The Effectiveness of the Touch Math Program in Teaching Addition to Students with Math Disability

Hanan Al-Hmouz *

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Abstract: The purpose of this study was to investigate the effectiveness of the Touch Math program, and the Math Curriculum Based Measurements (M-CBM) on mastering the basic addition facts for third grade students with Math Disability (MD). A total sample of 44 third grade students participated in the study. This study presents a comparison of two groups: The Touch Math and M-CBM group, and the Touch Math group. The intervention was implemented for 16 weeks. The findings indicated that both groups of the study achieved higher scores in math achievement as a result of applying Touch Math program, but Touch Math program and M-CBM had better results compared to just Touch Math program on students' performances during the intervention and follow-up phases. In addition, participants developed a positive increase/trend-line in their M-CBM addition skills because of using.

(**Keywords**: Special Education in Jordan; Mathematics Learning Disabilities; Touch Math Program; Math Disability).

فاعلية برنامج "توج ماث" في تدريس عملية الجمع للطلبة ذوي صعوبات التعلم في الرياضيات

حنان الحموز، جامعة مؤتة، الأردن،

ملخص: هدفت الدراسة الحالية إلى فحص فاعلية برنامج "توج ماث"، والقياس المبني على المنهاج الحسابي في إتقان الطلبة ذوي صعوبات التعلم المحددة في الرياضيات حقائق الجمع الأساسية. تكونت عينة الدراسة من 44 طالبًا وطالبة في الصف الثالث الأساسي. حيث يقارن البحث الحالي أداء مجموعة برنامج "توج ماث" والقياس المبني على المنهاج الحسابي، ومجموعة برنامج "توج ماث" فقط. تم تنفيذ برامج التدخل العلاجية السابقة لمدة 16 أسبوعًا. وقد أظهرت النتائج أن الطلبة في مجموعتي الدراسة قد حصلوا على علامات أعلى في التحصيل الحسابي نتيجة لتطبيق برنامج "توج ماث"، ولكن نتائج برنامج "توج ماث" والقياس المبني على المنهاج الحسابي كانت أفضل من نتائج برنامج "توج ماث" وحده خلال مراحل التدخل والمتابعة. بالإضافة إلى ذلك، طوّر المشاركون خط تقدم إيجابي في مهارات الجمع على القياس المبني على المنهاج الحسابي نتيجة لاستخدام برنامج "توج ماث".

الكلمات المفتاحية: (التربية الخاصة في الأردن، صعوبات التعلم المحددة في الرياضيات، برنامج "توج ماث"، صعوبات الرياضيات).

Introduction: Math Disability (MD) is defined as a "… specific learning disability affecting the normal acquisition of arithmetic skills" (Geary, 2004). MD, which is primarily a cognitive disorder, is considered a clinical diagnosis when a child's mathematics achievement is "substantially" below what would normally be expected, given the child's intelligence and educational opportunities (Mabbott & Bisanz, 2008). While problems in mathematics can be predicted as early as age four or five (Geary, Hamson, & Hoard, 2000), a full MD may be clearly diagnosed by third grade (Fuchs et al. 2009). Between 4% and 15% of school-aged children have difficulty learning mathematics (Garrett, Mazzocco, & Baker, 2006; Geary, 2004). More specifically, the percentage of school-age children with deficits affecting acquisition of skills in the area of mathematics is between 5% and 8% (Geary, 2004). Comparable prevalence was suggested in Jordan and Arab world as well (Author, 2017; McBride, 2007).

Mathematics is a subject that students with MD will encounter throughout their academic and daily life experiences. Special education teachers have reported that two out of every three students with disabilities experience mathematics problems (Riccomini & Witzel, 2010). Carpenter (1985) found that special education classrooms devote as much as one third of available instructional time to the remediation of mathematics deficiencies. However, even with a substantial portion of their academic time devoted to mathematics, students with disabilities experience persistent problems related to learning and applying mathematics. They usually perform basic addition facts only as well as third graders without disabilities, show growth patterns in mathematics of only 1 year for every 2 or more years of school, demonstrate proficiency levels equivalent to only fifth or sixth grade, demonstrate difficulties with word problem–solving skills, and show limited proficiency on tests of minimum competency (Mayrowetz, 2009).

* Mutah University, Jordan.

Although students with mathematical difficulties are a diverse group, they generally include those who perform in the low average range (e.g., at or below the 25th percentile) and may exhibit difficulties in one or many areas of mathematics (Geary, 2004; Geary et al., 2000). Characteristics of MD include memory deficits, inadequate use of strategies addressing mathematics, and difficulty with the transfer of mathematics skills to new learning environments (Kroesbergen & Van Luit, 2003). These students may also exhibit problems with retrieval of basic facts, display errors when following procedures, and use procedures for problem solving more typical of a younger student (i.e., finger counting, verbal counting) (Geary, 2004). In terms of basic mathematics facts, students with MD function below typically achieving peers in basic fact retrieval across elementary grade levels (Anderson, 2010) and are unable to master the four basic operations before leaving elementary school (Kroesbergen & Van Luit, 2003).

Researchers in the field of learning disabilities have historically focused their attention on the language characteristics of children with learning disabilities and specifically on reading (Rivera, 1997; Lerner, 2000). Although several researchers have conducted recently robust research in the area of MD (Baroody, Bajwa & Eiland, 2009; Geary, 2011; Gersten et al. 2009; Jitendra et al., 2013); still less attention has been given to the study of learning disabilities in the area of mathematics comparing to the area of reading (Bender, 2001; Swanson, Jerman, & Zheng, 2009). Although knowledge of mathematics is necessary in many every-day situations, most of the skills required involve the application of very basic mathematical concepts (Patton, Cronin, Bassett, & Koppel, 1997). Such fundamental mathematical information includes the four operations, namely addition, subtraction, multiplication, and division. The most basic of these operations, however, is addition, given that the three other operations are based on it (Lerner, 2000). Consequently, it is crucial that students with learning disabilities in mathematics become competent in this most fundamental operation, addition.

Although information on how children with learning disabilities in mathematics learn addition is quite limited, a good deal of research has examined how children without disabilities learn to add (Hughes, 1986). Perhaps the most complete study to date has been that by Carpenter and Moser (1984), who examined the different strategies that children use when performing addition problems at different stages of learning. They identified three strategies that children without disabilities employ for solving addition problems. Initially, children use a count-all strategy that consists of counting, with the use of fingers or other objects, each addend in an addition problem starting at 1 until all numbers have been counted. For example, when solving the problem 4 + 5, the child begins by holding up four fingers on one hand while counting to 4, and then holding up five fingers on the other hand while counting to 5. Finally, the child counts all the fingers that are held up in order to find the solution, in this case 9. The count-all strategy is limited, in that the child can only easily add to 10 using his or her fingers and will experience considerable difficulty when adding numbers greater than 10. At the early stages of learning, however, most learners use the count-all strategy. Once the count-all strategy has been learned, children generally move to a slightly more advanced strategy for solving addition problems. This method, called the count-on strategy, involves saying the first addend of the addition problem and then counting on from that number (Carpenter & Moser, 1984). For example, a child would solve the problem 4 + 5 by saying the first number, in this case 4, and then counting on from 4. While some children continue to use their fingers when counting on, most do not need to use concrete referents. Children eventually learn to begin the count with the largest addend, thus saving time. The final stage of addition learning identified by Carpenter and Moser (1984) involves storing and later retrieving addition facts from long-term memory. With repeated practice and reinforcement, children memorize basic addition facts and retrieve them from memory when needed. For example, in time, children memorize the addition problem 4 + 5 = 9.

The Touch Math approach appears to teach addition according to the same strategies that children naturally develop to solve addition problems. The system offers a method for teaching addition that involves count-all and count-on strategies but does not require the retrieval of stored facts from memory, an area of difficulty for many students with learning disabilities (Miller & Mercer, 1997). However, because students are encouraged to repeat their answers to problems aloud when using the Touch Math method, it is expected that addition facts will gradually be stored in a child's long-term memory, thereby enabling the child to employ the most advanced of the three addition strategies used by most children. Repetition of meaningful material has been found to aid retention (Marsh & Cooke, 1996). The Touch Math program also has the advantage of being a multisensory method, in that it involves the use of auditory, visual, and tactile information. Multisensory approaches have been encouraged by several researchers when introducing basic number concepts (Chinn & Ashcroft, 2001). Furthermore, the program assumes little prior knowledge of arithmetic on behalf of the learner. Finally, it is a discreet method that allows children to solve addition problems without indicating that a counting method is being used, thus allowing students to avoid the embarrassment of finger or tally counting. More information about Touch Math program is provided in the following section.

The Touch Math program is a multisensory method for teaching addition by breaking down the task of adding into small, logical steps without requiring the storage of arithmetic facts in memory. Indeed, it incorporates, to a considerable extent, the three most effective strategies identified by Miller, Butler, and Lee, (1998) for teaching mathematics to students with learning disabilities: step-by-step self-regulated instruction, use of manipulative and direct instruction. Touch Math program was developed by Janet Bullock in 1975 for children with math learning disabilities to help them to overcome their difficulties. This technique is based on the concrete-to-abstract instruction principle in mathematics teaching and learning. A student-oriented technique provides easier computation by means of the concrete learning of numbers as well as quicker counting without the use of fingers (Miller et al., 1998).

The touch math technique is based on counting by placing touch points (dots) on numbers (See Figure 1). This approach is of a multisensory nature, combining visual, auditory, and tactile sensations. The number concept is learned by placing points and dots on the numbers. The technique allows for a simultaneous presentation of concrete, semi-concrete, and abstract examples. During teaching, the dots upon the numbers are counted. These dots are placed systematically on the numbers. Depending on the presentation, they can take the form of objects, object pictures, or dots. First, the students learn the positions of the dots on each number. Following this process, the instruction continues with other instruction steps for addition problems. The students identify the largest number, identify the number that they chose verbally, and then count the dots on the other number to find the solution. Once the students have gained the necessary skills during these steps, the dots are removed and the students continue to count on from that number (Yikmis, 2016).

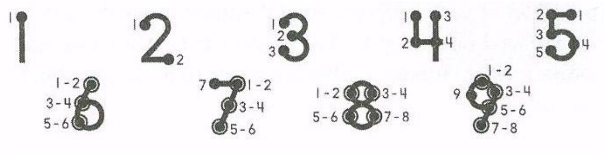

Figure 1. Illustration of the Touchpoints on Numbers 0-9 from Touch Math Program

In terms of theory, according to Dunn and Dunn (1978), there are three basic modes of processing information: visual, auditory, and tactile or kinesthetic. Sarasin (1998) noted that many children prefer to process information visually and can easily be frustrated by a teacher who uses the auditory mode of "telling" in order to teach. These children are visual learners. According to Dunn and Dunn (1978), visual learners process their information primarily through sight. To cater to this type of learner, the Touch Math program provides visual clues, such as arrows and Touchpoints. Some students prefer to listen in order to learn. These children are auditory learners. "These learners are usually verbal in nature, and often tend to think aloud" (Fielding, 1995, 29). Dunn and Dunn (1978) noted that auditory learners process their information primarily through sound, hearing, speaking, and listening. The Touch Math program provides for the learning style of these children by verbalizing the steps to the computation. The kinesthetic learner prefers physically doing something to learn the content. "Tactile or kinesthetic learners learn by doing. Traditionally, this type of learner has been the most neglected in education settings" (Mixon, 2004, 48). Dunn and Dunn (1978) wrote that kinesthetic learners process their information primarily through physically experiencing the information. Barbe and Milone (1980) maintained that 15% of elementary children are kinesthetically oriented, yet schools are predominately visually and auditorially oriented. In the Touch Math program, children count by touching the Touchpoints and saying the number. Mixon (2004) wrote to teachers "by addressing all three learning styles you will help students develop their weaker learning modalities as well as their stronger, more natural ones. Students can then become more versatile learners in varied settings" (48). Corno and Snow (1986) wrote, "the success of education depends on adapting teaching to individual differences among learners" (605). The Touch Math program provides for each of these types of learners.

With regards to the literature review, studies showed that using Touch Math can be an effective tool for students with disabilities whether they are elementary students with mild disabilities (Scott, 1993), kindergarten students with memory issues (Bielsker, Napoli, Sandino & Waishwell, 2001), third and fourth graders with intellectual disabilities, learning disabilities or other health impairments (Wisniewski & Smith, 2002), (Calik & Kargin, 2010), high school students with mild intellectual disabilities (Boon & Water, 2011), and middle school students with moderate intellectual disabilities (Boon, Cihak, & Fletcher, 2010). All the studies shared the same theme that students with all types of disabilities who have difficulty remembering math facts have more success with the Touch Math strategy/program than they do with traditional methods of solving addition problems. It was even noted that those students with no learning disabilities had success using TouchMath (Ullrich, 2013). However, it is worth documenting that previous studies had used different evaluation tools to determine the effectiveness of Touch Math program.

Researchers demonstrated the value of using normative-based assessments for accurately diagnosing a learning disability and curriculum-based measures for monitoring the effects of intervention (Abu-Hamour, Urso, & Mather, 2013). In addition, a report from the National Joint Committee on Learning Disabilities (2008) calls for comprehensive assessment of older students with learning disabilities conducted by professionals trained in adolescent learning. This report underscores the importance of comprehensive assessments to provide a complete picture of a student's strengths and weaknesses to inform intervention. With the integration of comprehensive evaluations and the implementation of intensive and systematic intervention and progress monitoring, educators will ensure that all students will success.

Researchers in particular have recommended curriculum-based-measurements (CBM) as an alternative assessment procedure for monitoring progress and guiding the selection of interventions (Deno, 2003; Hosp, Hosp, & Howell, 2007). CBM's validity and reliability are well established (National Center on Response to Intervention, 2012). For example, Math CBM (M-CBM) represents an empirically supported system of progress monitoring that has produced demonstrated effects on student achievement. M-CBM is an approach for assessing the growth of students in basic skills that originated uniquely in special education. M-CBM can be used effectively to gather student performance data to support a wide range of educational decisions, including screening to evaluate pre-referral interventions, determining eligibility for and placement in remedial and special education programs, evaluating instruction, and evaluating the reintegration and inclusion of students in general education programs (Abu-Hamour & Mattar, 2013; Deno, 2003).

Problem and Questions of the Study

Researchers in Jordan have stated in numerous reports, articles that the Jordanian educational system is in need of effective strategies, and programs to provide students with MD with an appropriate intervention (Author, 2014; Abu-Hamour & Mattar, 2013). Unfortunately, researchers' observation indicates that teachers of students with MD in Jordan are still using traditional methods to teach addition facts. Al-Khateeb (2008) and Al-Natour (2008), consultants to the Ministry of Education in Jordan, highlighted some of these challenges, including lack of screening and diagnostic tests, and lack of the knowledge about students with MD in public and private schools in Jordan. Thus, investigating scientifically based intervention such as Touch Math program for Jordanian students with MD is a necessity in Jordan as well as other Arab countries to provide better understanding for the needs of these students as early as possible. Although the touch math technique has been known for approximately 30 years, and studies have been conducted on its effectiveness in teaching math skills to children with certain disabilities, there are few studies on its effectiveness in teaching addition skills to children with MD in Jordan and other Arab countries. Therefore, the need for further studies on the effectiveness of this technique for children with MD is one of the purposes for this study.

The major purpose of this study was to evaluate the effectiveness of the Touch Math program and M-CBM on mastering the basic addition facts for third grade students with MD. On the other hand, students in the second group used just Touch Math program without M-CBM to determine the best practice when comparing the two study groups. The study problem is represented by the following questions:

Study Question 1: What are the differences between first group (Touch Math program and M-CBM) and second group (Touch Math program) on their addition achievement?

Study Question 2: What is the impact of Touch Math program and M-CBM or just Touch Math program in students' addition skills over time?

Study Question 3: To what extent students with MD will develop a positive increase/trend-line in their M-CBM addition skills because of using Touch math program?

Significance of the Study

In the absence of intensive instruction and intervention, students with MD and difficulties lag significantly behind their peers (Abu-Hamour & Mattar, 2013; Sayeski & Paulsen, 2010). Conservative international estimates indicate that 25% of students struggle with mathematics knowledge and application skills in general education classrooms, indicating the presence of mathematics difficulty (Mazzocco, 2007). Additionally, 5% to 8% of all school age students have such significant deficits that affect their ability to solve computation and/or application problems that they require special education services (Geary, 2004).

The content standards require both conceptual understanding and procedural fluency and call for students to be proficient with facts in all four operations (i.e., addition, subtraction, multiplication, and division) by the end of grade three in order to succeed in higher-order mathematics. If children fail to obtain mastery of these facts, they will likely have difficulty with more complex math skills, which could result in cumulative failure. Students' failure to meet math benchmarks for their respective grade levels is a continuing cause of great concern of parents, teachers, and school policy makers. Because proficiency with basic facts is assumed after grade three, students who continue to struggle must receive supplemental supports or interventions to meet the high academic standards of the grade-level curriculum. In other words, it is an important fact that children with MD, like other children with disabilities, have specific learning needs. Therefore, trying different teaching techniques is necessary to ensure their success in math classes.

Study Delimitations and Limitations

- Foremost of the limitations was external validity. Participants were third-grade students with MD from Jordan. The generalizability of findings to other geographic areas, grades, and students should be investigated further.
- The sample size of the study was small. Larger sample size is recommended in future research.

Terminology of the Study

Math Disability (MD). It is a specific learning disability affecting the normal acquisition of arithmetic skills (Geary, 2004). In this study, only students who scored <85 in the Calculation Test of WJ Arabic battery were included in the sample.

Touch Math Program. The Touch Math Program is a multisensory method for teaching addition by breaking down the task of adding into small, logical steps without requiring the storage of arithmetic facts in memory.

Touch Math Technique. The Touch Math Technique is based on counting by placing touch points (dots) on numbers (See Figure 1). This approach is of a multisensory nature, combining visual, auditory, and tactile sensations. The number concept is learned by placing points and dots on the numbers. The technique allows for a simultaneous presentation of concrete, semi-concrete, and abstract examples. During teaching, the dots upon the numbers are counted. These dots are placed systematically on the numbers. Depending on the presentation, they can take the form of objects, object pictures, or dots.

Curriculum-Based-Measurements (CBM). (CBM) is an alternative assessment procedure for monitoring progress and guiding the selection of interventions (Deno, 2003; Hosp et al., 2007).

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Method

This study uses a quasi-experimental, pre-test/post-test design as shown in Figure 2. Groups were randomly assigned to the instructional approaches: Group 1) Touch Math program and Math CBM, and Group 2) Touch Math program.

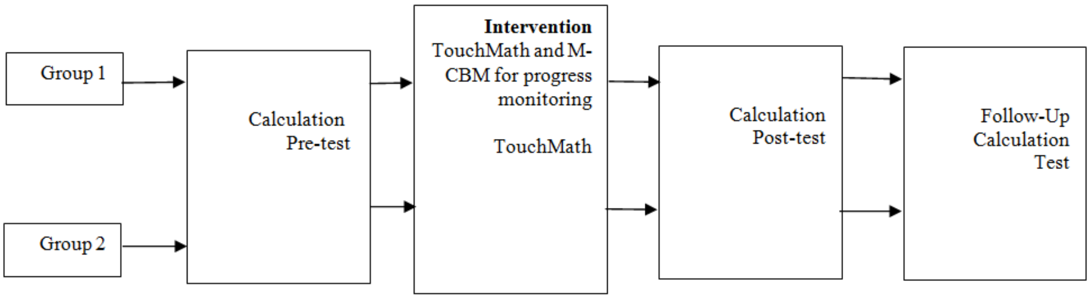

Figure 2. Research design incorporating pre-test, intervention, post-test, progress monitoring, and follow-up test.

Participants

Participants were selected through screening more than 400 students studying in third grade in two private schools in central region of Jordan for MD. Only 44 students who exhibited MD were included in the present study. The mean age was 104 months with a range of 103 to 107 months. Of the total sample, 21 were male and 23 female. These students were enrolled in the 2016/2017 academic year. The Touch Math and M-CBM group consisted of 22 students (10 male and 12 female) and the Touch Math group consisted of 22 students (11 male and 11 female). Across the two schools, curricular goals and objectives, materials and reading instruction methods were similar (e.g., Math is taught in English by using Arabic numerals). Students participated in a 40-minute lessons three times a week for approximately four months. For the purpose of this study, students who struggle with math were identified and nominated by their teachers to be participants in this study. Then, the study author diagnosis all participants using the Arabic Version of Woodcock-Johnson Tests to make eligibility decisions. In addition, for the purpose of this study, only students who scored <85 in the Calculation Test of WJ Arabic battery were included in the sample.

Consent forms were sent to parents, seeking their agreement for participation. Parents who agreed to let their children participate in the study were asked to complete a short questionnaire that addressed the inclusion criteria of this study. The participants were selected from a larger set of students who were assessed to meet the requirements for inclusion in the study: intelligence within the average range, native speakers of Arabic and fluent in English, no noted emotional or behavioral disorder, no noted attention disorders, and no sensory impairments. Two special education teachers (these teachers have a degree in special education and diploma in learning disabilities), both with instructional experience and trained in the intervention methodology; worked closely with the author to implement the intervention programs to the participants. To be included in the final data analysis, participants were required to attend at least 34 of the 40 scheduled practice sessions, complete all the tests, and have a written parental consent.

Measures

Woodcock-Johnson Arabic Tests. The Arabic version of Woodcock-Johnson Cognitive and Achievement Tests (WJ IV COG and ACH) were used to assess the cognitive and math calculation skills of the participants (WJ IV; Schrank, Mather, & McGrew, 2014). The WJ Arabic Tests are based on the Jordanian local norms that have been established in Jordan for individuals ranging in age from 4 years to 22 years. The WJ Arabic Tests are a comprehensive, norm-referenced, individually administered assessment of cognitive abilities and achievement. In general, the internal consistency reliability estimates for all WJ Arabic measures are uniformly high, most often with magnitudes in the .80s and .90s for individual tests, and in the .90s for clusters. The WJ Arabic battery is a perfect tool to identify students with MD since it relies on assessing multiple criteria of Cognitive and Achievement abilities by using CHC theory of cognitive abilities. To conduct this study, the general intelligence and the following broad cognitive abilities were measured by the WJ Arabic Tests: Long-Term Retrieval (*Glr*), Auditory Processing (*Ga*), Fluid Reasoning (*Gf*), Processing Speed (*Gs*), Short-Term Working Memory (*Gwm*), Visual-Spatial Thinking (*Gv*), Comprehension-Knowledge (*Gc*), Reading-Writing (*Grw*), and Quantitative Knowledge (*Gq*) (Author, 2015).

Calculation Test from WJ Arabic Tests. Calculation is a Test of math achievement measuring the ability to perform mathematical computations (Gq). The initial items in Calculation require the individual to write single numbers. The remaining items require the person to perform addition, subtraction, multiplication, division, and combination of these basic operations, as well as some geometric, trigonometric, logarithmic, and calculus operations. The calculations involve negative numbers, percents, decimals, fractions, and whole numbers. Because the calculations are presented in a traditional problem format in the Subject Response Booklet, the person is not required to make any decisions about what operations to use or what data to include. A correct response by the students received a score of one and a wrong response received a zero score. The students' final scores would correspond to total correct responses then converted to standard score using professional software for this purpose. This test was used as a criterion measure in both pre and post intervention testing, and in the follow-up phase.

Math Curriculum Based Measurement (M-CBM**).** When giving M-CBM computation probes, the examiner can choose to administer them individually or to groups of students. For the purpose of this study, the researcher used the multiple-skill addition worksheets that covered the targeted addition skills for this study and administered them individually. The student was given the worksheet and then asked to complete as many items as possible within 2 minutes. M-CBM assigns credit to each individual correct digit appearing in the solution to a math fact. By separately scoring each digit in the answer of a computation problem, the instructor is better able to recognize and give partial credit to a student. The probes were scored according to the correct digit system in this study (Hosp et al., 2007).

Procedure

Selected schools were approached by the author to coordinate the study work with the principals and teachers. Students in the first group received Touch Math program and M-CBM. Students in the second group received just Touch Math program. Due to the fact that students' individual addition skills were variant, both individualized and group teaching were used to move forward in applying the program, and to help all the students according to their abilities. The results of the WJ Calculation Test, the researchers' observations, and the errors analyses suggested that participants in this study: struggle to recognize patterns, such as largest to smallest; have difficulty learning and recalling basic math facts, such as 2 + 3 = 5; use fingers to count instead of using more advanced strategies, like mental math; have difficulty understanding place value; have trouble writing numerals clearly or putting them in the correct column; are very slow in retrieving facts or pursuing procedures; and have difficulties sequencing addition multiple steps. Students in the two conditions completed one pretest session, a post-tests session, and four days after the training ended, and a maintenance test that was conducted approximately two weeks after the completion of the program. The time between pre-test and post-test was 16 weeks for each of the groups. Both groups were given the same 48 lessons from the Touch Math program and were asked to solve 198 worksheets. In terms of progress monitoring, M-CBM probes were administered weekly. In this study, the researchers employed addition lessons only (see the next section for content details).

Touch Math Program

Beginning Addition. Prerequisites to Touch Math addition methods were abilities to count, recognize numerals, and write two-digit numbers. Children were encouraged to touch each point with their pencils and count. For example, to solve 5 +

4, students start with the 5 and count each Touchpoint. Next, they count “six, seven, eight, nine” while touching the points on the 4. They write the answer and repeat the problem with its answer aloud (See Figure 3 for further examples).

Addition with Continuance Counting. Continuance counting means to start with the largest number and count up from that number. The children touch the largest number, say its name, and continue counting. For example, to solve 9 + 4, according to the Touch Math program, the points are removed from the 9. In this problem, the children say “nine” (touching the 9) and count “ten, eleven, twelve, thirteen” (counting the points on the 4). Children will say and practice, “I cross out the largest number, say its name, go to the top of the column, and continue counting.”

Addition without Regrouping. The statement that children repeat while doing this two-digit problem is, “I start on the side with the arrow. The arrow is on the right side.” This is necessary because words and multi-digit numbers are read from the *left*. However, multi-digit addition problems are solved from the *right*. The arrow serves as a visual clue. For example, to solve 42 + 35, children start on the right side, and say “five” (pointing to the largest number – 5) and “six, seven” counting the Touchpoints on the 2. Then they moved to the tens place and add 4 and 3 using the same method. They were encouraged to read the problem and answer to reinforce reading and recognizing two-digit numbers.

Addition with Regrouping. Another visual clue that is added to the process of addition with regrouping is the box. Children were encouraged to say the arrow statement, “I start on the side with the arrow. The arrow is on the right side.” For example, to solve 23 + 39, the answer to the first column on the first problem is 12. They put the 1 (or one ten) in the box and the 2 below, then add 3 to 2 and 1, and get the final answer 62.

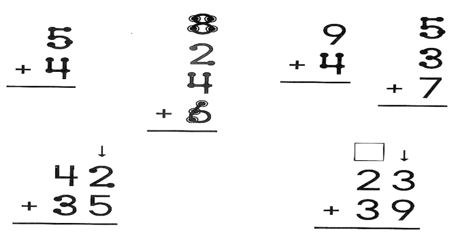

Figure 3. Examples of addition problems using Touch Math Program

Treatment integrity and Reliabilities

Treatment integrity checklists were used to measure the extent to which the teachers implemented the intervention correctly. These checklists were based on the critical components of the selected intervention. Each step on the checklist was scored as *completed* or *not completed*, and the percentage of steps completed accurately was determined. A total of 12 of the 40 teaching sessions were randomly selected to examine the fidelity of the intervention. While the teacher implemented the intervention, an observer independently and simultaneously conducted treatment integrity assessments. The average interobserver reliability was 98% (range 97–100%). In addition, the team of this study had weekly updates and discussions to address the crucial points in the delivery of the intervention and provide feedback. To ensure consistency of testing administration across the different phases of the study, the researcher and the teachers read from scripts and used timers. The researcher scored all tests twice and entered the data into an Excel spreadsheet. In terms of data entry reliability, all of the Excel data (100%) were checked against the paper scores and all discrepancies were resolved by examining the original protocols. The Statistical Package for the Social Sciences (SPSS), version 17.0, was used to analyze the data. Descriptive statistics (e.g., means, standard deviations), and *t-tests* for independent samples were used to investigate the study questions.

Results

Descriptive statistics of the study test scores are reported in Table 1 for the two groups of the study. These scores represent both pre- and post-intervention, and follow-up phases. Before providing the study's intervention, a Levene’s test was administered to the Calculation Pre-test for both groups. No violations of normality and homogeneity of variance were detected. The variances were equal for the Touch Math and M-CBM group, and the Touch Math group, F (1, 42) = .166, p = 0.685, p > .05. On average, students in the second group had slightly higher scores (M = 59.41, SD = 12.40) than students in the first group (M = 58.82, SD = 11.18). However, this difference was not significant t (42) = -.166, p = 0.869, p > .05. The following results are presented according to the study questions:

Study Question 1: *What are the differences between first group (Touch Math program and M-CBM) and second group (Touch Math program) on their addition achievement?*

The descriptive results indicated that the achievement of the Touch Math and M-CBM group was greater than that of the second group (just Touch Math) by the end of the intervention and in the follow-up phase. The visual representation of Table 1 is presented in Figure 4 as well.

Table 1. Means and standard deviations of the Calculation Test across the three phases.

	Group 1		Group 2	
	M	SD	M	SD
Pre-Intervention	58.82	11.18	59.41	12.40
Post-Intervention	67.50	10.07	63.77	12.47
Follow-Up	67.27	10.06	63.50	12.33

Note. n= 22 for each group, Group 1= Touch Math and M-CBM, Group 2= Touch Math, M= Mean, SD= Standard Deviation.

Post-Intervention Phase. All assumptions of performing independent *t*-tests were examined. No violations of normality and homogeneity of variance were detected. The variances were equal for the Touch Math and M-CBM group, and the Touch Math group, F (1, 42) = .471, p = 0. 497, p > .05. On average, students who had Touch Math and M-CBM achieved higher scores in Calculation Test (M = 67.50, SD = 10.07) than students who experienced just Touch Math program during the intervention (M = 63.77, SD = 12.47). However, this difference was not significant t (42) = 1.09, p = 0.282, p > .05. This result meets the researcher's expectations in terms of that the first group will outperform the second group, but no significant differences were found between the two groups (See Hypothesis 1).

Study Question 2: *What is the impact of Touch Math program and M-CBM or just Touch Math program in students' addition skills over time?*

Follow-Up Phase. All assumptions of performing independent *t*-tests were examined. No violations of normality and homogeneity of variance were detected. The variances were equal for the Touch Math and M-CBM group, and the Touch Math group, F (1, 42) = .422, p = 0. 520, p>.05. On average, students who had Touch Math and M-CBM achieved higher scores in Calculation Test (M = 67.27, SD = 10.06) than students who experienced just Touch Math program during the intervention (M = 63.50, SD = 12.33). However, this difference was not significant t (42) = 1.11, p = 0.273, p > .05. It is worth documenting as well that students' performance changes in the two study groups from post-intervention phase to follow-up phase were marginal. In other words, students in the two study groups maintained their addition skills even after finishing the Touch Math intervention program. This result meets the researcher expectation in Hypothesis 2. Changes in students' addition skills endured over time for the two study groups.

Study Question 3: *To what extent students with MD will develop a positive increase/trend-line in their M-CBM addition skills because of using Touch math program?*

Students progressed on their M-CBM addition skill from 7.14 correct digits in two minutes on the first probe to 13.66 by the last week of instruction. The estimated growth rate was 0.4 correct digits per week. Figure 5 provides information on the weekly growth for M-CBM addition skills. This result meets the researcher expectation in Hypothesis 3. Students with MD developed a positive increase/trend-line in their M-CBM addition skills as a result of using Touch math program.

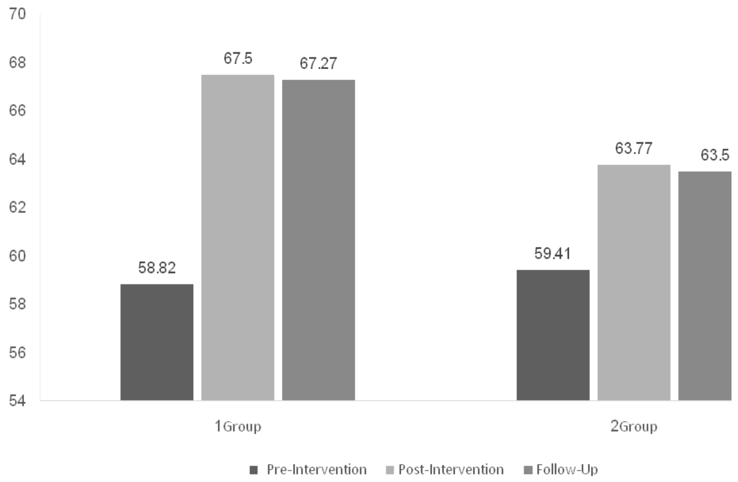

Figure 4. Mean performance on the Calculation Test for the two groups across the three phases.

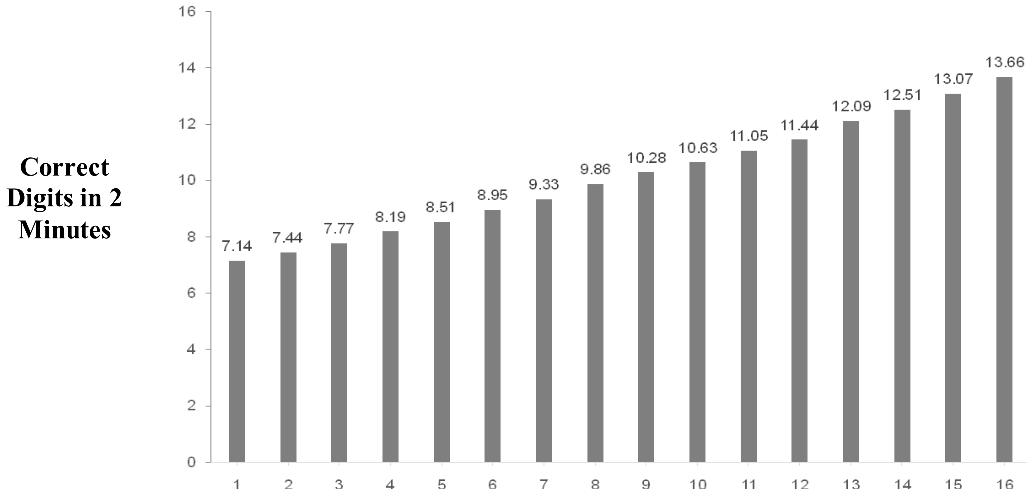

Figure 5. Graphic display of the mean performance on M-CBM measure reported in Correct Digits in Two Minutes

Social Validity

Evaluations of social validity focus on the satisfaction with the intervention's outcomes by those who use the intervention. The participants completed a four-item questionnaire in a yes/no format following the completion of the study. Specifically, the students were asked if they felt their addition skills improved during the intervention program. The researcher read to the participants each item on the student questionnaire and asked them to color in a happy face for ''yes'' or a frowning face for ''no.'' Results indicated that students involved in this study were satisfied with the tutoring procedures and assessment process. Approximately, 98% of the students believed that their addition skills improved because of the intervention program and the use of M-CBM. The teachers indicated that they liked the experience of teaching math by using the Touch Math scientifically based program and the M-CBM; and their students had increased their addition skills by the end of the study.

Discussion

Researchers in the field of learning disabilities have historically focused their attention on the language characteristics of children with learning disabilities and specifically on reading (Lerner, 2000). Less attention has been given to the study of learning disabilities in the area of mathematics (Bender, 2001). This lack of attention may be partially because of the complexity associated with the study of mathematics. As discussed earlier in the study, students with MD in Jordan frequently find addition tasks to be an obstacle in their mathematical progress. Many use inefficient and inaccurate counting methods and encounter difficulties in solving basic addition problems. Thus, the major purpose of this study was to evaluate the effectiveness of the Touch Math program and M-CBM on mastering the basic addition facts for third grade students with MD. The most important results of this study are discussed in the following sections.

On average, both groups of the study achieved higher scores in Calculation Test because of applying Touch Math program. Thus, the descriptive data findings were positive and support the efficacy of Touch Math program as an intervention to improve addition skills for third grade students with MD. These findings support and extend the literature on the effectiveness of Touch Math program in improving student basic mathematics facts (Boon et al., 2010; Boon & Water, 2011; Bielsker, et al, 2001; Calik & Kargin, 2010; Scott, 1993; Ullrich, 2013). As discussed earlier, all the studies shared the same theme that students with all types of disabilities who have difficulty remembering math facts have more success with the Touch Math program than they do with traditional methods of solving addition problems. The effectiveness of Touch Math program may be attributed to the following: a) Touch Math approach appears to teach addition according to the same strategies that children naturally develop to solve addition problems (Miller & Mercer, 1997); b) Touch Math program also has the advantage of being a multisensory method, in that it involves the use of auditory, visual and tactile information (Chinn & Ashcroft, 2001); and c) Touch Math program satisfy the needs of different types of learners, and use several modes of processing information (e.g., visual, auditory, and tactile or kinesthetic) (See Dunn & Dunn, 1978; Fielding, 1995; Mixon, 2004; Sarasin, 1998).

Students who had Touch Math and M-CBM achieved higher scores in Calculation Test than students who experienced just Touch Math program during the intervention and follow-up phases. In other words, the results of the Calculation Test, and the progress monitoring as determined by performance on the M-CBM over the study period showed that third grade students with MD who received Touch Math and M-CBM made greater growth in addition skills than the comparison group students who received just Touch Math program. This finding is consistent with previous research demonstrating that M-CBM increases student achievement and motivation (Abu-Hamour & Mattar, 2013; Stecker, Fuchs, & Fuchs, 2005). However, it is worth documenting that the differences between the two groups of this study were not significant; and this finding may be explained by the short period of applying the intervention and the small number of participants.

Students progressed on their M-CBM addition skills in a growth rate of 0.4 correct digits per week. These results also indicated that M-CBM is an appropriate measure for monitoring students' academic growth in math addition achievement. The third-grade students with MD showed steady growth rate during the 16 weeks of intervention. The estimated growth rate was 0.4 correct digits per week. Some researchers indicated that the expected weekly growth rate for M-CBM in third grade is 0.5 correct digits and above (see Abu-Hamour & Mattar, 2013; Deno, Fuchs, Marston, & Shin, 2001). However, this finding is expected since students with MD in this study performed less well than typically achieving students in other studies. This result suggests as well that M-CBM can be used for identifying students who are at risk of academic failure in addition skills. This research and previous studies lead us to conclude that M-CBM can discriminate between those students with and without math academic skills problems (Deno, 2003; Hosp et al., 2007; National Center on Response to Intervention, 2012).

These findings are particularly important with respect to instruction for students with MD as the trend in schools is toward full inclusion in general education classes (The Higher Council for the Affairs of Persons with Disabilities, 2017; U.S. Department of Education, National Center for Education Statistics, 2010). For these students to achieve success in inclusive classrooms, Yell and Walker (2010) recommended that schools to use mathematics programming that research has shown to be effective in the general education setting, and also adopt and use research-based progress monitoring systems such as curriculum-based measurements to collect data on student performance.

Finally, as with all intervention programs for classroom settings, providing efficient, teacher-friendly interventions that foster student engagement is necessary for continued implementation. Both the teachers who implemented the Touch Math program and the students with MD expressed satisfaction with the program. The teachers found the program to be easy to implement while keeping the students engaged in learning. The teachers also observed that as well as increasing test scores, the Touch Math program also increased students' self-esteem as a math student. Students also began to feel better about themselves as the Touch Math strategy was taught. They went from needing frequent help in completing assignments to being able to complete targeted worksheets independently.

Recommendations and Conclusions

1- Further research on Touch Math program and M-CBM should be done with a greater sample size, other types of math problems (e.g., subtraction, multiplication, and division), and over a longer period of time.

2- Researchers and practitioners should investigate other effective intervention math programs to be used in Jordan and Arab world. There is clearly a need for research in Jordan and Arab countries to identify more precisely, what constitute effective, scientifically based practice in teaching mathematics to students with MD. For example, cognitive strategy interventions are designed to improve performance through compensatory procedures or through more efficient functioning of weak or deficient cognitive processes. Strategy training can be incorporated into classroom instruction or conducted with an individual student. Mnemonic training, which is designed to increase retrieval of information, is the most common and most effective application in teaching math (Lloyd, Forness, & Kavale, 1998).

3- Finally, although that researchers and practitioners suggested that Arabic numerals are more scientifically based and can be used to facilitate helping students with MD; Jordan and most other Arab countries are still using the Hindu numeral system (e.g., 5 ،4 ،3 ،2 ،1) and not the Arabic numeral system (e.g., 1, 2, 3, 4, 5) in education, and particularly in public schools. Thus, policy makers should be informed about the results of this research to guide them in selecting the best educational practice for our children.

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