An investigation of the effectiveness of TouchMath on mathematics achievement for students with the most significant cognitive disabilities

by

Jessica A. Nelson

B.S., Kansas State University, 2006
M.S., Emporia State University, 2009

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF EDUCATION

Department of Special Education, Counseling, and Student Affairs
College of Education

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2019

Abstract

Students with the most significant cognitive disabilities often display deficits in mathematics. One method that has had limited research to determine the effectiveness with students with the most significant cognitive disabilities is a program called TouchMath. The purpose of this study was to investigate the use of the TouchMath strategy with students with the most significant cognitive disabilities in school settings. Interventions were compared and evaluated against the Council for Exceptional Children's *Standards for Classifying the Evidence Base of Practices in Special Education* (CEC-EBP). The results of the study confirmed what previous studies on TouchMath had shown that students made significant gains in the area of mathematical accuracy with single digit addition. Limitations are examined and recommendations for future research are given.

An investigation of the effectiveness of TouchMath on mathematics achievement for students with moderate and severe developmental disabilities

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Approved by:

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Students with the most significant cognitive disabilities often display deficits in mathematics. One method that has had limited research to determine the effectiveness with students with the most significant cognitive disabilities is a program called TouchMath. The purpose of this study was to investigate the use of the TouchMath strategy with students with the most significant cognitive disabilities in school settings. Interventions were compared and evaluated against the Council for Exceptional Children's *Standards for Classifying the Evidence Base of Practices in Special Education* (CEC-EBP). The results of the study confirmed what previous studies on TouchMath had shown that students made significant gains in the area of mathematical accuracy with single digit addition. Limitations are examined and recommendations for future research are given.

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Dedication

To my family: Brent, Finn, Lilly, Liam, mom, dad, Jeremy, and Sarah. Thank you for believing and supporting me along this journey. I love you.

Chapter 1 - Introduction

This chapter provides a review of some of the challenges faced by students with moderate and severe developmental disabilities. Students included in this category are intellectual disability (ID) and autism spectrum disorder (ASD). The focus of this research is on the academic interventions that are needed to help these students succeed in their everyday life. First, an overview of characteristics of students with moderate and severe developmental disabilities will be provided with an emphasis on academic instructional needs for this population. Next, an overview of mathematic interventions, specifically TouchMath will be outlined and discussed. Finally, the statement of the problem will be described, followed by the study's purpose and research questions.

Number Sense

Number sense is vital to a child's development and the outcome of many higher level thinking mathematical problems. Children, who do not develop strong number sense skills, may become at risk for failure in mathematics as the years go on (Sood & Jitendra, 2011). When we look at prior mathematical studies, we find that when children have not learned to compare numbers and count, the difficulties they are having in the area of mathematics, can be contributed to this (Sood & Jitendra, 2011). Students, who lack understanding of number sense, must receive explicit systematic instruction in this area. Some students, who enter school, are lacking a well-developed understanding of numbers (Case, 1985; Hiebert, 1986). More research is needed in the area of and the relationship of number sense to mathematical achievement in students with the most significant cognitive disabilities. When students lack the understanding for basic mathematical skills, they struggle later with mathematical achievement (Sood & Jitendra, 2011).

Piaget and Mathematics

Jean Piaget studied how children perform with "abstract symbolic reasoning and the biological influences on this reasoning (Huitt & Hummel, 2003). Piaget worked off of four main stages of development known as the stages of cognitive development. Stage one begins in infancy known as the sensorimotor stage. Stage two is the toddler age range that is considered the pre-operational stage. Stage three is the concrete operational stage that deals with elementary and adolescent, and finally stage four is the formal operational stage that included adolescence and adulthood.

The concrete operational stage is the stage of cognitive development where elementary and early adolescence learners fail. Piaget states that at this stage, students are using systematic manipulation of symbols and numbers to establish intelligence (Huitt & Hummel, 2003). Piaget strongly believed that everyone must pass through each of the four stages one by one. If you did not pass a stage, you were not able to move onto the next stage (Ojose, 2008). In stating this, if students have not passed through the sensorimotor or pre-operational stage, the concrete operational stage where mathematics begins would be very difficult for students.

For students to understand how to compute simple mathematical addition and subtraction problems, teachers must provide instruction where students have the option of showing and or demonstrating countless mathematical representations of a single problem (Ojose, 2008). Furthermore, having multiple ways of presenting the same math problem through the use of symbols or manipulatives may help the math problem become more meaningful for students (Ojose, 2008).

Students with Moderate and Severe Developmental Disabilities

The current numbers of students with moderate and severe developmental disabilities being served under the Individuals with Disabilities Education Act (IDEA) is 963,000. 425,000 fall under the IDEA category of intellectual disability while 538,000 fall under autism spectrum disorder (U.S. Department of Education, 2016). Intellectual disability (ID) is characterized by significant limitations in both intellectual functioning and in adaptive behavior as expressed in conceptual, social, and practical adaptive skills (Schalock et al., 2010). Autism spectrum disorder (ASD) involves a range of developmental disabilities characterized by issues in social communication and social interaction and restricted, repetitive behavior, interests, or activities (Centers for Disease Control and Prevention [CDC], 2018). With the passage of the No Child Left Behind Act of 2001, for one of the first times, schools needed to ensure that students with moderate to severe disabilities have access to and make progress in the general curriculum. This also includes students with moderate to severe disabilities needing to be assessed using grade-level academic standards (Copeland & Cosbey, 2008). Even with the changes in the laws, the academic outcomes for students with moderate to severe disabilities continue to be unsatisfactory.

Students with the Most Significant Cognitive Disabilities and Mathematics.

Having access to the general education state mathematics standards can be difficult for students with the most significant cognitive disabilities, as they do not have the early numeracy skills of other students. Number recognition, set making and counting, and rote counting are just a few of the early numeracy skills needed to be able to move on to higher level math skills such as problem solving (Jimenez & Staples, 2015). A large number of students with ID and ASD participate in the alternate assessment. In a study by Kearns et al., 6%-13% of students who took an alterative assessment in seven states involved in the study were able to count by rote to 5. Even worse, 12%-17% of students that were in the study did not have any awareness of numbers (Kearns et al., 2011). Acquiring basic skills and concepts such as addition and subtraction facts will help students with moderate to severe disabilities obtain more functional skills later on in their schooling (Westling & Fox, 2009). Historically, students classified with the most significant cognitive disabilities struggle with academic demands in elementary school. In particular, students with severe disabilities have difficulty in the area of mathematics. Students with the most significant cognitive disabilities need to be able to have basic math skills to independently engage and live in society. People without numeracy skills suffered worse disadvantage in employment than those with poor literacy skills alone (Parsons & Bynner, 2007). Furthermore, mathematics literacy is seen as a necessary aspect of adult independence (NMAP, 2008). To be able to add and subtract is an essential part of many independent living skills that students with moderate and severe disabilities will need to master. However, according to the previous literature, students with special needs have challenges and deficiencies in achieving the goals of mathematics (Kroesbergen & van Luit, 2003).

Academic Interventions for Students with the Most Significant Cognitive Disabilities.

When asked about subjects in school, some students state that math is "hard." In one study, 35% of the students stated that math was "difficult" compared to only 10% that stated reading was "difficult" (Mazzocco & Noeder, 2006). As teachers, we expect children to have some sort of conceptual understanding of how addition and subtraction works when they enter school (Klein & Bisanz, 2000). Children begin by learning mathematics by the use of counting based strategies such as verbal and finger counting. These strategies should develop into memory-based processes such as decomposition and retrieval (Siegler & Shrager, 1984). Based on a study by Gary and colleagues (2004) students with mathematical learning difficulties continued to use finger counting rather than move towards the memory-based processes. Children who have the most significant cognitive disabilities are at risk for having a far greater disadvantage to same aged peers if they are not taught how to count and calculate simple addition problems (Kaufmann & Dowker, 2009).

Students with disabilities were required to have access to the general curriculum including district assessments and state assessments (IDEA, 1997). The area of mathematics is one of the academic areas in which research is extremely limited (Browder, Jimenez, & Trela, 2012). The focus for many years on academic interventions for students with the most significant cognitive disabilities has been on functional curriculum. In multiple reviews of literature, systematic instruction using principles of behavior analysis were most effective when working with students who have moderate to severe disabilities (Spooner, Knight, Browder, & Smith, 2012). Systematic, direct instruction is one of the staples of behavior analysis which is how TouchMath should be taught. For students to have a high quality educational program, seven key points should be examined: (a) students should have access to typical peers, (b) exposure to the general curriculum with modifications, (c) access to modification and assistive technology as needed, (d) highly trained and knowledgeable staff, (e) open communication between the team and parents as well as school staff, (f) caring and positive environment, and (g) a balanced educational program (Downing and Peckham-Hardin, 2007).

Mathematic Interventions for Students with the Most Significant Cognitive Disabilities.

Students with disabilities are scoring below the basic level in the area of mathematics (National Assessment of Educational Progress, 2015). Since 2011, students with disabilities have not significantly improved in the area of mathematics. According to the National Council of

Teachers of Mathematics, students must understand the following five areas of mathematics: numbers and operations, algebra, geometry, measurement, and data analysis and probability. In the area of numbers and operations, students are expected to compute mathematics problems with fluency as well as understand numbers and the meanings of operations (NCTM, 2000). When teaching mathematics to students with the most significant cognitive disabilities, direct instruction is shown to be the most effective method when trying to increase basis mathematic skills such as numbers and operations (Browder et. al, 2008). Touchmath is a program that is designed to work on the area of numbers and operations through the use of direct instruction. More information about TouchMath is found in Chapter 2.

Rationale

Many studies on mathematic intervention for the general education population have been done. Even studies with students who have the label of learning disability have had numerous studies on math interventions. However, students with the most significant cognitive disabilities including ID and ASD have very few quality studies for mathematic interventions.

Purpose

The purpose of this study was to examine the effectiveness of TouchMath on math achievement involving students with the most significant cognitive disabilities. In this study, TouchMath will be implemented with four students who are diagnosed with ASD and ID in a resource setting. The study determined the impact TouchMath has on math achievement for each student. The following research questions will be investigated:

1: Does the implementation of TouchMath increase math achievement scores for students with moderate and severe developmental disabilities?

2: Can students maintain math achievement scores with the use of the TouchMath strategy over time based on probes?

Chapter 2 - Review of Literature

The purpose of this chapter is to provide a review of the existing literature base on the use of the TouchMath strategy for students with the most significant cognitive disabilities. Specifically, the literature review focused on mathematic achievement for students with the most significant cognitive disabilities. First, an overview of TouchMath will be provided.

TouchMath

TouchMath is a multisensory approach for use with basic computation math skills. The definition of TouchMath is with a student seeing, touching, saying, and hearing each digit, student achievement in basic computation will be higher than other students who do not use the TouchMath approach.

Each digit, numbers 1-9 has what is called a TouchPoint that matches with the numerical value of the digit. The numbers 1-5 have a single TouchPoint while numbers 6-9 use double TouchPoints represented by a dot inside of a circle.

Figure 2.1: TouchPoints. Copyright: TouchMath

When using TouchMath for computation purposes, the numbers with a single TouchPoint are touched once and counted aloud once. For the numbers that have the double TouchPoints, those dots are touched twice and said aloud twice.

The TouchMath method simplifies and clarifies all areas of computation, develops left/right directionality, reduces number reversals, reinforces number values, eliminates guesswork and helps to develop positive student self-images (TouchMath, 2004).

Previous Reviews

Upon searching for previous reviews on TouchMath with students with disabilities, only one review was found. Ellingsen & Clinton (2017) conducted a narrative review of the TouchMath instructional program. The review looked at computational skill repertories and the use of TouchMath for students that are at risk or have disabilities. The review also noted at what population of students the literature had been studying regarding TouchMath as an instructional program. Lastly, the study looked at the implications for practice regarding TouchMath. The search criteria and the terms they used seemed to be thorough and complete.

However, the researchers did not combine effect size data nor did they consider the issue of publication bias. The Council for Exceptional Children's *Standards for Evidence-based Practices in Special Education* guidelines was not used to determine if TouchMath is a possible evidence-based practice.

Systematic Review of Literature

The intention of this review was to examine findings on TouchMath by looking at and analyzing all published studies and dissertations regarding the use of TouchMath with students who have the most significant cognitive disabilities. The following research questions were used to guide this literature review:

Research Question 1: What is the effectiveness of teaching math to students with disabilities with the use of the TouchMath program?

Research Question 2: Is TouchMath considered an evidence-based practice when analyzed against the Council for Exceptional Children's *Standards for Evidence-based Practices in Special Education* (2014).

Methods

A systematic search of the peer-reviewed literature involving the use of TouchMath with students with disabilities was conducted. First, the databases Academic Search Premiere, PsychINFO, Education Full-text, and ERIC were searched using the following Boolean phrase: ("Touch math" OR "touchmath" OR "touch-math") A member of the research team also conducted an ancestral search by screening the reference list of the included articles and previous review to help find studies that may have been missed by the database search. The final database search was completed on April 1st, 2018.

Inclusion and coding process.

After the database search was finalized, the researcher screened the titles and abstracts of each article. Once the titles and abstracts were screened, a coding sheet was developed. Each study that met the standard for inclusion was coded using the following variables: (a) participant characteristics; (b) setting; (c) type of publication; (d) independent variable; (e) dependent variable, and (f) intervention agent. When looking at the participant characteristics, additional demographic variables were also recorded, which included age, student grade, race, and gender. When coding the setting researchers looked for a general education classroom, resource room, self-contained classroom, special day school, or residential school. Intervention agent was coded as a researcher, graduate student, teacher, or paraprofessional.

Inclusion criteria

To be included in the article, studies had to meet the following inclusion criteria. First, studies must have been published in a peer-reviewed journal. Second, studies must have presented the initial findings from an experimental investigation including randomized control trial, quasi-experiment with a control group, or single-case design. Third, the study had to include TouchMath as an independent variable. Fourth, students in the study needed to have a disability, and finally, the study must have been performed in a school setting.

Study Quality

The Council for Exceptional Children's *Standards for Evidence-Based Practices in Special Education* standards (CECEBP, 2014) was used to determine the quality of each study. The standards were used to assess the following eight domains for each study: (a) context and setting, (b) participants, (c) intervention agent, (d) description of practice, (e) implementation fidelity, (f) internal validity, (g) outcome variables, and (h) data analysis. A member of the research team coded each article that was included in the study. To meet the indicator in each domain, the author of the study had to clearly state the information in the article. Once the coding of the standards was completed, researchers calculated a percentage of the standards met for each study.

Study Outcomes and Data Analysis

Group design effect sizes. The four group designs that were found for this study needed to report means, standard deviation, and number of participants in each group of the study in order to calculate the group effect sizes. Three out of the four group designs provided the data needed to run the effect sizes. Comprehensive Meta-Analysis (CMA, Version 2.2.064) was used to calculate the effect sizes. CMA calculated *d* and the standard mean difference and then converted those results into Hedges's *g* statistic.

Single-case effect size. To determine the appropriate effect measure for SCD in this study, four metrics were examined: (a) response rate (RR) resulting from visual analysis, (b) the percent of non-overlapping data (PND) (Scruggs, Mastropieri, & Casto, 1987), (c) the standard mean difference (*d;* Busk & Serlin, 1992), and (d) Hedges's *g* for SCDs (Shadish, Hedges, & Putejovsky, 2014).

Table 2.1 *SCD Study Effects*

Study	RR/*n*	PND% (SD)	*g* (var.)	95% CI
Avant & Heller (2011)	3/3	93	1.961(1.421)	-0.375-4.297
Calik & Kargin(2010)	3/3	100	1.379(0.634)	-0.181-2.939
Cihak & Foust (2008)	3/3	94	0.662(0.219)	-0.255-1.579
Fletcher et al. (2010)	3/3	100	8.188(2.776)	4.923-11.453
Simon & Hanrahan (2004)	3/3	100	11.795(7.118)	6.566-17.024
Newman (1994)	4/4	98	6.633(12.204)	-0.214-13.481
Total	19/19	97.5(3.209)	-	-

Note: CI = confidence interval; *g* = Hedges' *g*; PND = percent of nonoverlapping data; RR = Response Rate; SD = standard deviation; var. = variance

Response rate was calculated by visually analyzing graphed data provided by each study. (Kazdin, 2011). The use of the *Procedures and Standards Handbook (Version 3.0)* from the What Works Clearinghouse (2014) was utilized to determine the response rate for each study. When looking at the graphed data, the researcher was specifically looking for changes in level, trend, and variability between baseline data and treatment phases. To calculate the overall response rate, the researcher took the total number of responses in a study and divided by the total in the intervention to determine if a functional relation was demonstrated.

Percent of non-overlapping data (PND, Sruggs, Mastropieri, & Casto, 1987) was used as it is one of the most widely used outcome measures in a single-case design meta-analysis (Scruggs & Mastropieri, 2013). PND is an extremely reliable method of evaluating SCD (Scruggs & Mastropieri, 2013). PND of ≥ 70% is thought of as an effective intervention, 50-69% is considered questionable, and <50% is thought of as ineffective (Scruggs & Mastropieri, 1998). PND measures the percent of intervention data points that surpass the greatest baseline data point. To calculate PND, the number of treatment points above the highest baseline data point was divided by the total number of treatment points (Scruggs et al., 1987).

Publication bias. The tendency to exclude the publication of studies with null results is a serious concern in special education research (Shadish, Zelinsky, Vevea, & Kratochwill, 2016) as well as in the social sciences (Cook, 2014; Maag & Losinski, 2015). Part of the problem being that there is not one agreed upon method for approaching publication bias in the field. The current meta-analysis addresses publication bias by using multiple approaches when looking at the data.

The analyses conducted included Egger's regression of the intercepts test (Egger, Davey Smith, Schneider, & Minder, 1997) and Duval and Tweedie's trim and fill method (Duval & Tweedie, 2000). Egger's regression of the intercept test takes the standard error and divides it by the effect size. The size of the treatment effect is displayed as the regression line, while the bias is captured by the intercept. If the intercept is zero, there is likely no bias present. An intercept of more than zero would indicate the presence of publication bias. Duval and Tweedie's trim and fill method inputs the included studies into a funnel plot. It is expected the funnel plot be symmetric with the studies distributed evenly on either side of the mean effect. In the event the studies are not symmetric, it is determined where the missing studies would likely fall if included and the effect size is recalculated with the new data points. The final approach included studies not limited to peer-reviewed studies but included all publically available studies.

Results

The initial search produced 35 results. After removing duplicates, 23 articles remained. The researchers screened the titles and abstracts discovering that 22 articles remained for possible inclusion. These twenty-two articles were then measured against the inclusion criteria, ending with 6 articles that fit the criteria. Hand searches of *American Journal on Intellectual and Developmental Disabilities,* and *Intellectual and Developmental Disabilities* did not result in any further studies to include in this meta-analysis. A search of the references of the previous review led us to an additional 5 studies to be included. Finally, 11 articles were included in the review. See Figure 1 for a detailed flow diagram of the search procedures.

Study Characteristics. A total of 331 participants were included in the 11 studies that were included in this current meta-analysis. The number of participants ranged from 3 (Avant & Heller, 2011) to 110 (Bedard, 2002). The mean age of participants ranged from 6.5 years old to 13.3 years old. The overall mean age of the participants included was 8.9. However, the mean age does not include the three studies that did not report ages of participants. Male and female participants were almost even between the 11 studies. Of the 11 studies, 52.6% were male participants. Refer to Table 2 for additional details of study characteristics.

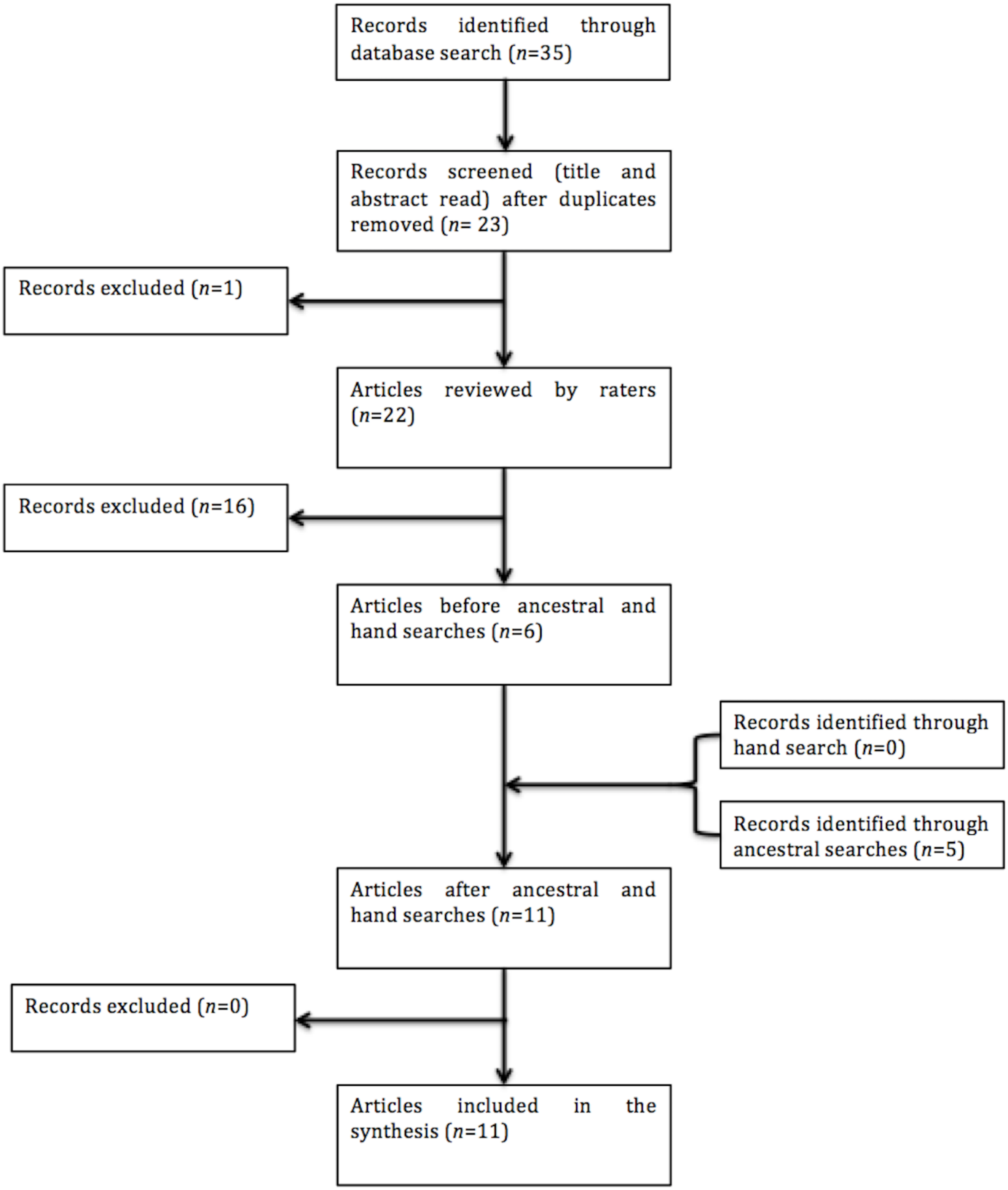

Figure 2.2: Flow diagram of search procedures

Table 2.2

Study Characteristics

Study	*N*	Age	Gender	Setting	Intervention Agent	Dependent Variable	Design
Avant & Heller (2011)	3	8	67% M	RR	Teacher	Percentage Correct	SCD
Bedard (2002)	110	6.5	DNS	SC	Teacher	Math Achievement	Quasi
Calik & Kargin (2010)	3	8	33% M	RR	Researcher	Math Achievement	SCD
Cihak & Foust (2008)	3	7.3	33% M	RR	Teacher	Percentage Correct	SCD
Dulgarian (2012)	20	DNS	65% M	DNS	Researcher	Percentage Correct	SCD
Fletcher et al., (2010)	3	13.3	67% M	SC	Teacher	Percentage Correct	SCD
Jhaveri et al., (2012)	22	7-8	DNS	GE	Researcher	Math Achievement	RCT
Mostafa (2013)	60	DNS	73% M	DNS	Teacher	Math Achievement	RCT
Simon & Hanrahan (2004)	3	10	33% M	RR	Teacher	Percentage Correct	SCD
Newman (1994)	4	10.75	50%M	SC	Researcher/Teacher	Percentage Correct	SCD
Uzomah. (2012)	100	DNS	DNS	GE	Researcher/Teacher	Math Achievement	Quasi

Note: CS = Case Study; DNS = Did Not Specify; M = Male; RR = Resource Room; SC = Self-Contained; SCD = Single Case Design; SD = Special Day

Effects of Studies. Table 2.3 displays the results of the effects for Hedges *g* for both SCD and group designs. The total effect size was large (g = 2.302 [0.533], p = 0.000). Effect sizes ranged from a high of g = 11.795 and a low of g = 0.521.

Table 2.4 shows the results of the response rate (via visual analysis) and PND (Scruggs et al., 1987). Visual analysis of graphs resulted in a response rate of 100%. The overall PND was 97.5%, which is interpreted as an effective intervention based on the guidelines provided by Scruggs and colleagues (1987). The range of PND included a high of 100% (Calik & Foust, 2010) and a low of 93% (Avant & Heller, 2011) demonstrating an effective outcome for all SCD studies included in the analysis.

Table 2.3

Effect Sizes

Design	Study	DIS	*g*	SE	var	Lower Limit	Upper Limit	Z	p
RCT	Jhaveriet al. (2012)	LD	2.295	0.384	0.148	1.542	3.048	5.975	0.000
RCT	Mostafa (2013)	LD	2.983	0.373	0.139	2.252	3.714	7.998	0.000
Quasi	Uzomah (2012)	Other	0.618	0.203	0.041	0.220	1.016	3.041	0.002
SCD	Dulgarian (2012)	LD	0.521	0.436	0.190	-0.334	1.376	1.195	0.232
SCD	Newman (1994)	ID	6.633	3.493	12.204	-0.214	13.481	1.899	0.058
SCD	Simon & Hanrahan (2004)	LD	11.795	2.668	7.118	6.566	17.024	4.421	0.000
SCD	Fletcher et al. (2010)	Other	8.188	1.666	2.776	4.923	11.453	4.915	0.000
SCD	Cihak & Foust (2008)	ASD	0.662	0.468	0.219	-0.255	1.579	1.415	0.157
SCD	Avant & Heller (2011)	Other	1.961	1.192	1.421	-0.375	4.297	1.645	0.100
SCD	Calik & Kargin (2010)	ID	1.379	0.796	0.634	-0.181	2.939	1.732	0.083
Total			2.302	0.533	0.284	1.257	3.346	4.317	0.000

Note: DIS=disability = Hedges *g* *SE*=Standard Error; var = variance; Z = Z-score; p = p-score; CI = confidence interval

Study	RR/*n*	PND% (SD)	*g* (var.)	95% CI	
Avant & Heller (2011)	3/3	93	1.961(1.421)	-0.375-4.297	
Calik & Kargin(2010)	3/3	100	1.379(0.634)	-0.181-2.939	
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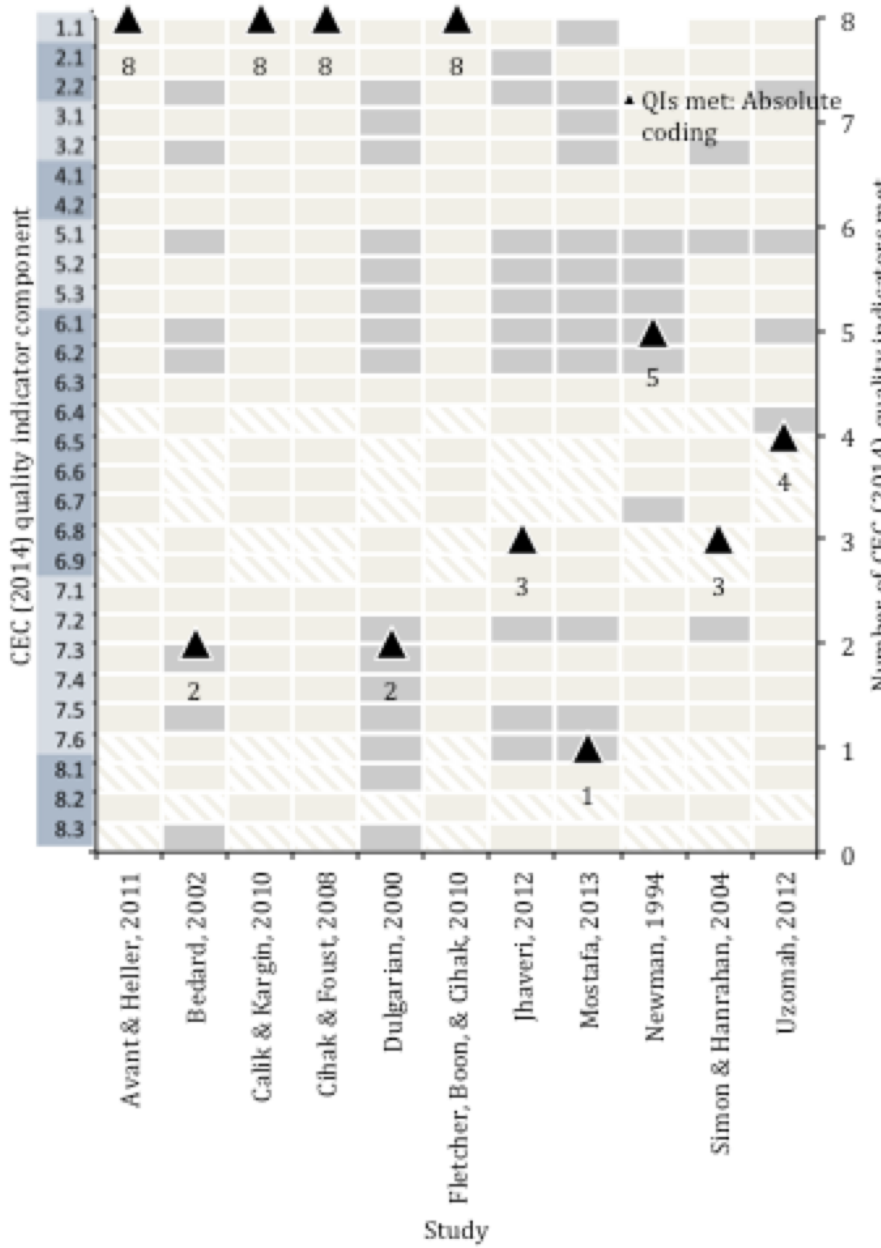
Fletcher et al. (2010)	3/3	100	8.188(2.776)	4.923-11.453	
Simon & Hanrahan (2004)	3/3	100	11.795(7.118)	6.566-17.024	
Newman (1994)	4/4	98	6.633(12.204)	-0.214-13.481	
Total	19/19	97.5(3.209)	-		-

Note: CI = confidence interval; *g* = Hedges' *g*; PND = percent of nonoverlapping data; RR = Response Rate; SD = standard deviation; var. = variance

Table 2.4 SCD: Response rate and PND

TouchMath and the CEC (2014) Standards for Evidence-Based Practices. Each study was compared to the CEC-EBP (2014) to establish the quality of each study. Four studies met all of CEC's quality indicators (Avant & Heller, 2011; Calik & Kargin, 2010; Cihak & Foust, 2008; Fletcher et al., 2010). The percentage of met indicators was computed for all studies. The most commonly omitted indicator (n=7) looked at the use of implementation fidelity through the use of a checklist (indicator 5.1). Based on the information, TouchMath could be considered a possible evidence-based strategy. One other commonly omitted indictor looked at whether the study controlled and systematically manipulated the independent variable (n=6; indicator 6.1). Figure 2.3 provides further information about the quality indicators met by each of the studies.



Note: Left *y* axis displays the components of CEC (2014) quality indicators (QI). Shaded cells indicate the component was met; gray cells denote the component was not met; diagonal lines signify the component did not apply to the study. The right *x* axis shows the number of absolute QI.

Figure 2.3: CEC quality indicators

Discussion

The current meta-analysis examined effects of mathematics achievement with the use of TouchMath on students with disabilities. Included studies all showed TouchMath to be an effective intervention for students with disabilities. Based on the *Council for Exceptional Children Standards for Evidence-Based Practices in Special Education* (2014), TouchMath is potentially an evidence-based practice according to the standards as two to four methodologically sound single subject studies with positive effects were found in this study.

Implications for practice. Based upon the data from the current TouchMath literature, teachers should consider the use of TouchMath with students who struggle with math achievement in the areas of addition and subtraction facts. Some critical components of TouchMath gathered from this study were the following: (1) TouchMath must be taught using direct instruction of the dot-notation system; (2) the use of modeling how to count the points on each number, feedback when the number is counted incorrectly, clear explicit instructions, guided practice though the use of the dots on the numbers, and specific praise for using the strategy as taught will increase the success of the intervention; (3) TouchMath may also be used in conjunction with behavior modification strategies such as reinforcement systems.

Limitations and Future Directions

A number of limitations exist for this current study meta-analysis. First, the study included studies that were not included in the previous review (Ellingsen & Clinton, 2017), so it is possible the current search did not include all studies that would have met inclusion criteria. The second limitation is the small number of studies included in the review. The number of studies used to calculate an overall effect size was ten as one of the studies was omitted from effect size calculations due to a lack of appropriate data. Additional studies would be needed to provide enough evidence to establish TouchMath as an evidence-based practice. With the small number of studies available to be in the study along with the fact that 7 out of 11 of the studies were SCD studies, effect size could have been increased. Previous research suggests that SCD effect sizes, like *g,* may be overinflated (Valentine et al., 2016).

Overall, results of the current literature review indicate TouchMath could be considered a possible evidence-based strategy for students with disabilities. More research is needed in this area to prove that it can be utilized in the classroom as an evidence-based strategy and it deserves future research.

Chapter 3 - Method

This study used a multiple baseline with probes across participants design. Students at one elementary school that were identified as having the most significant cognitive disabilities by staff and also had IEP goals in the area of addition and subtraction were chosen to be in the study. All students were baselined for math achievement in the area of addition and started the TouchMath interventions after a stable baseline was obtained. Following the intervention, analysis of data collected was used to answer the following research questions:

1: Does the implementation of TouchMath increase math achievement scores for students with the most significant cognitive disabilities?

2: Can students maintain math achievement scores with the use of the TouchMath strategy over time based on probes?

Experimental Design

This study evaluated the TouchMath strategy on the mathematics accuracy of addition facts of students with the most significant cognitive disabilities using a multiple baseline with probes across participants. The multiple baseline across participants design is the most widely used of all three forms of design as teachers often have more than one student who needs support to learn a skill (Cooper, Heron, &Heward, 2007). Effect is demonstrated when using a multiple baseline design by showing the changes only when the intervention is applied (Kazdin, 2011). Ethical concerns are also alleviated with a multiple baseline design as withdrawing the intervention is not needed (Kazdin, 2011).

To ensure that one of the students did not access the intervention, one student, after stable baseline was achieved started the intervention while the other students continued with baseline.

Setting, Participants, and Materials

Setting.

Following IRB approval, one elementary school was invited to take place in the study. The school was chosen based on the need for mathematics interventions as expressed by their special education teacher. The study took place in a rural, public school district in the Midwest portion of the United States. The intervention took place in a special education classroom where the students spent at least half of their day. The classroom had 1 special education teacher, 4 paraprofessionals, and six other students present at the time of the intervention. The intervention took place at a kidney shaped table behind three dividers so the student and the teacher were the only ones in the intervention area. The school serves free lunch to 73% of their population and another 12% receive reduced lunch. The schools demographics are 85% Hispanic, 5% Asian, and 9% Caucasian.

Participants.

Four elementary students participated in the study based on the following criteria: (a) the student is being served under the IDEA as having a disability, (b) the student is between the ages of 5 and 13, (c) the student must have an addition math goal stated in the IEP, (d) the parent must return the consent form. Participant four moved two weeks into the study. The teacher was unaware he was moving and did not know of his whereabouts. He had not started intervention yet therefore he was dropped from the study.

Participant 1. Lincoln was in fourth grade at the time of this study. Lincoln is a 10-year-old male who has a diagnosis of Autism and speaks English. According to Lincoln's most recent ABAS-2, "Lincoln encounters great difficulty in all areas assessed by the ABAS-2. This is seen in all environments in the school setting. The curriculum will need to be modified significantly so as to be of benefit to Lincoln. His educational program should include self-help skills and functional academics. He will require a curriculum that is at his instructional level and is presented in all modalities concretely so he is able to grasp concepts. Lincoln will require much more practice and drill than same aged peers. Practicing these concepts is vital so he will be able to transfer his knowledge and application to the real world."

Participant 2. Georgia was in first grade at the time of this study. Georgia is a 6-year-old female who has a diagnosis of Autism and speaks English. According to Georgia's teachers, in math, Georgia can count objects up to 80. Georgia can sort by shape, color, and size. Georgia can label colors (red, orange, yellow, green, blue, purple, pink, white, brown, and black). She can label several shapes (circle, oval, rectangle, square, diamond, heart, star, hexagon, pentagon, octagon). Georgia displays basic problem-solving abilities. It is important that Georgia's day be consistent and routine.

Participant 3. Aliyah was in third grade at the time of this study. Aliyah is a 9-year-old female who has a diagnosis of Autism and speaks English. According to teacher report, it is estimated that Aliyah's cognitive abilities are in the lower 1% of all children her age. Aliyah was administered the FISH which is an assessment instrument as well as sample lesson plan for each item evaluated for individuals with significant developmental delays. At this time, Aliyah knows 27% of the skills in the curriculum independently.

Participant 4. Jose was in second grade at the time of this study. Jose is a 7-year-old male who has a diagnosis of Autism and speaks English. According to teacher report, Jose's overall cognitive ability score is in the extremely low range of ability with a standard score of SS=32; <.1% percentile rank (based on the 2 subtest conversion). Jose was given the Wechsler's

Nonverbal Scale of Ability (WNV). Jose has a history of significantly delayed communication that prompted the administration of this particular battery that allows for a measurement of general cognitive ability without the use of verbal subtests.

This score suggests that Jose may experience significant difficulty in learning a variety of academic skills needed to meet age and grade level standards. Jose may require a specialized instructional plan in order to meet his needs.

Adult Participants. One special education teacher was directly responsible for implementing the intervention, providing all assessments, and collecting the permanent product data. The teacher was a 27-year-old Caucasian female who held a Bachelor's degree in elementary education with an emphasis in special education. The teacher was working on her final year in a Master's degree program for low-incidence special education. She held teaching licenses from the state in elementary education and a wavier in adaptive special education. She has taught for two years in the elementary school where she is currently teaching.

The researcher performed data collection and analysis. The researcher was a 35-year-old Caucasian female who held a Bachelor's degree in elementary education, a Master's degree in adaptive special education, and a third year doctoral student. She held teaching licenses from the state in both elementary education and K-8 adaptive special education. She also held the credential of a Board Certified Behavior Analyst. She had previously taught for nine years in a resource room setting at the elementary level.

The intervention took place during the student's regular mathematics time in the resource room. This time was already built into the student's schedule.

Materials.

For this study, the materials from TouchMath addition kit were utilized. The lessons were created by the researcher and followed the order of the worksheets that were provided in the kit. Checklists were created by the researcher to be used by the teacher during instruction. Examples of the lessons and the checklists can be found in Appendix A. Materials that were used in the intervention include number cards with dots on each number, addition worksheets with dots on each number, and addition sheets with dots removed from each number. Examples of these materials can be found in Appendix B. Each worksheet used in the intervention was collected by the teacher and sent to the researcher for data analysis.

Dependent Variables, Procedures, and Social Validity

Dependent Variables.

Mathematics Accuracy. The dependent variable was the percentage of single-digit addition problems that each student could correctly answer. Curriculum based measurement (CBM) was used to determine how many addition facts students were able to perform without assistance from the teacher. According to Fuchs & Fuchs (2005), CBM is a standardized and systematic method to progress monitor students. All students were asked to complete a CBM while the teacher watched. If the students asked for help, the teacher would simply say, "try your best." For the purposes of this study, mathematics accuracy was defined as: "Accuracy is how close a measured value is to the actual (true) value" (NCTM, 2000).

Procedures

Participant Selection. Participants were selected based on scores obtained from the universal screening conducted by the school district. Students included either had an IEP goal or showed a need for number sense support were selected to participate in the study.

TouchMath Training. Once consent was obtained from each parent of the students selected for the study, the teacher participated in an hour long training of TouchMath provided by the researcher. The training consisted of learning about each number and how many dots were to be placed on each number and where the dot placement should be on the number. For example for the number 2, you place the first dot at the start of the number and the second dot at the end of the number. The next topic was covering CBM's that students would be taking and the order in which they would take them. The final piece was going over the lessons plans for each day and making sure that the teacher understood the order of lessons and how to use the checklist.

Baseline. Students were given a worksheet with 10 single-digit addition problems on it. During baseline, the teacher did not provide instruction, feedback, or assistance of any kind. Looking at the number of addition problems that each student solved correctly and then dividing that number by the amount of problems on the CBM collected baseline data. Baseline consisted of a minimum of three sessions. After each student completed their baseline phase, students were then trained on the dot notation system. Students were allowed 20 minutes to complete the worksheet. If the students said they were done before the 20 minutes, the teacher collected the worksheet. All students finished the worksheet before the 20 minutes was completed.

Intervention. TouchMath addition (2004) was used to deliver the intervention to each of the participants. Before the lessons were introduced, two pre-lessons were given to the students to teach them about TouchPoint and how each pointed represented the number. Once the two pre-lessons were delivered, the student would then start with lesson 1. Pre-lessons and lesson examples can be found in Appendix A. Each lesson lasted approximately 30 minutes and occurred daily until the addition intervention kit was completed. A total of nine lessons were taught to each student during the intervention stage. During the intervention phase, students were presented with an addition worksheet where TouchPoints were applied to each number. Students would then count the TouchPoints to get the sum of the two single-digit numbers. A checklist for each lesson was developed to ensure the teacher was delivering the intervention with integrity. The worksheets were scored by the researcher and a gradate student and then calculated by summing the number of correct response and then dividing those response by the total number and multiplying by 100. Maintenance probes were then conducted as each student finished the intervention to determine generalization of the skill.

Data Analysis. To determine the appropriate effect measure for SCD in this study, two metrics were examined: (a) response rate (RR) resulting from visual analysis and (b) the percent of non-overlapping data (PND; Scruggs, Mastropieri, & Casto, 1987).

Treatment Fidelity. A daily lesson checklist was utilized to ensure treatment fidelity during this study. The checklist systematically stated lesson procedures, teacher prompts, and which addition worksheet should be used for which day. The teacher completed a checklist for 100% of the TouchMath intervention lessons.

Interobserver Agreement. Interobserver agreement (IOA) was collected by the teacher and the researcher. The researcher trained a graduate student to check the accuracy of the addition problems on each sheet. The answer key was provided to the graduate student by the researcher and independently scored 30% of the math addition probes. IOA was calculated by adding the number of agreements and then dividing those agreements by the total number of agreements and disagreements and then multiplying that number by 100 (Gast & Ledford, 2014.)

Social Validity. At the conclusion of this study, social validity was assessed through an evaluation by the participating students. The Children's Intervention Rating Profile (CIRP) (Witt

& Elliot, 1985) was given to the students by the researcher. The CIRP has strong psychometric properties and is a widely used measure of social validity (Ennis, Jolivette, & Boden, 2013). The CIRP obtains social validity information from the student's perspective through the use of a 7-item questionnaire. Due to the level of cognitive ability of the students in the study, a happy face or a sad face was present. (Happy face=I agree, sad face=I do not agree). Higher scores on the CIRP represent higher treatment acceptability. For this particular instrument, the higher the scores are, the higher the social validity is. An example of the CIRP can be found in Appendix C.

Chapter 4 - Results

The percentages of correct addition problems are presented in figure 4.1. Overall, significant improvements in mathematics accuracy were shown based on data collected from the intervention phase as well as maintenance phase. All three of the participants showed significant improvements in the intervention phase using the method of the TouchPoints. Correct responses from all three participants are shown in the baseline, intervention, as well as the maintenance phases of the study.

Participant 1. As shown in Figure 4.1, participant one performed between 0-10% on his first three single digit addition math probes. The participant was only able to complete one single digit addition math problem correctly in the baseline phase. Once the intervention phase started, participant one ranged from 75-100% correct on his daily TouchMath worksheets. In the maintenance phase, participant one was able to maintain his accuracy on daily math probes without the TouchPoints present. These scores ranged from 80-100% correct. Visual analysis shows a swift immediate effect following the implementation of the intervention phase. Participant was also able to maintain this effect through the maintenance phase. When looking at participant one's data over the baseline and intervention phase, the PND for participant one is 100%.

Participant 2. Participant two ranged in baseline on single digit addition math probes from 0-20% as seen in Figure 4.1, with the last three probes at 0%. Once intervention was started with participant two, the range of correct problems on her daily TouchMath worksheet was 30-100%. In the maintenance phase, participant two ranged from 20-80% on daily math probes without TouchPoints on the numbers. Upon visual analysis of the graph, participant two had more variability than participant one had. You can observe that participant two also had a swift and immediate effect following the implementation of the intervention phase. However, the teacher reported that as the TouchMath worksheets became longer, participant two would “refuse” to complete all of the assigned problems. Due to this, you will see the variability in the data. Participant two would only complete up to ten problems before crawling under the table. When looking at participant two’s PND between baseline and intervention phase, again the PND was at 100%. After the completion of the study, the teacher reached out to the researcher asking for help as she had gathered more data that participant two would crawl under the table and “shut down” when asked to do the numbers with double TouchPoints (6, 7, 8, 9). The teacher reduced the number of problems on the page for participant two and increased the amount of reinforcement the student received for completing these problems. The data began to show that the student was able to complete all of the math problems using her double TouchPoints.

Participant 3. Finally, participant three ranged in baseline scores from 0-30% on his single digit addition math problems. Probes 6-16 were all scored at 0% accuracy. During intervention, participant three ranged in accuracy from 35-80% on his single digit addition TouchMath pages. Finally in the maintenance phase, the range of scores for participant three was 30-90% on his daily math probes without TouchPoints. Visual analysis of participant three over baseline compared to intervention phase again shows a significant increase following the implementation of the intervention phase. When calculating the PND for participant three between baseline and intervention phase, the PND was 100%.

Participant 4. Participant four that was mentioned in chapter three left the school during his first week of baseline probes. The teacher could not give any details due to confidentiality issues. The student was not in a place where he could continue the TouchMath intervention and therefore was dropped from the study.

Based on teacher observation and teacher report, participants two and three had multiple behaviors during the intervention and maintenance phases of the study. Participant two would crawl under the table and refuse to work on any math problems that had the numbers 6-9 present in them.

Social Validity

The results of the adapted CIRP survey indicated that students felt the TouchMath strategy was effective for them. In question 1, the survey asked students if TouchMath was "too much for them." Two students agreed and one student did not agree (M = .67 for agree). In question 2, the survey asked students if they understood why TouchMath was picked. Two students agreed and one did not agree (M = .67 for agree). Question 3 asked if the student would use TouchMath again. All three students agreed they would use this strategy again (M = 100). Question 4 of the survey asked if TouchMath was a good strategy to help students. Again, all three students agreed to this question (M = 100). Question 5 asked if the student understood what they needed to do for the TouchMath strategy. All three students agreed with this question (M = 100). Question 6 asked whether the student wanted to try the TouchMath strategy again. Once again, all three students agreed to the statement in the survey (M =100). Finally, question 6 asked whether a student would tell a friend who is struggling with math to try TouchMath. All three students agreed to this question (M = 100).

According to the teacher who implemented the intervention in her classroom, she reported that the TouchMath intervention was extremely beneficial to her students. She used the intervention strategy with a variety of age and academic and all students showed improvement in math achievement scores. The teacher reported that the program allowed for her students to move at their own pace. Teacher stated, "I love that it targets several major senses (tactile, auditory, visual) which made it easy for my students to catch on. The repetitive nature of the lessons was essential for student success. Each new lesson they built momentum by practicing previously learned skills, which lead them to have the motivation to learn the new skill that day." The teacher reported that she did wish that students could have worked more on single Touchpoint numbers (1-5) for the first few lessons before adding double Touchpoint numbers (6-9). The teacher reported that teaching other adults this strategy was easy and that was an added bonus to this experience. The teacher has stated this was a positive experience and she would continue to use TouchMath in the future.

Table 4.1

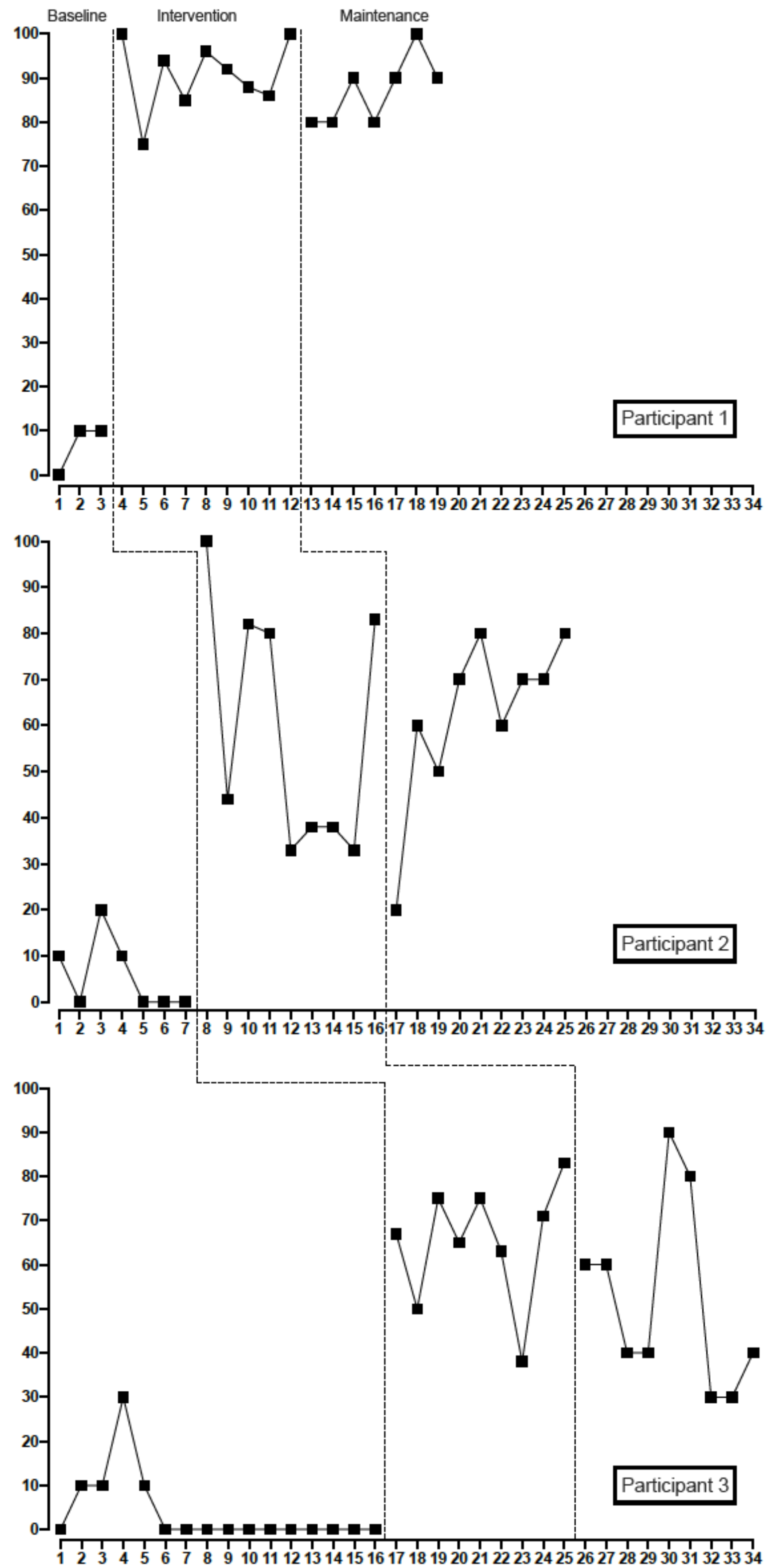
Participants

	Total	*M*	*Sd*
Participant 1	27	100	2.67
Participant 2	27	0.71	2.67
Participant 3	27	100	2.67

Note: M=mean of responses. Sd= standard deviation

Summary of Findings

The purpose of this research was to determine the effect the intervention program TouchMath had on math achievement for students with the most significant cognitive disabilities. The study examined two main research questions: (a) does the implementation of TouchMath increase math achievement scores for students with moderate and severe developmental disabilities, and (b) can students maintain math achievement scores with the use of the TouchMath strategy over time based on probes? The result of the study indicated that TouchMath could be an effective intervention in increasing math achievement scores for students with the most significant cognitive disabilities. All three participants demonstrated a significant increase in single digit addition math accuracy from baseline to intervention phase with the use of TouchMath and the TouchPoints. To answer the second question, all students were able to remain at or above baseline levels in the maintenance phase of the intervention showing that they were able to generalize and maintain math achievement scores over time. Participants two and three displayed behaviors during both the intervention and maintenance phase of the study, which shows in the variability of the data. Even with the behaviors and the variability of the data, visually we can still see a strong demonstration of effect through the use of the TouchMath intervention for all participants in the study.



% correct

Figure 4.1: Percentage of correct single-digit addition mathematics problems using the TouchPoint strategy by participant.

Chapter 5 - Discussion

The purpose of this study was to examine the effectiveness of TouchMath addition on students with the most significant cognitive disabilities. Generally, TouchMath addition seems to be an effective strategy to address deficits in addition mathematical accuracy in students with the most significant cognitive disabilities. The current study examined effects of mathematics achievement with the use of TouchMath on students with disabilities. Specifically, the study sought to examine not only the effectiveness of TouchMath with students with disabilities but if TouchMath could be considered an evidence-based practice when analyzed against the Council for Exceptional Children's *Standards for Evidence-based Practices in Special Education (*2014). The TouchMath sessions were carried out in a special education classroom with three students with Autism Spectrum Disorder. The study utilized a multiple-probe design (Baer, Wolf, & Risley, 1968; 1987; Horner & Baer, 1978) involving three phases: (a) baseline, (b) intervention, and (c) maintenance. This chapter will summarize the results of the study, provide implications for practice, and discuss the limitations and suggestions for future research.

TouchMath

Results of this study were consistent with previous research concerning the use of TouchMath for students with disabilities. The effectiveness of the program showed positive results for students with the most significant cognitive disabilities. Listed below are the two research questions that this study sought to answer.

RQ1: Does the implementation of TouchMath increase math achievement scores for students with the most significant cognitive disabilities? Yes, according to the results discussed in chapter four, all three students achieved gains in their mathematics scores. The use of TouchMath was effective in helping all three students succeed in this category.

RQ2: Can students maintain math achievement scores with the use of the TouchMath strategy over time based on probes? Yes, based on the results achieved from the maintenance phase of the intervention, all three students again were able to maintain at or above the baseline level from the intervention.

Implications for practice. Based upon the data from the current TouchMath literature, teachers should consider the use of TouchMath with students who struggle with math achievement in the area of addition facts. Some critical components of TouchMath that were gathered from this study were that TouchMath must be taught using direct instruction of the dot-notation system. The use of modeling how to count the points on each number, feedback when the number is counted incorrectly, clear explicit instructions, guided practice though the use of the dots on the numbers, and specific praise for using the strategy as taught will increase the success of the intervention. TouchMath may also be used in conjunction with behavior modification strategies such as reinforcement systems.

Limitations of this Study

In this study, the classroom teacher was able to successfully implement the TouchMath intervention to three students with the most significant cognitive disabilities. The results showed that all three students made significant gains in the area of mathematics accuracy. However, a number of limitations exist for this current study and should be addressed. First, the small sample size makes it difficult to generalize findings to other students with similar disabilities (Kennedy, 2005). All three students had the disability label of Autism and all three had a mathematics goal they were working towards on their IEP's. With the small sample, it is difficult to determine if the same results could be achieved with other students who have the same disability category. Secondly, the results from this study for students with the most significant cognitive disabilities cannot be anticipated to generalize to students in other geographical areas or schools with different backgrounds. Thirdly, this study only looked at single digit addition with numbers 0-9. More studies would be needed to determine if this skill would transfer to larger digit addition or even generalize over to subtraction. Future research should be conducted to validate the findings of this study with diverse populations, larger sample sizes, and other geographical locations.

Overall, results of the current study indicate TouchMath could be considered a possible evidence-based strategy for students with disabilities. More research is needed in this area to suggest that it can be utilized in the classroom as an evidence-based strategy and it deserves future research.

Recommendations for Future Research

Future research should establish the role and relationship between number sense and mathematical achievement for students with the most significant cognitive disabilities. Moreover, most studies that looked at TouchMath only looked at whether students could use the dot notation system for addition and subtraction. More research should be looked at in the area of multiplication and division and if the dot notation system generalizes to these areas of mathematics. Researchers should also look at if the dot notation system could be used in a whole group classroom setting. Most of the studies have been done either individually or in small groups.

Additionally, more studies are needed in the area of TouchMath through the use of the Council for Exceptional Children's Guidelines. More studies will be needed with larger sample sizes, in different geographical areas, as well as other students with disabilities to determine if TouchMath can be considered an evidence based practice.

Conclusion

This study suggested that TouchMath is effective in teaching students with the most significant cognitive disabilities. Based on the results, TouchMath showed an increase in all participants mathematics scores in the area of addition accuracy. This current study expanded previous research that was done in the area of TouchMath. In line with previous findings, teachers who follow the format of direct teaching with the dot notation system provided by TouchMath produce effective outcomes in the area of single digit addition. These findings are in line with previous research findings in the area of TouchMath for stduents with the most significant coginitive disabilities (Calik & Kargin, 2010).

Learners need direct instruction in order to master basic math facts. If mastery of basic math facts are not achieved, more complex mathematical skills such as reasoning tasks and using money may not be mastered (Cihak & Foust, 2008). Based on these research findings as well as previous findings in the area of TouchMath, teachers should consider the use of TouchMath for mathematics instruction in their classroom for students with the most significant cognitive disabilities.

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Appendix A - Lesson Plan

Lesson 1

TouchMath Adding Ones

Lesson Overview:
The purpose of this lesson is to let students practice using dot notation on adding the number one.

Student Objectives:
The student will utilize dot notation when adding the number one to other numbers.

Materials:
TouchMath Posters
TouchMath worksheets
Pages 11-13
White boards, expo markers

Establish the Context for Student Learning

1. Show the student the posters on the wall of the numbers 1-9.
2. Have the student touch each dot on each number while counting aloud.

Lesson:

3. Write the following examples on the white board. The numbers should all have dots (you will place the dots on the numbers before giving the board to the student:
4. 1 + 1=
5. Have student touch each dot while counting: 1, 2 aloud
6. Next example: 2 + 1= (again place the dots on the numbers before giving it to the student).
7. Student will touch each dot and count aloud: 1, 2, 3
8. Continue with the following problems: 1 + 5, 4 + 1, 6 + 1, 2 + 1. (Place the dots on each problem before giving the board to the student.

Independent Practice:

9. The student will complete the 12 problems without assistance from an adult.
10. Worksheet pages 11, 12, and 13.

Figure 5.1: Touchmath Lesson plan examples

Lesson 6

TouchMath Adding Sixes

Lesson Overview:
The purpose of this lesson is to let students practice using dot notation on adding the number six.

Student Objectives:
The student will utilize dot notation when adding the number six to other numbers.

Materials:
TouchMath Posters
TouchMath worksheets
Pages 33-38
White boards, expo markers

Establish the Context for Student Learning

1. Show the student the posters on the wall of the numbers 1-9.
2. Have the student touch each dot on each number while counting aloud.

Lesson:

3. Write the following examples on the white board. The numbers should all have dots (you will place the dots on the numbers before giving the board to the student:
   a. 6 + 1=
4. Have student touch each dot while counting: 1, 2, 3, 4, 5, 6, 7 aloud
5. Next example: 6 + 2= (again place the dots on the numbers before giving it to the student).
6. Student will touch each dot and count aloud: 1, 2, 3, 4, 5, 6, 7, 8
7. Continue with the following problems: 6 + 3, 6 + 4, 6 + 5, 6 + 6. (Place the dots on each problem before giving the board to the student.

Independent Practice:

8. The student will complete the 12 problems without assistance from an adult.
9. Worksheet pages 33-35.
10. Pages 36-38 are optional practice and will not be included in data from today.

Appendix B - Lesson Materials

Name:______________ Date:______________

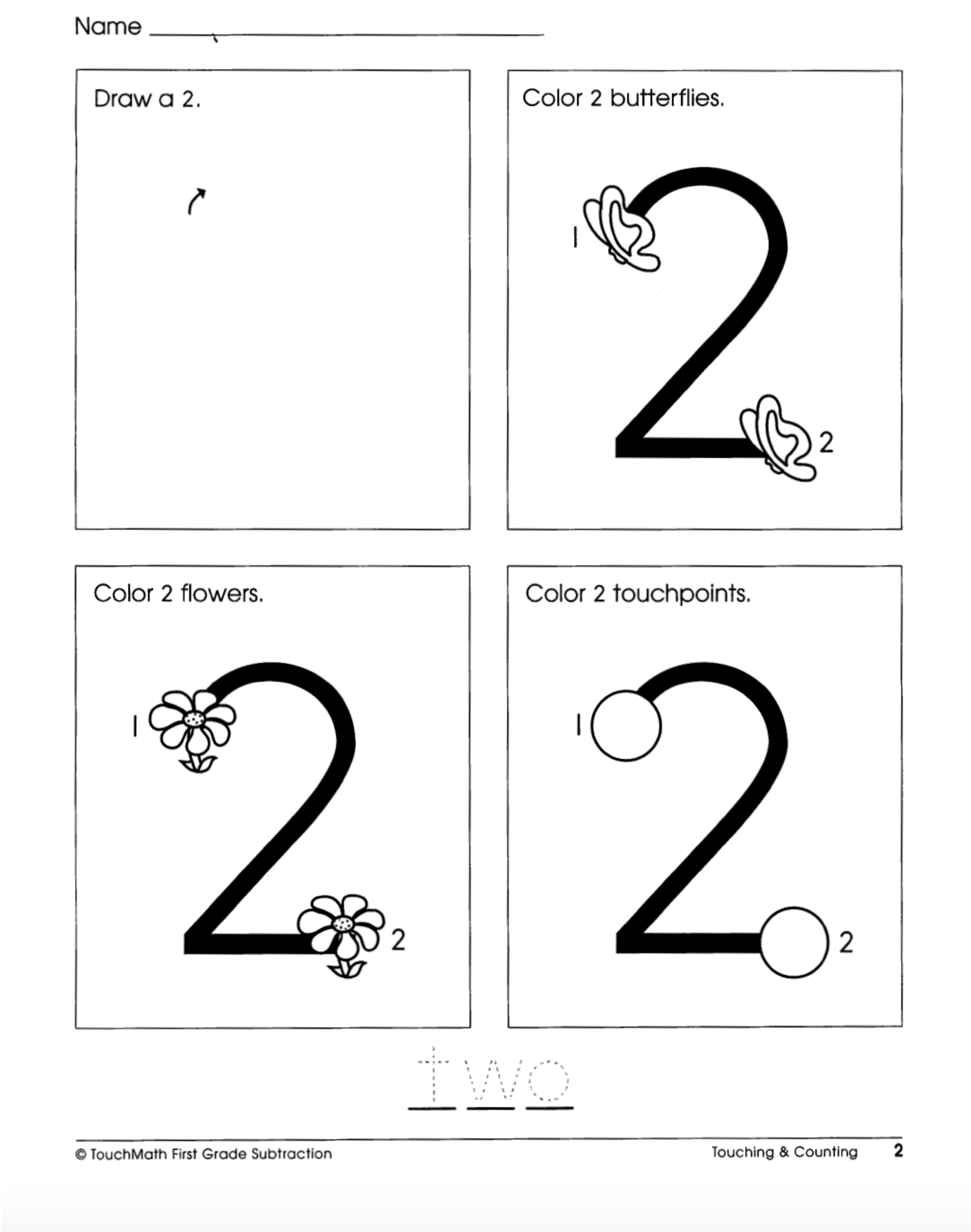
Addition Worksheets

4	6	9	2	2
+4	+1	+0	+6	+6

5	4	7	9	8
+1	+6	+3	+1	+1

Figure 5.1: Example of Baseline Probe

Figure 5.2: Poster used in classroom



Name ______________________

Draw a 2.

Color 2 butterflies.

Color 2 flowers.

Color 2 touchpoints.

two

© TouchMath First Grade Subtraction

Touching & Counting 2

Figure 5.3: TouchMath worksheets used in intervention phase

Name ______________________________

9 + 1 ———	5 + 1 ———
8 + 1 ———	7 + 1 ———

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Name ______________________________

$$\begin{array}{r} 4 \\ +\ 2 \\ \hline \end{array}$$

$$\begin{array}{r} 7 \\ +\ 1 \\ \hline \end{array}$$

$$\begin{array}{r} 6 \\ +\ 2 \\ \hline \end{array}$$

$$\begin{array}{r} 5 \\ +\ 3 \\ \hline \end{array}$$

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Appendix C - Social Validity Survey

TouchMath
CIRP Survey

Student:
Date:

The purpose of this survey is to gather feedback on what you thought about the TouchMath intervention. This survey is anonymous. Please be honest with your response.

Read each statement below. Decide agree or disagree and circle the corresponding face.

Adapted Version of the Children's Intervention Rating Profile

1. The Touchmath strategy was too much work for me.	I agree	I do not agree
2. I understand why the TouchMath strategy was picked to help me with math.		
3. I can see myself using the TouchMath strategy again.		
4. The TouchMath strategy is a good way to help students.		
5. I clearly understood what I needed to do with the TouchMath strategy.		
6. I would want to try the TouchMath strategy again.		
7. If my friend was having trouble in math, I would tell him/her to try the TouchMath strategy.		

Figure 5.4: CIRP survey given to students