

Action Research Report Proposal: The Effects of a Multisensory Approach to the Mastery of  
Basic Multiplication Facts on Elementary Students with Learning Disabilities

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As students move into their 3<sup>rd</sup> grade year in Palm Beach County schools, they are preparing to take the Florida Standards Assessment (FSA) high-stakes test for the very first time. Their scores will determine if they are retained and for some students, their foundational mathematics deficits make their success almost impossible. Even if students are able to remember the process for mathematical operations, their inability to perform basic computations limits their success. The computation methods of addition and subtraction are introduced as early as preschool while multiplication and division are introduced and tested in the same year (third grade). The FSA test design and blueprint shows that 48% of the assessment is based on the knowledge students can apply in the area of operations, algebraic thinking, and numbers in base ten, which includes computations in multiplication (FSA, 2014). If students are unable to complete multiplication computations then they stand to lose points in the largest reporting category of the FSA test, drastically hindering their ability to pass. Therefore, teachers must be able to enhance foundational deficits with an appropriate intervention program to offer students the ability to be successful in the curriculum and high-stakes testing.

The Palm Beach County curriculum scope and sequence introduces students to multiplication and division in the first trimester of 3<sup>rd</sup> grade. Students begin learning about these computations illustratively, using arrays and creating equal groups in picture form. Very quickly, the curriculum shifts to focus on rote memorization of the facts. For some students, all it takes is practice to learn the times tables. For others, especially those with processing deficits and retention issues, multiplication computation quickly becomes an unachievable task. After the fourteen-day sequence of instruction ends, the students are expected to relate multiplication to

division in the next unit. Students that did not achieve the skill set for computation are now at a deficit for the remaining units that include multiplication as a prerequisite for the learning goal. Not only does this affect their success in the curriculum, it impedes their ability to pass a high-stakes test for the first time that they are taking it.

Based on observations as well as technology-based diagnostic scores, students can solve multiplication problems based on the lower tables but specifically struggle with the upper times tables. Given that the intermediate grades require a strong foundation in these tables, students are struggling with content across this strand, which affects their ability to access the remaining mathematics curriculum. Students need multisensory instruction in mathematics in order to enhance their ability to solve computations in multiplication and division. While it's true that students need to understand the conceptual process of multiplication and division, it is also important that they can perform the operations accurately and quickly in order to problem solve so that they can be successful in the curriculum. According to NCTM (2014) when students practice mathematics concepts, the design of the lessons should be concise, explicit, and engaging. A multisensory approach will provide those elements and assist students in retaining the multiplication facts they need in order to problem solve.

The purpose of this study is to determine whether the use of a multisensory multiplication instructional program improved retention of multiplication facts for students with specific learning disabilities. The program consisted of pictorial cues and stories to assist in memorization of multiplication facts. Using pictorial cues and stories related to the process of multiplication helped students anchor their knowledge and improve automaticity. By using this program to reinforce skill deficits, students may gain access to the remaining mathematics curriculum in the area of operations and algebraic thinking.

The action research took place in a Palm Beach County, Title I elementary school. The four students involved in the study were 3<sup>rd</sup> graders, two of which had been previously retained students. All four students had been identified as having specific learning disabilities (SLD) and required Individual Education Plans (IEP). The Exceptional Student Education (ESE) teacher worked with the general education teacher and provided the intervention. The ESE teacher was responsible for collecting data before, during, and after the intervention program. The ESE teacher designed a probe that was linked to the intervention program.

The research process began by obtaining permission from the principal. Next, informed consent was obtained from the parents/guardians of the students that participated. They were provided with the purpose of the research, which is to improve retention of multiplication facts for students with varying exceptionalities by using a multisensory multiplication instruction program. Parents/guardians were provided with information about the potential benefits to students, which may be gaining access to the curriculum and improved preparation for the FSA. The resources that were necessary to complete the study included the multi-sensory mathematics program titled 'Times Tales' along with multiplication probes that focused on the content of the program (the upper times tables) and the picture cue cards and accompanying DVD. In the program, the students participated in an interactive DVD program that reinforced the multiplication facts with anchor stories and pictorial cues. The program ran for two weeks for part one of the system (two weeks of intervention, two weeks of generalization) and four weeks for part two of the system (two weeks of intervention, two weeks of generalization). Each week, the students were probed to track data. Throughout the program, the students transferred their knowledge of the pictorial cues and stories to numerical values to aid in their retention of multiplication facts.

### **Literature Review**

Karande, Mahajan, and Kulkarni (2009) emphasize that classroom teachers, parents and the general public must increase awareness and provide support for students with specific learning disabilities (SLD). Quite often, teachers expect to use the same methods to teach students with SLD and achieve the same results as they would with their grade-level peers. Unfortunately, these methods are not effective in some cases and cause even further delays in acquiring essential, foundational education for students. One area where the deficits are evident in research is mathematics, specifically in the domains of operations and algebraic thinking. Min Wook and Bryant (2016) assert that elementary students with SLD exhibit difficulty in the recall/retention of multiplication facts. The inability to perform basic calculations in mathematics decreases access to the remaining mathematics curriculum, which requires multiplication as a requisite factor for operational application. These deficits impede the academic progress of students with specific learning disabilities in the mathematics curriculum, therefore ill-preparing him/her to pass the high-stakes test and make progress in meeting grade-level curriculum expectations.

### **Strategies for Improving Multiplication Skills**

There are many approaches to improving the recall/retention of multiplication facts for students with specific learning disabilities; however, research from Nelson, Burns, Kanive, and Ysseldyke (2013) suggest that multisensory interventions combined with fact rehearsal strategies may be a more effective tool in retention of multiplication facts for students with SLD. Many multisensory intervention programs include approaches that increase the skill set required for multiplication. In reviewing the literature, it was evident that in addressing deficits regarding students with SLD, mini-games and mnemonic devices such as anchor or peg word activities are

among multisensory approaches that may enhance fact rehearsal strategies, which are commonly used as an intervention for multiplication remediation.

### **Fact Rehearsal**

Rave and Golightly (2014) designed a study to quantify the effectiveness of a specific fact rehearsal program (Rocket Math) in improving basic multiplication fluency. The focus of this study was the examination of the effect of the Rocket Math (commercially accessible) math fluency intervention program on students' multiplication fluency and recall. The students involved in the study were all in 5<sup>th</sup> grade. The participants were in three different classes on the same campus. The study spanned over a nine-week period and assessed 33 general education students and 11 special education students. The study utilized a pre-test/posttest non-experimental design approach and yielded results in terms of level advancement in the program. Students with special education provisions advanced an average of 12.55 lessons over the 28 session program. Typical students averaged a 16.15 lesson advancement in the 28 session program. Results from the study indicated that the Rocket Math program may be a viable mathematics fluency intervention in the general education/special education setting. This study suggests that fact rehearsal programs garner stand-alone benefits for students with SLD; however, it does not address how the addition of multisensory components would further increase student recall/retention of multiplication facts.

Another study conducted by Dennis and Falcomata (2016) aimed to distinguish between the effects of two different interventions, one rooted in number sense and one that provided extensive practice intervention, for students with mathematics learning disabilities. Participants in the study were 2<sup>nd</sup> graders (six total) that had previously been eligible for services under an Individualized Education Plan (IEP), were receiving support for mathematics-based special

education services as per their IEP, were not Limited English Proficient (LEP), and that scored less than 20% on a screener test comprised of basic math facts. Dennis and Falcomata (2016) described the significance of mastery in this domain by emphasizing that foundational mathematics fact-based retrieval serves as a base for future domain achievement in mathematics. Using a combined procedural approach to their experimental design, Dennis and Falcomata were able to track student transformation by conducting an individual trial-by-trial analysis. All students were initially screened and then the participants were split into two groups. One group received the number sense first interventions (NSF) while the other received extensive practice first (EDF) interventions. Following the initial interventions, both groups concurrently received extensive practice interventions. Dennis and Falcomata further analyzed the data in regard to fact retrieval by using a multiple probe design to account for fact retrieval performance. Participants in the NSF group demonstrated a 4.02 point increased score in fact retrieval from their baseline score of 1.47 points, while participants in the EPF group reported 1.46 point increase from their baseline score of 0.64 points. Participants in the NSF intervention group presented a marked improvement. Results from this study suggest that the number sense intervention is more successful for transformation and generalization; however, the increase in solving basic facts is largely attributed to the extensive practice intervention that both groups received. The researchers recommend using the two interventions concurrently.

Poncy, Skinner, and Axtell (2010) developed the Detect, Practice, and Repair (DPR) approach to mathematics remediation, which aimed to increase the recall of basic math facts by focusing only on the facts that the student needed to remediate. Based on their research, many neuro-typical students do not acquire automaticity in mathematical facts and this hinders their development because they spend most of their cognitive power on solving the computation and

then fall short on the application of problem-solving to satisfactorily complete the problem. The study utilized DPR strategies and techniques with seven 3<sup>rd</sup> grade students (8-10 years old) that were struggling with recalling their multiplication facts. Six of the students were African American and one student was identified as Hispanic. None of the students had been identified as receiving special education services. Poncy, Skinner, and Axtell designed their experiment using a multiple-probe-across-problem-sets approach. Their measurements were collected by analyzing the digits correct per minute, or DCM, of their participants. Research indicated that students using DPR procedures presented a 63% increase in DCM from their baseline score after a two-week period of intervention. The total amount of time using in the two weeks towards interventions was just over two hours. The results of the study indicated that DPR may be an effective measure to increase automaticity in neuro-typical students; however, more research would be necessary to determine the efficacy of the program in relation to other programs as well as with students with SLD.

### **Mini-Games**

According to Bakker, Van den Heuvel-Panhuizen, and Robitzsch (2016), students that are identified as having special needs are often below grade-level in comparison to their peers. In order to address the need for increased performance in mathematics for students with special needs, their research team designed a study that attempted to improve the mathematical reasoning ability said students. Bakker, et al. asserted that the use of online mathematics mini-games is considered an approach to improving the multiplicative reasoning ability of special education students. The study spanned the course of two, 10-week intervention periods with a control group and an experimental group. The researchers utilized a pretest–posttest control-group design for the 81 students that participated in the study. The students attended cluster sites



for special education at the primary elementary level. Over the course of the study, both the experimental and the control group participated in mini-games; however, the experimental group participated in 16 multiplication based mini-games and the control group participated in 16 non multiplication-based mini-games. The results suggested that the mini-games improved multiplication fact knowledge in regard to basic recall and retention; however, the results of procedural and conceptual knowledge did not differ between the experimental and control groups. It is important to note that this study included teacher-led lessons as well as discussion-based interactions between peers, so the mini-games were used in tandem with typical instruction.

In a similar study, Skarr, Zielinski, Ruwe, Sharp, Williams, and McLaughlin (2014) presented test subjects with direct instruction flashcards and reinforced the instruction with a math racetrack mini-game during the study. Upon completion of the study, all participants mastered the targeted math facts and generalized them from oral to written composition. The study was designed to assess if a 3<sup>rd</sup> grade student (male) without learning disabilities (LD) and two 5<sup>th</sup> grade student (male and female) with learning disabilities would benefit from the paired use of direct instructional strategies in multiplication facts and mini-games during after school programming. The study, similar to the study designed by Bakker et al., combined mini-games with direct instruction strategies to maximize the context and exposure that students have to the content. Multiple exposures in different contexts may increase the retention and application of such concepts.

Another study employed the use of mini-games in a technology-enhanced methodology using an iPad to implement the intervention. In the study, Min Wook and Bryant (2016) selected participants were selected based on the following criteria: (a) the student was programmed as a

4<sup>th</sup> or 5<sup>th</sup> grade student, (b) the student was eligible for services under SLD, (c) the student has an IEP, and (d) the student scored at frustration level on the multiplication pretest (Min Wook & Bryant, 2016). The participants were two male and two female 5<sup>th</sup> grade students with learning disabilities. The study utilized iPad applications as a one-to-one intervention to improve multiplication fact performance. Student increased their fact retrieval scores following the interventions delivered throughout the duration of the study. Another result of the study was improved mathematical reasoning strategy application; specifically, after the study the participants moved from using juvenile strategies such as counting on to more developed strategies such as automatic retrieval. Min Wook and Bryant cite the Common Core State Standards for Mathematics in emphasizing that basic mathematical fluency is critical to developing foundational mathematics understanding and reasoning skills and further assert that the intermediate elementary grades depend so heavily on this domain that it demands fluency by the end of grade five.

Bryant et al (2015) found inconsistent results in their study, tracking the performance of students with learning disabilities with interventions that were teacher-led vs. technology-led. Using an alternating treatments design, the study included six participants identified as having SLD and compared app-based instruction (AI), teacher-directed instruction (TDI), and combined instructional approaches (CI). Although their study had limitations regarding content (probes were designed to capture only the 4/8 multiplication tables), the results favored teacher-led interventions. The TDI approach presented greater results than all other approaches in 50% of the students. In the students that did not present higher results with the TDI approach, 66% presented greatest results using the CI approach. Only one student presented the greatest results with the AP approach. The study suggested that a combination of approaches is more successful

when mediating students with SLD/LD. Further, they assert that in their research, very few applications actually teach mathematical concepts; rather, they are designed to reinforce skills and concepts through practice opportunities.

### **Mnemonic Devices and Peg Word Activities**

While research supporting the use of mnemonics in education is plentiful, its application in multiplicative fluency is limited. Nelson, Burns, Kanive, and Ysseldyke (2013) designed a study that excluded students with SLD but included 90 third and fourth grade students that scored at or below the 25<sup>th</sup> percentile in standardized mathematics testing. The focus of their study was the comparison of practice-based intervention with mnemonics-based intervention. The mnemonic used in the study was specific to multiplication facts and not a process-oriented mnemonic device (Nelson et al., 2013). This was not a combined approach design and it yielded results that indicated that practice-based intervention is more effective when compared solely to mnemonics-based intervention with typical, low-achieving students. The researchers discussed the efficacy of interventions that were designed with such a variance between the expected results and the actual performance level of the students, citing that neither intervention group was able to perform at the expected proficiency rate by the termination of the study. According to Nelson et al., one of the limitations of their study was that the interventions must match the skill level of the students that are participating. The researchers deduced that skill level must be taken into account when calculating the student response to different interventions.

The lack of research regarding mnemonics and students with moderate intellectual disabilities inspired a study by Zisimopoulos (2010), which further addressed the area of mnemonics. The focus of the study was to determine the efficacy of a paired technique that included a picture-fading method with modified keyword mnemonics. The study included two

students with moderate intellectual disabilities. Previous research set forth data regarding students with mild intellectual abilities, which prompted the researchers to design an experiment with students that had more moderate impairments. The participants in the study were elementary students, one in 3<sup>rd</sup> and one in 4<sup>th</sup> grade with moderate intellectual disabilities. Both students went to the same school located in Nafpaktos, Greece. Based on classroom observations and data, neither student had mastered their multiplication facts in either the general education or the special education setting. The method involved using a modified pegword strategy to represent a multiplication equation coupled with a picture-fading technique. Zisimopoulos (2010) utilized a single-subject multiple baseline design across subjects in the study. The participants in the study met the established criterion scores of mastery (greater than 90%) by the end of the study. After the study was completed the researchers completed generalization sessions across different settings, teachers, and formats. The setting for the study was clinical for experimental purposes; so the results would not be generalized to the general education setting for implementation purposes. Further, the study did not aim to address problem solving and real world application of multiplication skills (Zisimopoulos, 2010).

Freeman-Green, O'Brien, Wood, and Hitt (2015) conducted a study that included six 8<sup>th</sup> grade students who qualified by their SLD eligibilities. The study incorporated mnemonics into mathematical problems solving to determine if there was a significant improvement in the reasoning skills of students with SLD when exposed to the mnemonic SOLVE (Study the problem, Organize the facts, Line up a plan, Verify your plan, and Evaluate your answer). Students who participated in the study were able to accurately perform grade-level calculations and one-step word problems but struggled with multi-step problems and mathematical reasoning skills required to be successful in upper-level courses, such as algebra. The study utilized a

multiple-probe-across participants design. While post-intervention scores varied among participants, the researchers used a strategy-knowledge test to determine the increase in knowledge from pretest to posttest. All participants scored a baseline of 0% on the pretest. Post intervention, the participants' posttest scores ranged from 91-100%. The study suggested that students with SLD exposed to the problem-solving techniques benefitted from an increased ability to solve word problems in mathematics. Further, the study asserts that students were able to generalize the problem-solving techniques into another domain (inequalities) with noted success; however, the study did not track the efficacy of the technique over a long-term period (Freeman-Green et al.).

While the study conducted by Freeman-Green et al. focused solely on students with SLD, Bottge, Rueda, Ya-Hui, and Jung Min (2007) conducted a study that included 128 middle school student participants, 13 of whom were students identified with learning disabilities. There were a total of 60 male participants and 68 female participants. The study aimed to reduce the achievement gaps for students, including those with learning disabilities, by employing Enhanced Anchored Instruction (EAI) techniques. Bottge et al. utilized a specific method of implementing EAI, which involved the integration of two mathematics-based collaborative group problems as well as a design approach that allowed all participants to receive instructional interventions (multiple measures administered in repeated waves within a nonequivalent dependent variable design). In one of the collaborative group problems, students scored a baseline of 30% (non-SLD) and 10% (SLD). The next data point measured performance after a four-week intervention period, in which the score increased in both cases to an 80% (non-SLD) and a 65% (SLD), marking a range of a 50-55% increase after intervention. The research results suggest that there was a potential benefit for students that used EAI in both the reading and

mathematics subject areas. Research further suggests that the students with LD were able to maintain the academic objectives that they acquired during the study.

This literature review supports the need to consider whether the use of a multisensory multiplication instructional program used in tandem with fact rehearsal strategies improves the retention of multiplication facts for students with SLD. In order to effectively evaluate multisensory approaches, exploring the application of mini-games and mnemonic devices (peg word activities) used in conjunction with fact rehearsal strategies would determine the efficacy of the approach. Multisensory approaches have been researched and suggested as effective instructional teaching tools for students with SLD; however, this proposed action research aims to focus on the recall/retention of multiplication facts as it is a critical component of mathematics foundational knowledge and an indicator of future success in the curriculum.

Action Plan/Methods	
<b>Name:</b> Kelly Green	<b>School:</b> Boca Raton Elementary
<b>Research Question(s):</b> Does the implementation of a multisensory multiplication instructional program used in tandem with fact rehearsal strategies improve the retention of multiplication facts for elementary students with specific learning disabilities (SLD)?	
<b>Intervention:</b> <i>Describe the intervention you will implement to accomplish the outcomes you seek for your students?</i> The intervention tool was a multisensory multiplication instructional program (Times Tales) that included a 30-minute DVD to be viewed daily over two, two-week periods to master the upper multiplication tables. Another component to the DVD was daily visual cue identification and practice cards that incorporated multiplication and division equations. In order to track the efficacy of the program: <ul style="list-style-type: none"> <li>daily pictorial/numerical probes were given to assess student progress. These probes had the pictorial cue equations on one side (problem set of 16) and the numerical equations on the other side (problem set of 16).</li> </ul>	

- The experimental design used in this study was the one group, pretest posttest design.

**Data Collection:** *Describe the specific approaches you will use to collect data before, during, and/or after your intervention. You need to “triangulate” your data; thus, you need at least 3 different data sources (e.g., tests, observations, interviews). Also, be specific about what each data source measures (e.g., you are using a test that measures reading comprehension or using observation to tally bullying behaviors). Next, describe the type of data that you obtain with each source (e.g., scores from a test of subtraction facts or a frequency of bully events observed).*

**Data Source 1:** *Before implementing my intervention, I administered the multiplication probes for each instructional cycle of the program. This consisted of a 32-question multiplication problem **probe**. When the eight-week instructional program was completed, I re-administered the same assessment (32 multiplication problems in numerical and pictorial form) to determine if the implementation of the program was effective in improving the retention of multiplication facts.*

*Data: Pretest/baseline and posttest **probe** scores of upper multiplication facts*

**Data Source 2:** *Before and after the instructional program was completed, students completed a paper/pencil **structured questionnaire** to determine patterns and trends of the participants’ attitudes towards mathematics and multiplication. The feedback was quantified for use in the discussion of the results of the study.*

*Data: **Structured questionnaire** results analyzed to determine trends and patterns*

**Data Source 3:** *Observation of participants applying multiplication fact knowledge to respond to flash cards at the end of each week. Data was kept via tally sheet.*

*Data: Observational data of application of multiplicative fact knowledge to respond to flash cards.*

**Time Line** (see separate sheet):

*This action research plan will be completed within an eight-week time frame. The next section delineates the breakdown of the eight-week implementation and debrief.*

<b>Action Plan/Methods: Timeline</b>		
<b>Tasks</b>	<b>Timeline</b>	<b>Resources</b>
<p>Obtained Principal's permission to conduct action research</p> <p>Informed parents</p> <p>Confirmed receipt of consents</p> <p>Administered structured pre-questionnaires to students</p> <p>Administered pretest/baseline probes of upper multiplication facts</p>	<p>December 5<sup>th</sup>, 2016</p> <p>December 19<sup>th</sup>, 2016</p> <p>Week of December 19<sup>th</sup>-23<sup>rd</sup></p> <p>Week of December 19<sup>th</sup>-23<sup>rd</sup></p>	<p>Letter of consent</p> <p>Log of consents</p> <p>Developed questionnaires</p> <p>Pretest/baseline probes</p>
<p>Implemented multiplication instructional sequence, including 30-minute DVD program, 10-minute fact rehearsal, and daily probes (pictorial/numerical) for part one of the program</p> <p>Collected data points for pictorial probes</p> <p>Collected data points for numerical probes</p> <p>Tally fact mastery based on flash cards per student</p>	<p>Week of January 16<sup>th</sup>-20<sup>th</sup> (1/16/17 is a school holiday)</p> <p>Week of January 23<sup>rd</sup>-27<sup>th</sup></p>	<p>Times Tales DVD</p> <p>Times Tales pictorial cue/numerical flashcards</p> <p>Daily probes for part one</p> <p>Data point collection excel spreadsheet</p> <p>Tally sheet</p>
<p>Implemented multiplication instructional sequence, including 30-minute DVD program, 10-minute fact rehearsal, and daily probes (pictorial/numerical) for part two of the program</p> <p>Collected data points for pictorial</p>	<p>Week of January 30<sup>th</sup>-February 4<sup>th</sup></p> <p>Week of February 6<sup>th</sup>-February 10<sup>th</sup></p>	<p>Times Tales DVD</p> <p>Times Tales pictorial cue/numerical flashcards</p> <p>Daily probes for part two</p> <p>Data point collection</p>



probes  Tally fact mastery based on flash cards per student  Collected data points for numerical probes		excel spreadsheet  Tally sheet
Collect data points for pictorial probes  Collect data points for numerical probes  Tally fact mastery based on flash cards per student	Week of May 8 <sup>th</sup> -May 12 <sup>th</sup>  Week of May 15 <sup>th</sup> -May 19 <sup>th</sup>  Week of May 22 <sup>nd</sup> -May 26 <sup>th</sup>  Week of May 30 <sup>th</sup> -June 2 <sup>nd</sup>	Daily probes for parts one and two  Data point collection excel spreadsheet  Tally sheet
Administer structured post-questionnaires to students	Week of May 30 <sup>th</sup> -June 2 <sup>nd</sup>	Developed questionnaires

### Findings, Limitations, Implications

#### Data Analysis

The data collected were analyzed by comparing pre- and post-test results from four different measures. The first measure consisted of four weekly probes for program one and four weekly probes for program two. Each probe consisted of 32 numerical and pictorial multiplication problems. Scores were based out of 32 problems, 16 numerical and 16 pictorial. Determining the correct number of items on each assessment and then dividing that number by the total number of problems on the assessment was the method of calculating the assessment scores. This analysis was completed for four sets of probes for part one of the program and four sets of probes for part two of the program.

The second measure consisted of a paper/pencil-structured questionnaire to determine patterns and trends of the participants' attitudes towards mathematics and multiplication. The

questionnaires were given prior to instructional sequence and post instructional sequence. The feedback was quantified for use in the discussion of the results of the study. Responses

The third measure consisted of observations of participants applying multiplication fact knowledge to respond to flash cards at the end of each week of the instructional sequence. Data for multiplication facts was kept via tally sheet. Weekly data sheets were kept for participants in the study. Student oral responses of multiplication facts were analyzed to determine the efficacy of the instructional program while it was in progress.

### **Findings**

The results of the study were consistent with those of similar studies conducted by Skarr et al. (2014) and Min Wook and Bryant (2016). When presented with a multisensory approach to learning basic multiplication facts, students were able to achieve mastery of facts with structured interventions. The interventions provided multiple means of instruction and included audio/visual, mnemonic, and game-based support for learners. Students participating in this study looked forward to the sessions and could sense that they were improving in basic fact recall. In addition to the students' overall basic multiplication fact assessment score progress, their pre- and post- intervention questionnaires and observations were analyzed. The following sections provide a discussion of the results.

**Weekly Probes/Assessments for Programs One and Two.** The results indicated that four out of four students achieved gains in their recall of basic multiplication facts for program one. As seen in Figure 1, there was an average increase of 78% per student from the pre-test to the post-test. Student A showed the most significant increase from the pre- to the post-test, demonstrating a 92% increase in score. Student C demonstrated the least percent of increase (56%); however, Student C's baseline score on the pre-test was the highest of all four students.

As indicated in Figure 2, four out of four students demonstrated an increase in the recall of basic multiplication facts for program two. In the second program, Student A showed the least significant gains from pre-test to post-test, demonstrating a 75% increase in score and an overall score of 78%. Students B and C showed the most significant increase in scores at an 84% increase overall. The average gains for all students were an 81% increase in overall score for program 2. Figure 3 delineates the increase in score from pre-test to post-test by student. In comparing the average increase in both programs, Student B exhibited the most significant increase (88%) in the recall of multiplication facts overall. All students noted an average increase in score of at least 70%.

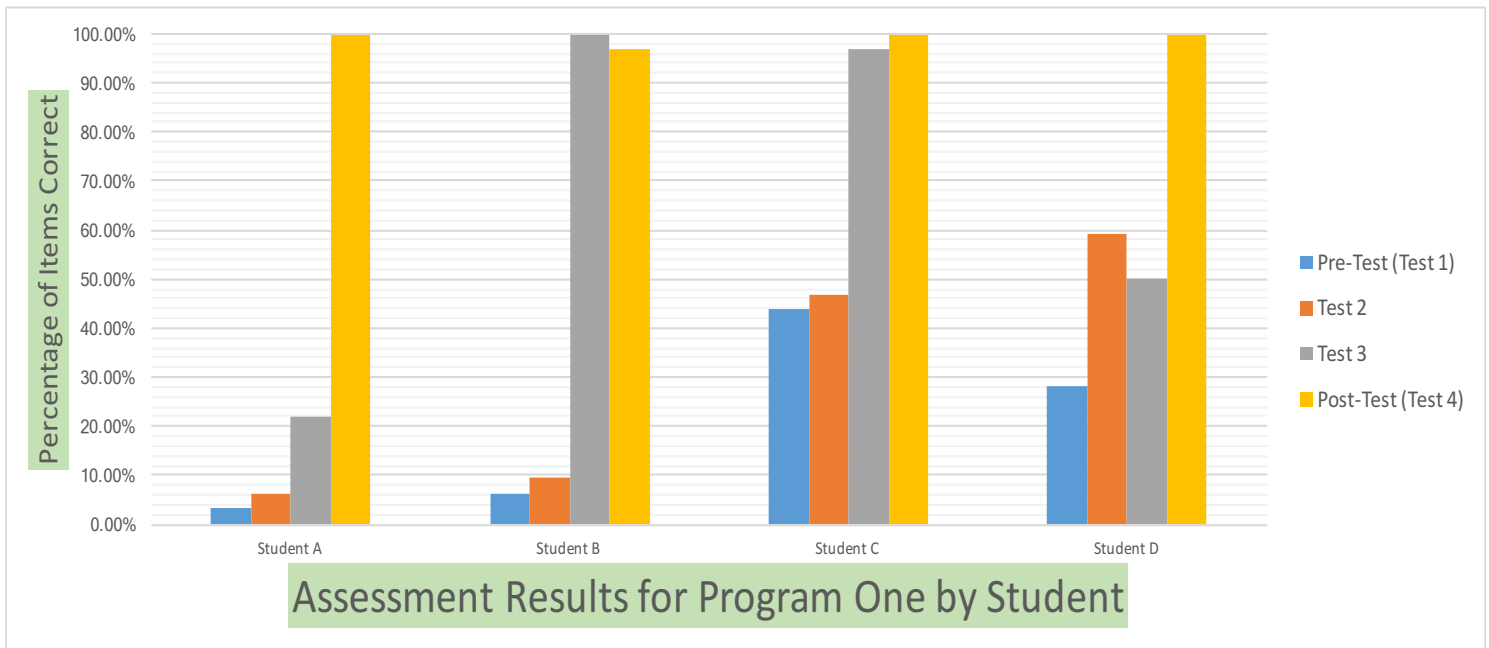


Figure 1. Comparison of assessment results for program one multiplication probes.

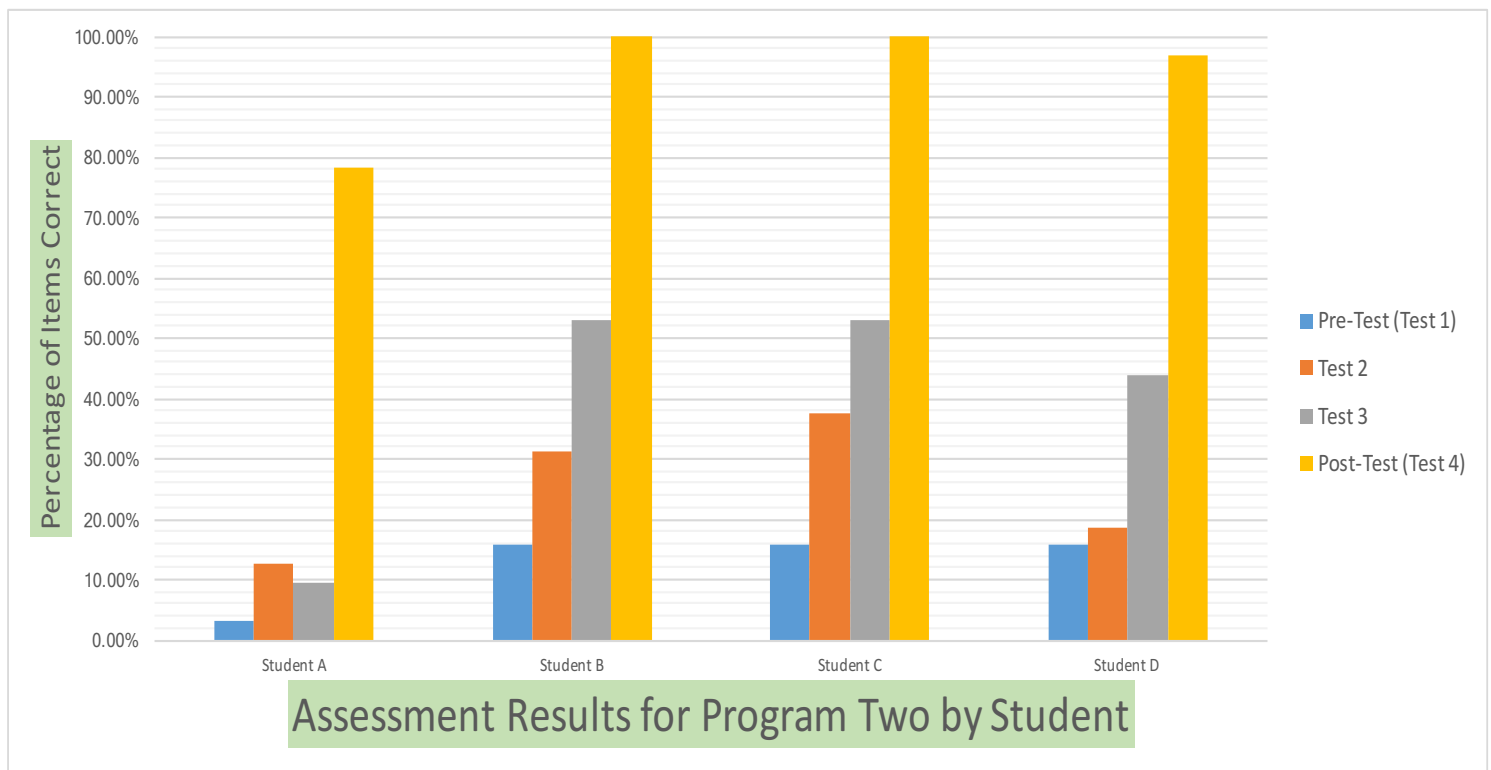


Figure 2. Comparison of assessment results for program two multiplication probes.

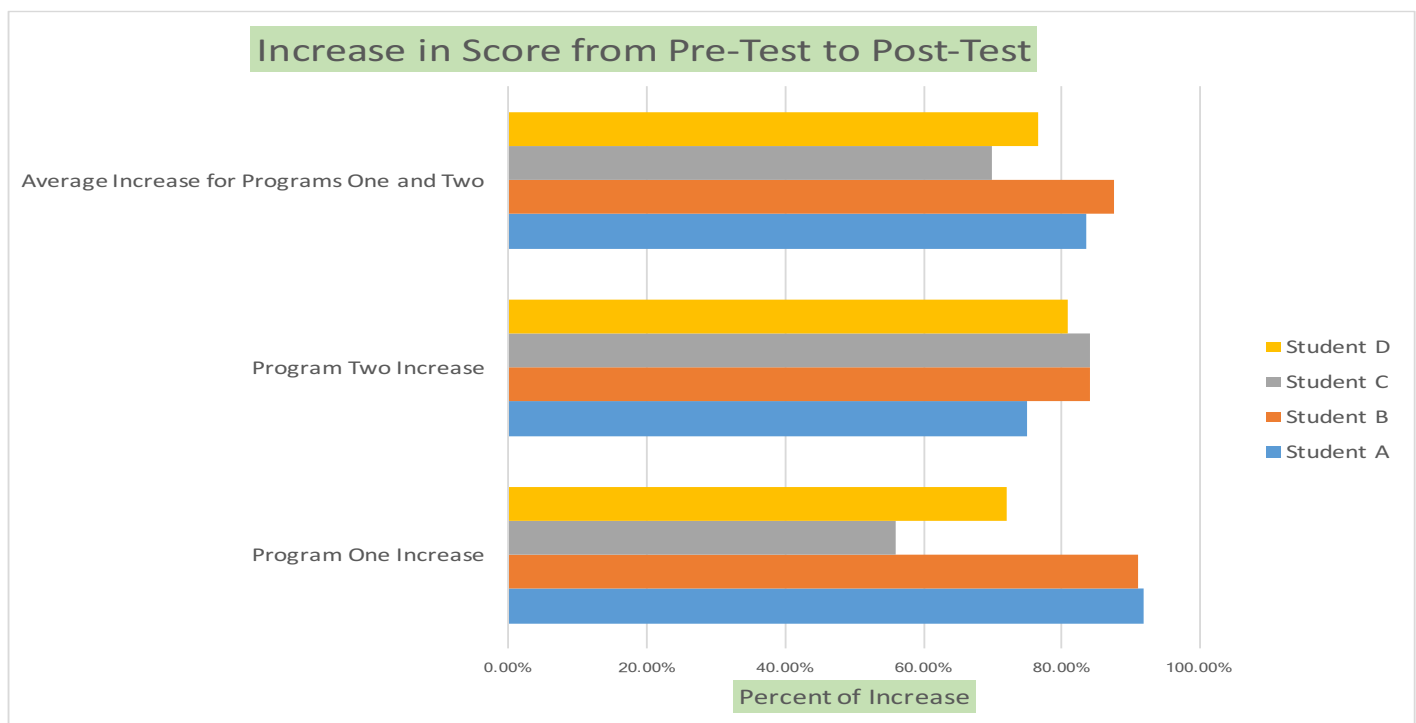


Figure 3. Comparison of average increase in scores for programs one and two assessments.

**Pre- and Post-Intervention Student Questionnaire.** The results of the pre- and post-intervention student questionnaire are presented in Table 1. The responses indicated that there was no change in the percentage of students who stated that it's fun to play math games with friends. There was no change in the percentage of students that think math will help them with their daily life. There were gains in percentages of students who disagreed that math was hard to understand. There was a reduction in the percentage of students that would be nervous to take a timed multiplication test. Post intervention, 100% of students agreed a little that math was their favorite subject in school. There were also gains in percentages of students who disagreed that they would prefer writing homework to math homework. Even though some students agree a little and some students agree a lot, all students agree that teachers give too much math homework pre- and post-intervention.

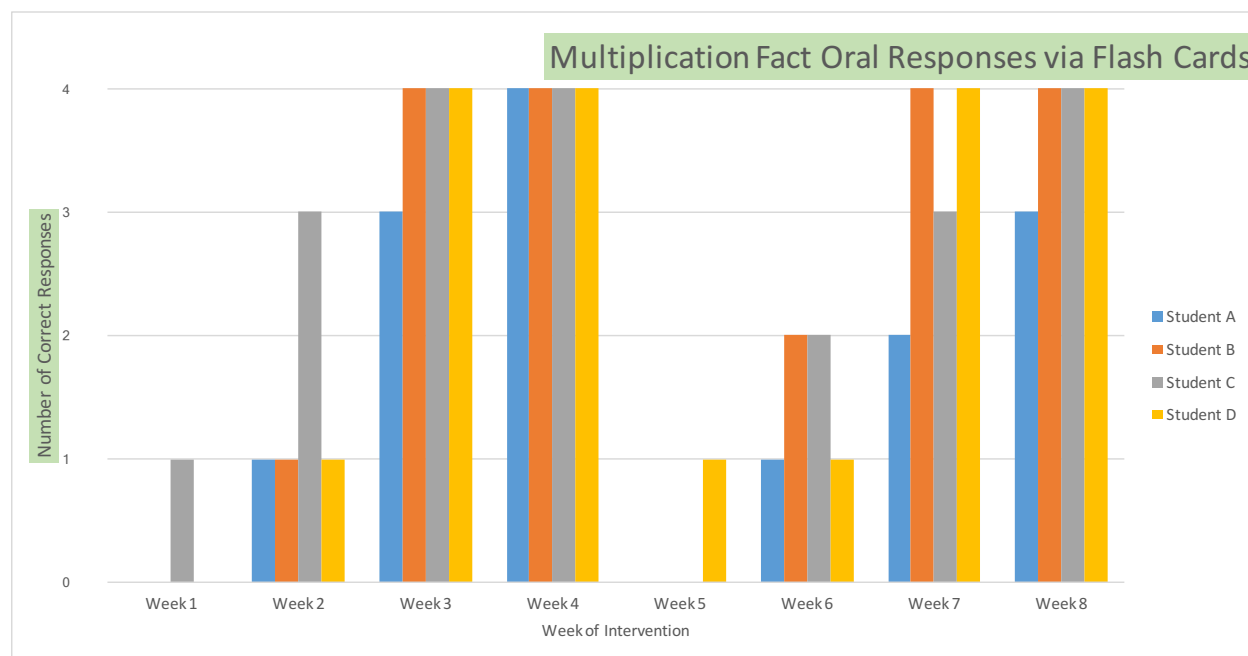
*Student Questionnaire*

Question	Pre-Intervention Response	Post-Intervention Response
I think teachers give too much math homework.	Agree a lot: 100% Agree a little: 0% Disagree a little: 0% Disagree a lot: 0%	Agree a lot: 75% Agree a little: 25% Disagree a little: 0% Disagree a lot: 0%
I think learning math will help me in my daily life.	Agree a lot: 75% Agree a little: 25% Disagree a little: 0% Disagree a lot: 0%	Agree a lot: 75% Agree a little: 25% Disagree a little: 0% Disagree a lot: 0%
I need to know multiplication to understand other math problems.	Agree a lot: 50% Agree a little: 25% Disagree a little: 25% Disagree a lot: 0%	Agree a lot: 75% Agree a little: 25% Disagree a little: 0% Disagree a lot: 0%
Math is hard for me to understand.	Agree a lot: 50% Agree a little: 50% Disagree a little: 0% Disagree a lot: 0%	Agree a lot: 0% Agree a little: 0% Disagree a little: 100% Disagree a lot: 0%

Question	Pre-Intervention Response	Post-Intervention Response
It is easy for me to multiply two numbers in my head.	Agree a lot: 0% Agree a little: 25% Disagree a little: 25% Disagree a lot: 50%	Agree a lot: 50% Agree a little: 25% Disagree a little: 25% Disagree a lot: 0%
I would be nervous to take a timed multiplication text.	Agree a lot: 75% Agree a little: 0% Disagree a little: 0% Disagree a lot: 25%	Agree a lot: 0% Agree a little: 25% Disagree a little: 25% Disagree a lot: 100%
If I could take another reading class instead of math class, I would do it.	Agree a lot: 50% Agree a little: 25% Disagree a little: 0% Disagree a lot: 25%	Agree a lot: 0% Agree a little: 25% Disagree a little: 50% Disagree a lot: 25%
I would rather have writing homework than math homework.	Agree a lot: 25% Agree a little: 25% Disagree a little: 0% Disagree a lot: 50%	Agree a lot: 0% Agree a little: 0% Disagree a little: 50% Disagree a lot: 50%
Math is my favorite subject in school	Agree a lot: 0% Agree a little: 50% Disagree a little: 25% Disagree a lot: 25%	Agree a lot: 0% Agree a little: 100% Disagree a little: 0% Disagree a lot: 0%
It's fun to play math games with my friends.	Agree a lot: 100% Agree a little: 0% Disagree a little: 0% Disagree a lot: 0%	Agree a lot: 100% Agree a little: 0% Disagree a little: 0% Disagree a lot: 0%

**Observations of Participants.** As shown in Figure 4, all four students made gains in responding to multiplication fact rehearsal in the latter weeks of the intervention phases. For program one, the first two weeks was initial intervention while the latter were generalization, and for program two the structure was the same. All four students scored 50% or above in the weeks of generalization, and for the most part averaged 75% or higher in those weeks. The weeks of initial intervention yielded the lowest scores, with 75% of students scoring a 0% in rehearsal of multiplication facts. The students' oral rehearsals of multiplication facts correlated with their

improved scores in assessments/probes. Students were able to generalize their recall skills in this area, which was separate from the designated intervention probes and required quicker processing skills than the other form of assessment.



*Figure 4.* Number of correct responses on multiplication fact oral rehearsal using flash cards.

## Limitations

There were several limitations to the study. The interventions would have ideally been administered consecutively for program one and program two, but due to Florida Standards Assessment (FSA) testing the interventions were spaced approximately 6 weeks apart. The ESE teacher that committed to administering the interventions was directed to administer Florida Standards Alternate Assessment (FSAA) for two students, which left a scheduling issue for interventions. The sample size was also a limitation of this study. The intention was to include a sample of 8 students; however, due to students changing schools, moving classes, and chronic absenteeism the sample size only consisted of 4 students with specific learning disabilities. Additionally, the study targeted children in 3<sup>rd</sup> grade, so the results are only indicative of the

performance of students at this level; however, two of the four students in the study were previously retained so the results do show a level of differentiation in regard to that aspect.

### **Implications**

Multisensory approaches can smooth the progress acquisition of basic multiplication facts. Many students improved in their recall of multiplication facts. Further, many students began to express confidence in the game-based activities that were a part of the intervention. Students completed the probes more and more quickly as the interventions progressed. The accuracy in their responses to multiplication facts increased, and they began to comment that multiplication “was easy” and that they already knew these questions. For students with specific learning disabilities, retention of multiplication facts is likely to become an issue. Using anchor strategies that multisensory approaches provide allows students to build on that schema for increased retention and application of basic math facts.

### **Dissemination**

The results of this study were shared with school administrators as well as the Mathematics Coach. The ESE Coordinator reviewed the findings of the study and the school has constructed an implementation plan for the intervention in the following school year. The research will also be shared with faculty members at Florida International University and students pursuing a Master’s Degree in Special Education. The study was submitted in proposal form to the Council for Exceptional Children (CEC) Convention and Expo on March 31, 2017. Additionally, results from the study were shared with the Trigger Memory company, founders of the Times Tales intervention series.



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## Appendix A: Student Questionnaire

## General Directions

In this questionnaire, you will find questions about yourself. Some questions ask for facts and other questions ask for your opinions. Read each question carefully and answer as accurately as possible. You may ask for help if you do not understand the question. **Shade only one answer on the answer key.**

1) I think teachers give too much math homework.

- A. Agree a lot
- B. Agree a little
- C. Disagree a little
- D. Disagree a lot

2) I think learning math will help me in my daily life.

- A. Agree a lot
- B. Agree a little
- C. Disagree a little
- D. Disagree a lot

3) I need to know multiplication to understand other math problems.

- A. Agree a lot
- B. Agree a little
- C. Disagree a little
- D. Disagree a lot

4) Math is hard for me to understand.

- A. Agree a lot
- B. Agree a little
- C. Disagree a little
- D. Disagree a lot

5) It is easy for me to multiply two numbers in my head.

- A. Agree a lot
- B. Agree a little
- C. Disagree a little
- D. Disagree a lot

6) I would be nervous to take a timed multiplication text.

- A. Agree a lot
- B. Agree a little
- C. Disagree a little
- D. Disagree a lot

7) If I could take another reading class instead of math class, I would do it.

- A. Agree a lot
- B. Agree a little
- C. Disagree a little
- D. Disagree a lot

8) I would rather have writing homework than math homework.

- A. Agree a lot
- B. Agree a little
- C. Disagree a little
- D. Disagree a lot

9) Math is my favorite subject in school

- A. Agree a lot
- B. Agree a little
- C. Disagree a little
- D. Disagree a lot

10) It's fun to play math games with my friends.

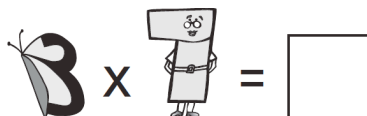
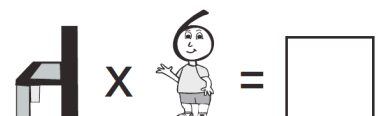
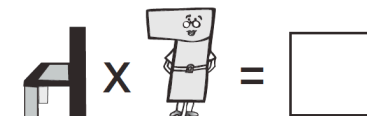
- A. Agree a lot
- B. Agree a little
- C. Disagree a little
- D. Disagree a lot

## Appendix B

### Pictorial Cues Probe/Assessment for Part 1

***Practice Test***

Part 1

Name: \_\_\_\_\_  
Score: \_\_\_\_\_

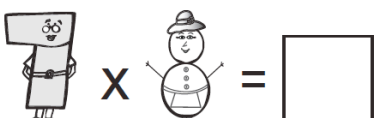
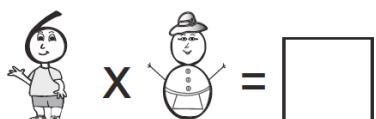
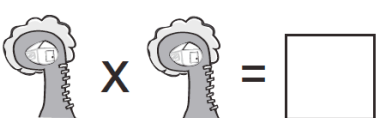
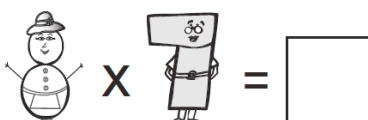
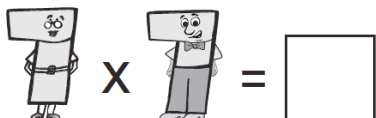
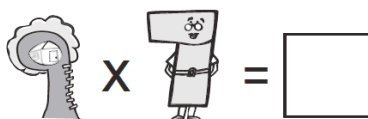
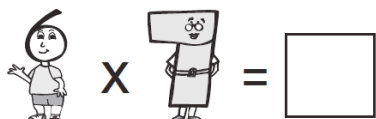
## Appendix C

## Pictorial Cues Probe/Assessment for Part 2

**Practice Test**

Name: \_\_\_\_\_

Score: \_\_\_\_\_



## Appendix D

## Numerical Cues Probe/Assessment for Part 1



Name: \_\_\_\_\_  
Score: \_\_\_\_\_

$7 \times 3 = \square \quad 9 \times 3 = \square$

$9 \times 4 = \square \quad 6 \times 4 = \square$

$3 \times 9 = \square \quad 7 \times 4 = \square$

$8 \times 4 = \square \quad 3 \times 6 = \square$

$4 \times 9 = \square \quad 3 \times 8 = \square$

$6 \times 3 = \square \quad 4 \times 7 = \square$

$4 \times 6 = \square \quad 3 \times 7 = \square$

$4 \times 8 = \square \quad 8 \times 3 = \square$

### Appendix E

#### Numerical Cues Probe/Assessment for Part 2





Name: \_\_\_\_\_  
Score: \_\_\_\_\_

$6 \times 6 = \square$

$9 \times 8 = \square$

$7 \times 9 = \square$

$8 \times 6 = \square$

$6 \times 7 = \square$

$9 \times 7 = \square$

$7 \times 7 = \square$

$9 \times 6 = \square$

$8 \times 9 = \square$

$8 \times 7 = \square$

$9 \times 9 = \square$

$8 \times 8 = \square$

$6 \times 8 = \square$

$7 \times 6 = \square$

$7 \times 8 = \square$

$6 \times 9 = \square$

## Appendix F

Authorization for a School to Serve in a Research Study

## *Authorization for a School to Serve in a Research Study Project*

Project: The purpose of this study is to examine the effects of multisensory instruction on the mastery of multiplication facts for elementary students with learning disabilities

Researcher: Kelly Green

Employment Affiliation: ESE Contact/Teacher

Phone number: 561-544-1717

Location of the study: Boca Raton Elementary

Supervising University Professor: Dr. Elizabeth Cramer

Purpose of the study: The purpose of this study is to examine the effects of multisensory instruction on the mastery of multiplication facts for elementary students with learning disabilities.

Researcher: Kelly Green

Procedures to be followed: Procedures include multisensory instruction/intervention and multiplication probes to determine efficacy of the program

Time and duration of the study: 30 minutes daily over an 8-week period

Benefits of the study: Students may benefit from increased multiplication fact fluency

Persons who will have access to the records data recordings or other documentation: Kelly Green and Dr. Elizabeth Cramer

When the records, data, recordings, or other documentation will be destroyed: Within one year of the end of the study

I understand that participation in this project is voluntary, and I understand that a parent or guardian may withdraw his/her child from the study at any time by notifying the researcher.

Statement of confidentiality: The participation of the students in this project is confidential. Only the researcher, collaborators, and supervising professor will have access to the students' identities and to information that can be associated with their identities.

Please check the appropriate box and sign the form:

☐ I give permission for my school to participate in this project. I understand that I will receive a signed copy of the consent form. I have read this one and understand it.

☐ I do not give permission for my school to participate in this project line signature of principal

---

Signature of principal

---

Date

## Appendix G

## Informed Parent Consent

**Informed Consent Form**  
*Authorization for A Minor to Serve  
as a Research Participant*

Dear Parents,

I will be conducting a study in our classroom to investigate the influence of multisensory instruction on the mastery of multiplication facts for elementary students with learning disabilities. I am writing to ask permission to use the data I collect from your child during this process. Participation in the study involves only regular classroom activities. You may contact me at anytime regarding your child's participation. My phone number is 561-544-1717. The principal of the school has approved the study.

The purpose of the study is to see if the use of the Times Tales multisensory multiplication program improves the retention of multiplication facts. The study will take place at Boca Raton Elementary school and will last for approximately eight weeks. During this period, your child will participate daily in a 30-minute intervention that includes a multimedia presentation (DVD) and accompanying quiz to measure the success of the program. For the duration of the study, your child will receive this intervention either before school, during lunch, or after school based on the schedules of the participants.

During the study, I will collect various forms of data determine whether the multiplication intervention was successful. Possible types of data that I will collect include samples of students' work, surveys/questionnaires, interviews, observations, and test scores. Benefits of participating in the study include increased multiplication facts retention and possibly higher scores on state standardized tests. The only people with access to information collected during the study are myself and my supervising professor. Your child's participation in this project is strictly confidential. Only myself and my supervising professor will have access to your child's identity into information that can be associated with your child's identity. Within one year of the study's completion the data documentation will be destroyed. Use of data from your child is voluntary. You may contact me at anytime if you do not wish to have your child state included in the study. Please check the appropriate box below and sign the form:

☐ I give permission for my child stated to be used in the study. I understand that I will receive a signed copy of this consent form. I have read this from and understand it.

☐ I do not give permission for my child stated to be included in this project.

\_\_\_\_\_  
Signature of parent/guardian

\_\_\_\_\_  
Student name

\_\_\_\_\_  
Date