populations of students with other disability categories.

Another limitation of the current study was the inconsistent method of intervention delivery across participants due to constraints related to the COVID-19 pandemic. Two of five participants were delivered the intervention completely in a remote instructional capacity within the home environment, while the other three participants received the intervention via a hybrid/in-person/remote delivery schedule. Students were given flexibility regarding their educational setting at the time of intervention delivery due to the COVID-19 restrictions. Of this hybrid intervention delivery, two participants participated remotely for one of the five intervention sessions due to a scheduled remote-learning day for the entire school. Another participant participated remotely on two of five intervention sessions due to a hybrid schedule that was developed to transition them to the brick-and-mortar education setting slowly. When participants were physically in the school during intervention sessions, they were transitioned to a separate room from their classroom that was quiet and distraction-free. However, when participants were within their home environment, the researcher had less control of environmental factors that could interfere with participants' ability to attend to the task at hand. For example, Tommy's one remote session within the home environment was interrupted by a younger sibling. The researcher worked with Tommy's parent to remove the sibling from the room to free the environment of distractions before beginning the session.

Recommendations for Future Research

The current study was only the second to replicate the adapted version of Taped Problems Intervention (VTPI), as well as the first study to deliver TPI procedures remotely. Future research is necessary to further contribute to the literature base in this area by replicating the VTPI procedures and investigating their effectiveness on a wide range of students of varying ages, disability status, and math fact skills. It is also recommended that future research investigate the use of traditional TPI procedures within a remote capacity.

In the current study, analyses of individual student data suggested that most participants demonstrated an increase in multiplication fact fluency skills, but not to the same degree. It is recommended that future research increase the number of intervention sessions to explore the effectiveness of VTPI procedures in increasing math fact fluency. Additionally, students' skill levels at the start of the intervention varied widely. Future research should investigate the VTPI procedures to determine modifications that may be useful for participants with certain learning problems (e.g. learning disabilities, attention-deficits, intellectual disability) or other impediments that may reduce the effectiveness of common intervention procedures.

Future studies may benefit from comparing results of students with similar baseline measures of DCPM to see if results are the same or different since the present study's participants' abilities were differing from the start. Also, the addition of a reinforcement component to each intervention or intervention session may be explored to see if DCPM results change with extrinsic reinforcement. Lastly, future studies should deliver interventions during different times across the school year to determine if results are affected by the grading period, holidays, and school year fatigue.

Summary

With the COVID-19 pandemic disrupting the educational practices and forcing educators to adapt to remote learning, the demand for empirically-based research on the delivery of math fact fluency interventions remotely has increased. The current study explored the remote delivery of the evidence-based math fact fluency intervention Taped Problems Intervention (TPI) and an adapted version of the intervention (VTPI) delivered via Zoom, by evaluating and comparing their effectiveness for increasing multiplication fact fluency of five middle school students with Emotional Disorders.

Overall, the current study revealed support for VTPI procedures for increasing multiplication fact fluency, moreover VTPI procedures yielded greater DCPM gains than TPI procedures for four out of the five students. Additionally, the current study revealed that DCPM gains could be made when traditional TPI procedures are delivered remotely. Participants unanimously endorsed that the VTPI procedures helped them do better in school and that the procedures could help other kids too. Researchers should continue to replicate the VTPI procedures to expand the literature of math fact fluency interventions that can be delivered remotely. By developing a strong evidence-base to this area of research, educators will have the opportunity to widen their toolkit of academic interventions that can be implemented at times of educational instability.

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Table 1

Schedule for Baseline, Intervention, and Assessment Activities

Session	Activity Schedule
1	Child Assent Probe Order: A-1, B-1, C-1 Introduce interventions VTPI (2) TPI (1)
2	Probe Order: C-2, B-2, A-2 VTPI (1) TPI (2)
3	Probe Order: B-1, A-1, C-1 TPI (1) VTPI (2)
4	Probe Order: B-2, C-1, A-1 VTPI (1) TPI (2)
5	Probe Order: A-2, C-2, B-2 TPI (2) VTPI (1)
6	Probe Order: B-1, A-1, C-2 Student Acceptability Ratings
7 (1 week after session 6)	Probe Order: C-1, A-2, B-1 Generalization Probes: A, B, C

Table 2

Digits Correct Per Minute (DCPM) across Phases and Participants

Participant	Baseline	Intervention Mean	Maintenance	Generalization
Tommy				
VTPI	5.5	20.2	29	27
TPI	5.0	13.8	20	22
Control	20.5	18.9	19	24.5
Brittany				
VTPI	38.0	48.5	47.5	52.5
TPI	30.5	48.6	43.5	41
Control	37.0	49	56.5	40
Anthony				
VTPI	18.5	26.9	24.5	21
TPI	22.5	29.1	25.5	23.5
Control	20.0	20.1	14	16
Nick				
VTPI	6.5	12.8	15	15
TPI	2.0	8.3	9.5	15.5
Control	5.0	12.8	14.5	18
Noah				
VTPI	0.0	5.6	9	11
TPI	2.0	4.4	5.5	6
Control	1.5	3.8	3.5	4.5

Table 3

Percentage of Nonoverlapping Data (PND) by Participant

	Percent of Nonoverlapping Data	More Effective Intervention
Tommy	100%	VTPI
Brittany	80%	TPI
Anthony	60%	VTPI
Noah	80%	VTPI
Nick	100%	VTPI

Note: Suggestions for interpreting PND scores: 90 and above – very effective treatments; 70 to 90 – effective treatments; 50 to 70 – questionable treatments; below 50 – ineffective treatments (Scruggs and Mastropieri, 1998)

Table 4

Student Acceptability Responses for VTPI

	Tommy	Brittany	Anthony	Nick	Noah
1. The audio-recording and presentation practice was easy.	3	2	1	3	2
2. The audio-recording and presentation practice was too hard.	4	6	1	6	3
3. I like this more than other ways I practice math.	6	1	1	1	1
4. The audio-recording and presentation practice could help other kids too.	2	2	1	1	1
5. I liked the way we used audio-recording and presentation for math.	5	1	1	2	2
6. Using audio-recording and presentation practice has helped me do better in school.	3	1	1	1	1

Note: 1=Strongly Agree, 2=Agree, 3=Slightly Agree, 4=Disagree, 5= Slightly Disagree, 6=Strongly Disagree

Table 5

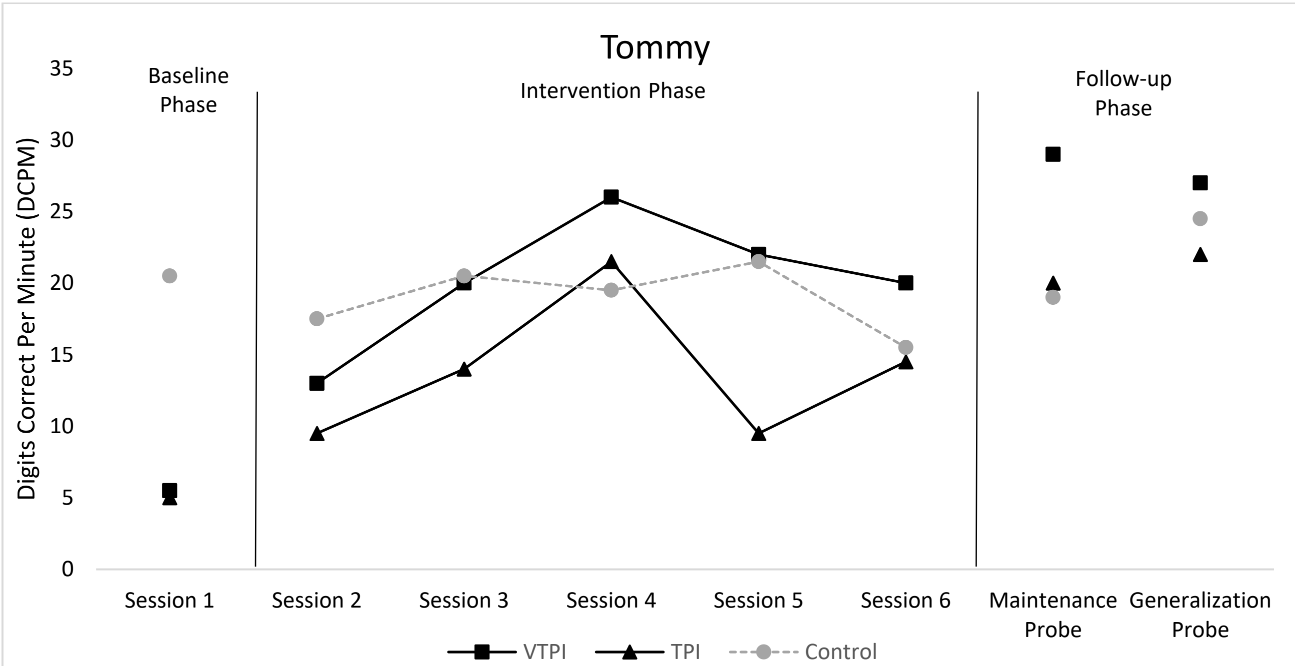
Student Acceptability Responses for TPI

	Tommy	Brittany	Anthony	Nick	Noah
1. The audio recording and worksheet practice was easy.	3	1	1	2	1
2. The audio recording practice was too hard.	4	6	1	5	3
3. I like this more than other ways I practice math.	6	3	1	3	1
4. The audio recording and worksheet practice could help other kids too.	2	2	1	1	3
5. I liked the way we used the audio recording for math.	5	2	2	4	2
6. Using the audio recording practice has helped me do better in school.	2	1	1	2	1

Note: 1=Strongly Agree, 2=Agree, 3=Slightly Agree, 4=Disagree, 5= Slightly Disagree, 6=Strongly Disagree

Figure 1

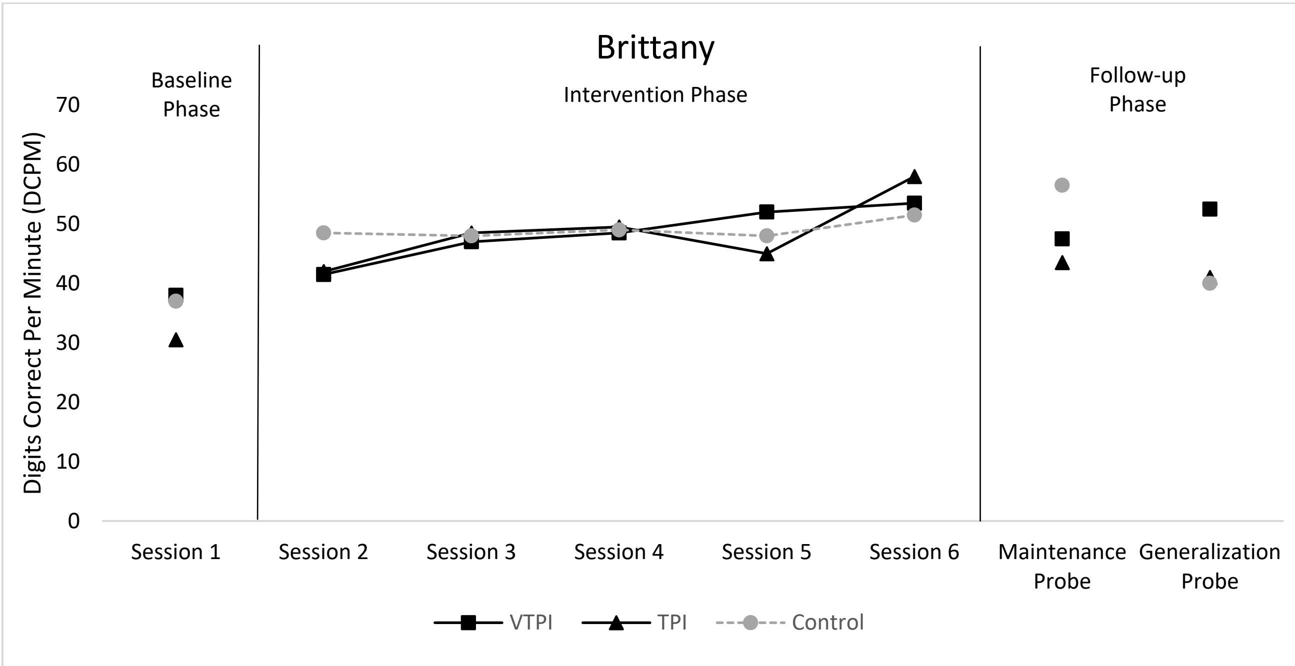
Digits Correct Per Minute (DCPM) across Phases for Tommy



Note. Session 2 took place remotely from Tommy's home.

Figure 2

Digits Correct Per Minute (DCPM) across Phases for Brittany



Note. Session 2 took place remotely from Brittany's home.

Figure 3

Digits Correct Per Minute (DCPM) across Phases for Anthony

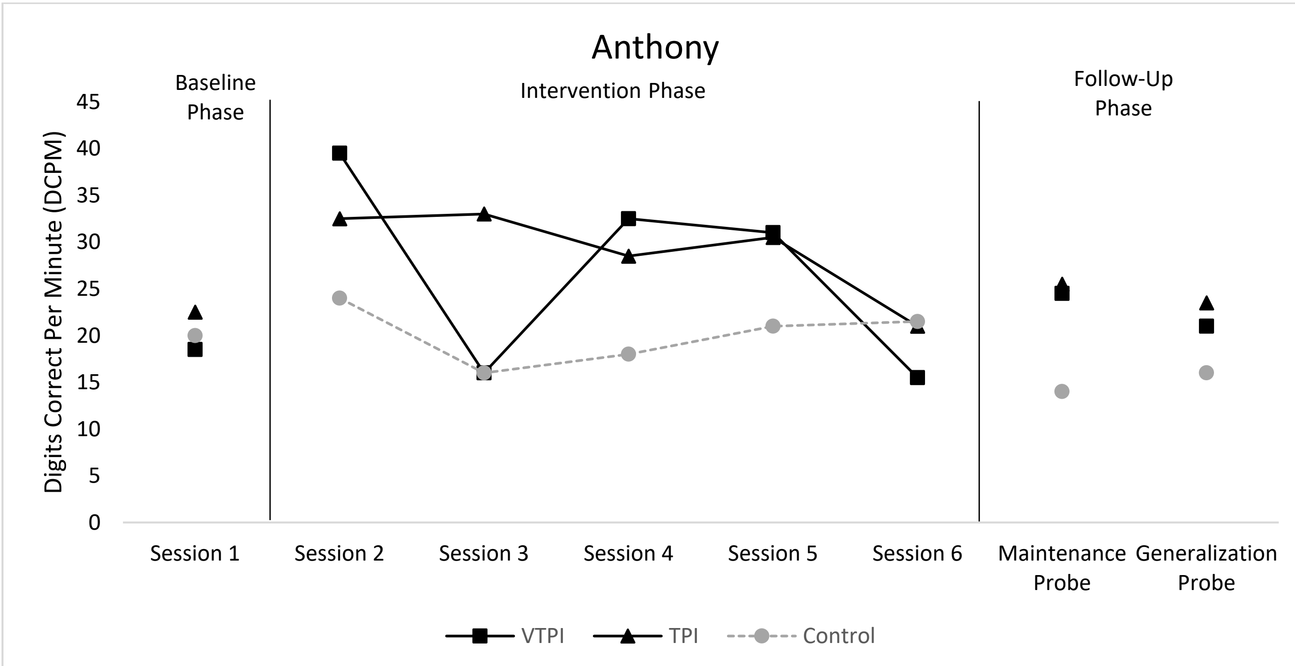
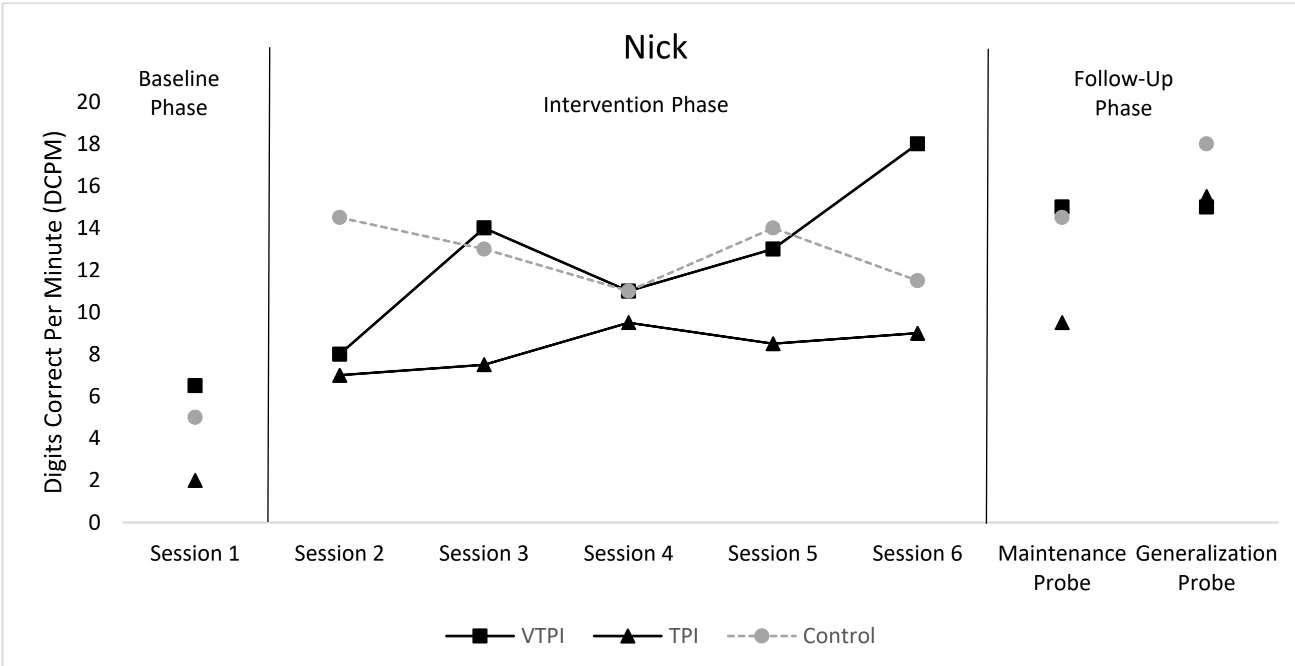


Figure 4

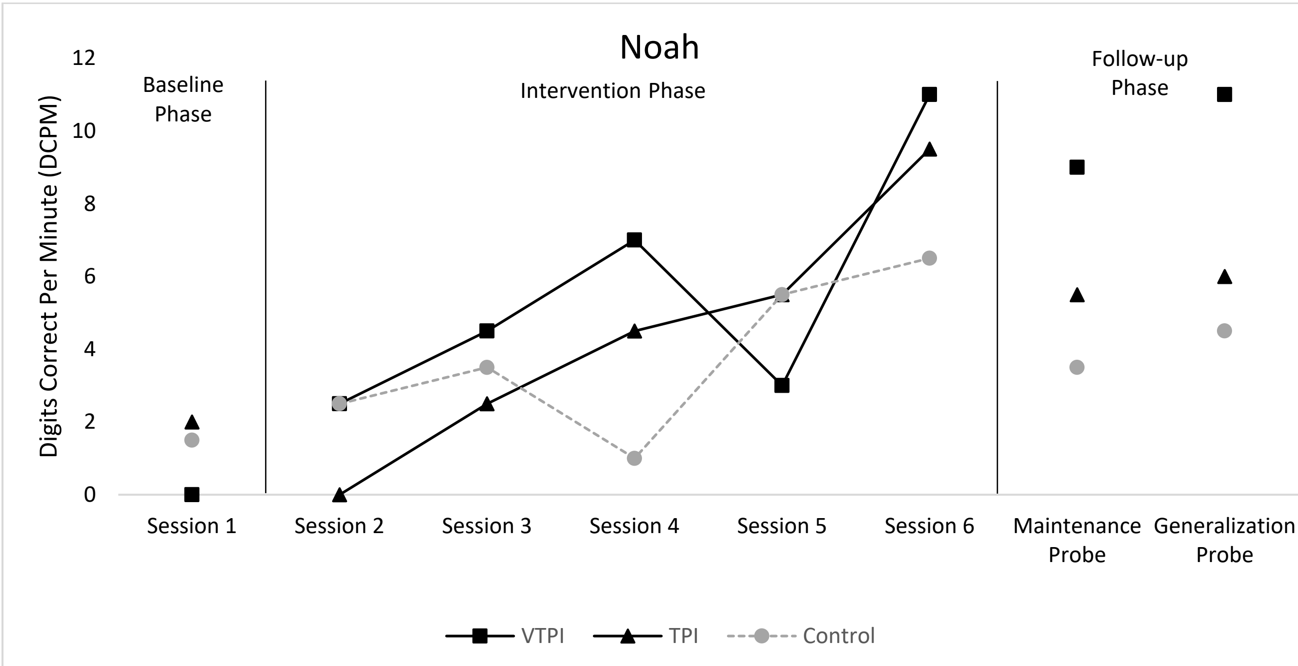
Digits Correct Per Minute (DCPM) across Phases for Nick



Note. Sessions 1, 2, 4, and 7 took place remotely from Nick's home.

Figure 5

Digits Correct Per Minute (DCPM) across Phases for Noah



Appendix A

Problem sets were derived from Poncy & Duhon (2017) and were adapted into three assessment probes. Problem set A was used for the VTPI condition, problem set B was used for the TPI condition, and problem set C was assigned to a third problem set for a control condition. See the table below for specific problem sets by condition.

Table A1

A (VTPI)	**B (TPI)**	**C (control)**
9 x 8	8 x 8	4 x 2
3 x 3	5 x 4	8 x 7
5 x 2	5 x 7	4 x 6
7 x 7	7 x 9	9 x 2
9 x 6	7 x 2	7 x 4
2 x 8	3 x 4	7 x 3
5 x 3	6 x 6	2 x 6
6 x 7	3 x 9	5 x 5
6 x 5	6 x 3	3 x 2
3 x 8	4 x 8	8 x 5
4 x 4	5 x 9	6 x 8
4 x 9	2 x 2	9 x 9

Generalization problem sets were created by transposing the three assessment problem sets. See the table below for three generalization problem sets created.

Table A2

A	B	C
8 x 9	8 x 8	2 x 4
3 x 3	4 x 5	7 x 8
2 x 5	7 x 5	6 x 4
7 x 7	9 x 7	2 x 9
6 x 9	2 x 7	4 x 7
8 x 2	4 x 3	3 x 7
3 x 5	6 x 6	6 x 2
7 x 6	9 x 3	5 x 5
5 x 6	3 x 6	2 x 3
8 x 3	8 x 4	5 x 8
4 x 4	9 x 5	8 x 6
9 x 4	2 x 2	9 x 9

Appendix B

Date: ________________ Session #: _______ Student: ________________________

Session Facilitator: ___________________ Observer: ___________________________

Procedural Integrity Checklist for VTPI Delivery

1. ____ Initiate screen-share and ensure student can hear the sample recording.

2. ____ Read intervention instruction script aloud.

3. ____ Start presentation.

4. ____ Monitor participant's engagement by encouraging them to provide verbal answer for each problem presented.

5. ____ When presentation is finished, praise participant for participation.

6. ____ At end of session, share reinforcement activity with participant.

Appendix C

Date: ________________ Session #: _______ Student: ________________________

Session Facilitator: ___________________ Observer: ___________________________

Procedural Integrity Checklist for TPI Delivery

1. ____ Ensure participant has a pencil and correct Follow-Along sheets.

2. ____ Prompt participant to record name and date on the top of the page.

3. ____ Read intervention instructions script aloud.

4. ____ Initiate screen-share and ensure student can hear the sample recording.

5. ____ Start recording.

6. ____ Monitor participant's engagement in completing TPI Follow-Along sheets.

7. ____ When recording ends, prompt participant to place Follow-Along sheets in provided folder.

8. ____ Positively praise participant for participation.

Appendix D

Adapted Version of the Children's Intervention Rating Profile- VTPI intervention rating

	Strongly Agree	Agree	Slightly Agree	Slightly Disagree	Disagree	Strongly Disagree
1. The audio-recording and presentation practice was easy.	1	2	3	4	5	6
2. The audio-recording and presentation practice was too hard.	1	2	3	4	5	6
3. I like this more than other ways I practice math.	1	2	3	4	5	6
4. The audio-recording and presentation practice could help other kids too.	1	2	3	4	5	6
5. I liked the way we used audio-recording and presentation for math.	1	2	3	4	5	6
6. Using audio-recording and presentation practice has helped me do better in school.	1	2	3	4	5	6

What didn't you like about the audio-recording and presentation practice?

___

___

___

How did you like the math practice using audio-recording and presentation?

___

___

___

Source: Adapted from Witt, J.C. & Elliott, S.N. (1985). Acceptability of classroom intervention strategies. In Kratochwill, T.R. (Ed.), *Advances in School Psychology, Vol. 4*, 251 – 288. Mahwah, NJ: Erlbaum.

Appendix E

Adapted Version of the Children's Intervention Rating Profile- TPI rating

	Strongly Agree	Agree	Slightly Agree	Slightly Disagree	Disagree	Strongly Disagree
1. The audio recording and worksheet practice was easy.	1	2	3	4	5	6
2. The audio recording practice was too hard.	1	2	3	4	5	6
3. I like this more than other ways I practice math.	1	2	3	4	5	6
4. The audio recording and worksheet practice could help other kids too.	1	2	3	4	5	6
5. I liked the way we used the audio recording for math.	1	2	3	4	5	6
6. Using the audio recording practice has helped me do better in school.	1	2	3	4	5	6

What didn't you like about the audio recording and worksheet practice?

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How did you like the math practice using the audio recording and worksheet practice?

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Source: Adapted from Witt, J.C. & Elliott, S.N. (1985). Acceptability of classroom intervention strategies. In Kratochwill, T.R. (Ed.), *Advances in School Psychology, Vol. 4*, 251 – 288. Mahwah, NJ: Erlbaum.