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TouchMath 1, 2, 3

Association with Kindergarten and 1st Grade Math Achievement Growth

Prepared by McREL International for TouchMath

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This study evaluates the efficacy of a commercial product, TouchMath, developed by TouchMath. The authors of this paper are employed by McREL International, a private 501(c)(3) nonprofit corporation specializing in research and evaluation services, which was contracted by TouchMath to design and carry out the study. None of the researchers receive commission on sales of the products.

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- Analysis and alignment of curriculum, instruction, assessment, and standards
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- Research, data analysis, logic models, and program evaluations
- School improvement recommendations, action planning, implementation support, and technical assistance

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Executive Summary

TouchMath contracted with McREL International to study the program's effectiveness in improved math achievement and testing performance of students identified for additional support to develop basic math skills and to identify previous studies that may be eligible to meet the Every Student Succeeds Act (ESSA) Tiers of Evidence and What Works Clearinghouse (WWC) certification requirements. TouchMath is a commercial, evidence-based tool using multisensory engagement and the Concrete-Representational-Abstract model to support students in developing abstract mathematic connections and problem-solving.

TouchMath submitted 28 published studies to guide the current study design. McREL researchers conducted a correlational study to investigate the possible association between TouchMath use and math achievement. The study, conducted during the 2021–22 school year, included an analytic sample of 150 kindergarten and 1st grade students across three elementary schools in Washington, D.C., New Jersey, and Kentucky. Schools received the program and curriculum materials, an implementation fidelity checklist, and access to virtual professional development in using the product. TouchMath staff generally provide onsite professional development and at-the-elbow coaching. The COVID pandemic, however, disrupted the process due to the shift from in-person to remote, online teaching and learning. School staff were asked to determine a cut-off score on beginning-of-year assessments (NWEA MAP, iReady), which then was used to place students performing below this cut-off score in the TouchMath treatment group and students performing above it in the comparison group.

Using means comparisons, the study showed a statistically significant larger increase in average score growth and proportion of score growth from the beginning to the end of year NWEA MAP scores for students in the treatment group compared to the comparison group. The study further showed an increase in score growth and proportion of growth from beginning to end of year iReady scores for students in the treatment group. However, the iReady differences between treatment and comparison groups were not statistically significant.

The 28 studies submitted by TouchMath were further screened using the Public Study Review Guide (SRG) provided by the WWC. Eight of the screened research studies were identified as eligible for full review by the WWC. Seven studies used a single case design (SCD) methodology and required further review by SCD-certified reviewers. One study used a quasi-experimental design (QED) and can be reviewed using the WWC group design standards. The study using a QED includes a sample that demonstrates baseline equivalence and is eligible to meet Tier 3 of the ESSA Tiers of Evidence and WWC group design standards. For this study to be included in the WWC as meeting standards with reservations, it must be submitted and reviewed by the WWC. The study screening conducted by McREL does not confirm the studies will meet WWC standards. However, the volume of studies conducted on the efficacy of TouchMath demonstrate evidence of efficacy across different settings (urban, suburban, rural schools), samples (students with special needs and students without special needs), and contexts (US and international schools from OECD countries such as Germany, India, Saudi Arabia, Singapore, and Turkey). The alignment of this evidence with WWC standards will be determined after the studies are submitted and reviewed by the WWC.

Background

The TouchMath program is a commercial, evidence-based tool used to improve students' math achievement. The design incorporates a "dot notation system" that enables students to solve computational tasks using multisensory tools, which does not require students to retrieve and regurgitate arithmetic facts or to use potentially stigmatizing approaches such as finger counting. While existing research has reported positive findings to support the effect of TouchMath on student math outcomes (i.e., addition and subtraction skills), more research is needed to better understand the full potential of TouchMath, particularly for students who are struggling. The extant body of literature, summarized below, shows the research basis for key components underlying the TouchMath design—explicit math instruction, mathematical problem-solving reflection and monitoring, concreteness fading (concreteness, representational abstract sequence), and number lines.

Explicit Math Instruction

Explicit instruction aims to minimize the ambiguity between the roles of teachers and students (Archer & Hughes, 2010; Hudson & Miller, 2006; Stein, Kinder, Silbert, & Carnine, 2006). A notable feature of explicit instruction is frequent and purposeful interactions between teachers and students focused on academic content, which usually includes teacher modelling of specific strategies, students' application of the approaches, and timely feedback to students. Classroom teachers model mathematical skills by demonstrating the steps students need to solve mathematical problems. When high-quality explicit math instruction is implemented well, it effectively promotes students' long-term academic success (Doabler et al., 2015), especially among students with mathematics disabilities (Baker, Gersten, & Lee, 2002; Bryant et al., 2011; Clarke et al., 2011; National Mathematics Advisory Panel [NMAP], 2008; Orosco, 2014).

Mathematical Problem-Solving Reflection and Monitoring

Problem-solving skills include reasoning and analysis, argument construction, and innovative problem-solving strategies. These skills apply to all academic content (e.g., mathematics, science, social science) and curricula across all grade levels. Students' problem-solving skills can directly impact their academic growth (Montague et al., 2011) and performance on state and national standardized assessments as well as college entrance exams (Kirsch et al., 2007; Lesh, Hamilton, & Kaput 2007). However, traditional classroom materials and formats (e.g., textbooks, lectures) do not provide students with rich experiences to develop problem-solving skills (Jones & Tarr, 2007; Ruggeri, 2021). Woodward and colleagues (2018) showed that students learn and develop mathematical problem-solving better when guided by teachers to help them think about what and why they use specific strategies and then reflect on their processes (Woodward et al., 2018). Teachers support student use of reflection tools though reflection prompts, modelling the reflection process, and incorporating students' thinking processes so they develop self-monitoring and reflection skills.

Concreteness Fading (Concreteness-Representational Abstract Sequence)

Concrete materials, the physical, virtual, and pictorial objects that are widely used in classrooms (Bryan et al., 2007), provide practical tools to apply real-world knowledge (Schliemann & Carraher, 2002), induce physical or imagined action (Glenberg et al., 2004), allow learners to construct their own knowledge of abstract concepts (Brown et al., 2009), and promote perceptual brain processing (Evans-Martin, 2005). Abstract materials, on the other hand, eliminate perceptual details and focus learners' attention on structure and representational aspects, rather than surface features (Kaminski et al., 2009; Uttal et al., 2009). When either approach is used exclusively, it does not effectively contribute to students' long-term learning. One promising remedy is the use of concreteness fading (Fyfe et al., 2014; McNeil & Fyfe, 2012) in which teachers use concrete materials in the early stages of instruction and then gradually introduce abstract materials over time to foster memory transfer and increased knowledge development (Wecker & Fischer, 2011). While this approach has received some evidential support with college undergraduate populations (Goldstone & Son, 2005; McNeil & Fyfe, 2012), other findings are mixed (Braithwaite & Goldstone, 2013; Johnson et al., 2014; Tapola et al., 2013).

Number Lines

Number lines, mathematical representations of magnitudes between sets of real numbers (i.e., whole, rational, irrational, positive, and negative numbers), are commonly used in contemporary state mathematics standards (Barbieri et al., 2019; Jayanthi et al., 2018). Consistent use of number lines during math instruction can help students build mathematical understanding and improve overall math performance (Dyson et al., 2018; Lannin et al., 2020). The literature shows that number lines are an effective strategy to facilitate the learning of mathematical concepts and procedures (Fuchs et al., 2021).

Prior Research on the Efficacy of TouchMath

Recent studies, such as findings from a meta-analysis of national and international studies, showed that TouchMath contributed to improved math performance for students with special needs (Kot et al., 2018). Ellingsen and colleagues (2017) conducted a systematic review of additional studies and found that TouchMath was effective for some students with special needs and not for others. The researchers concluded that study design contributed to the differential outcomes.

Four studies demonstrate the effects of TouchMath strategies and tools on single-digit addition. Avant and Heller (2011) found students with physical disabilities correctly calculated sums up to 20 using the TouchMath strategy. The TouchPoints™ strategy was effective in improving students' addition knowledge and skills (Cihak & Foust, 2008). When the TouchMath strategy was compared to teaching the number line to build students' addition skills, TouchMath was more effective (Fletcher et al., 2010). Even students with "the most significant cognitive disabilities," (p. 2) accurately solved single-digit addition problems (Nelson, 2019). Students learned the TouchMath Dot-Notation method, applied it to novel problems, and continued to use the skills months after learning it (Simon & Hanaran, 2007). Uzomah (2012) found TouchMath contributed to increased math achievement scores and Waters & Boon (2011) concluded that it influenced students' subtraction skills (using money), yet skill retention ended when students were no longer exposed to the strategy.

Problem Statement

A special administration of the National Assessment of Educational Progress (NAEP) was conducted by the National Center for Education Statistics (NCES) in 2022 to capture changes in student math and reading performance during the COVID-19 global pandemic. The results showed the largest decrease in math performance since the assessment was first administered in 1990. Twenty-six percent of fourth graders and 38% of eighth graders performed below the *NAEP Basic* (which demonstrates partial mastery of prerequisite knowledge and skills that lead to proficiency on the NAEP). Average scores decreased for student who perform at the 10th and 25th percentiles and those who perform at higher levels (75th and 90th percentiles).[1] NAEP assesses students' mathematical knowledge and skills and how they apply them to solve problems. Although the 2022 NAEP results are mediated by the pandemic effects on student learning, the results showed *historic* declines in student performance. Decreased performance levels will likely persist and require teachers to employ instructional practices demonstrated to improve student performance such as those described above.

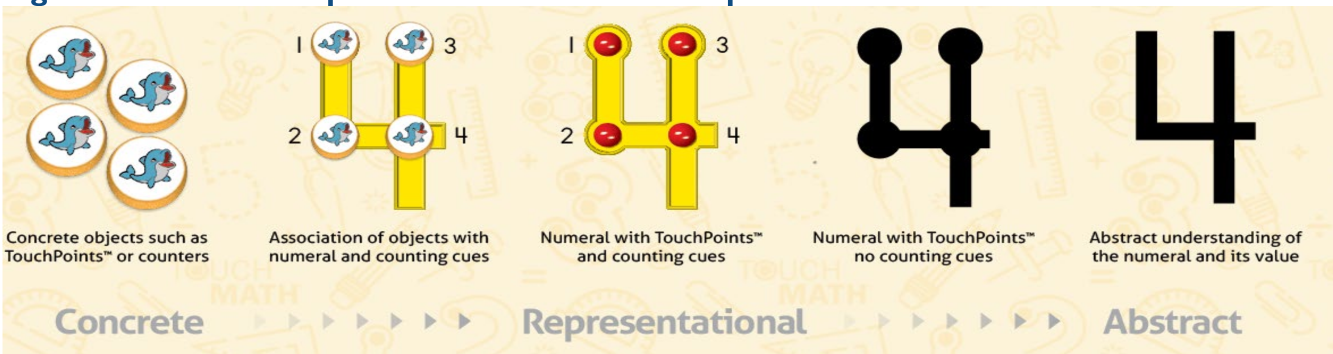
TouchMath, an instructional tool founded on WWC-identified best practices (Woodward et al., 2017), was designed to support students in general and special education, those requiring short-term intervention or remediation, students learning English as a second language, and those who perform above or below grade level. Although it is suitable for a broad range of students, existing research focused on students with special needs, only. Little research exists that shows how TouchMath may improve outcomes of different students in the general education settings. The current study and research screening was designed to address this gap in understanding the effectiveness of TouchMath.

TouchMath Description

The TouchMath program utilizes multisensory techniques to teach students to solve math problems and improve the outcomes for students struggling with grade-level math content. The program is grounded in the Concrete-Representational-Abstract continuum (also known as concreteness fading), a sequence of instructional practices and research-based best practices that reflect how most students learn in mathematics and science subjects (Fyfe, McNeil, Son, & Goldstone, 2014). Figure 1 shows how TouchMath applies the concept of concreteness fading to establish the continuum by which the concrete, physical embodiment of a concept becomes increasingly abstract over time. The program uses manipulative materials, modeling, drawings, and pictures to help students develop abstract mathematical thinking. As students see, say, hear and touch using TouchPoints™ on the numerals, they make the connection between the numeral and the quantity it represents.

[1] NAEP Mathematics Assessment Highlights, https://www.nationsreportcard.gov/highlights/mathematics/2022/.

Figure 1. Concrete-representational-abstract sequence[2]



The TouchPoints™ technique, as presented in Figure 1, enables learners to interpret ambiguous abstract symbols within concrete objects and provides both perceptual and physical experiences that ground abstract thinking. These experiences help students store images and kinesthetic experiences in their memories, which are accessible if and when abstract symbols lose their meaning. Learners then can focus on generalizable mathematics properties, which facilitates and deepens their understanding (Fyfe et al., 2014).

TouchMath implementation is guided by six recommended practices that significantly improve student math achievement:

- ***Systematic instruction*** during intervention to develop student understanding of mathematical ideas.
- ***Mathematical language*** development through clear and concise mathematical language that supports students' language development and helps them effectively communicate their understanding of mathematical concepts.
- ***Representations,*** which are a set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures.
- ***Number lines*** to facilitate the learning of mathematical concepts and processes, build understanding of grade-level material, and prepare students for more complex mathematics learning.
- ***Word problems*** deepen students' mathematical understanding and support their capacity to apply mathematical ideas.
- ***Timed activities*** are a strategy to build student fluency in mathematics.

Study Design and Methodology

Correlational Study Overview

TouchMath contracted with McREL International to study the program's effectiveness in improved math achievement and testing performance of students identified for additional support to develop basic math skills. Students from five schools across districts in Kentucky, California, Washington, D.C., and New Jersey comprised the original sample. The study occurred during the 2021–22 school

[2] Image source: https://www2.touchmath.com/numerals/

year and was guided by one research question: To what extent is TouchMath intervention exposure associated with growth in standardized math score outcomes?

Design

The original study comprised a regression discontinuity design (RDD) and correlational design based on the number of students in each school. Educators were asked to identify students to receive the intervention (treatment group) based on an independently determined cut-off score on formative standardized math assessments. Students below this cut-off score received the TouchMath intervention, and those above this cut-off score (comparison) did not. Participating schools conducted three assessments—beginning, middle, and end of school year—to measure students' growth in mathematics achievement. Schools used either the NWEA math MAP or iReady assessments to track students' progress over time. School staff participated in virtual professional development sessions to implement TouchMath with fidelity. In-person professional development resumed in Summer of 2022.

Data Collection

Schools provided student data from the 2021–22 school year after standardized testing data became available. These data included information on students' participation in the TouchMath intervention, grade level, free or reduced lunch eligibility, gender, race, individualized education program (IEP) status, and English language learner status. Also included were standardized math assessment data in scale scores for beginning, middle, and end of year for the specific assessment administered by the school.

Analytic Sample

The original sample included 649 K–8 students across the five participating schools—82 students in the treatment group and 567 in the comparison group. Evaluators created an analytic sample by determining whether the data elements needed for analysis were available. Cases were included in the analytic sample if they minimally contained: individual student assessment results at multiple time points and whether both treatment and comparison students were included in each grade level. The sample was further reduced by treatment and comparison group composition. Three schools remained in the sample, however, the evaluation team needed to further reduce the sample because students who received the treatment were in different grades than those who comprised the comparison group. Evaluators examined the association between grade level and math assessment growth rates to determine which cases would comprise the analytic sample. Table 1 shows the breakdown of the population in the analytic sample reduction process.

Table 1. Data reduction elements and sample sizes

Data Element	Sample size number changes		
	Total #	Treatment #	Comparison #
Original sample	649	82	567
Cases with assessment data at multiple time points	621	72	549
Cases with treatment and control groups by grade level*	212	72	140
Final Analytic Sample	150	65	85

Note: The analytic sample was reduced to cases representing kindergarten to second grade due to the lack of treatment students in grade three and above.

Of the three schools remaining in the sample, two used the iReady assessment and one administered the NWEA MAP. In one school, all kindergarten students comprised the treatment group while all 1st and 2nd grade students comprised the comparison group. The evaluation team found statistically significant differences between grade levels for math assessment growth rates between 1st and 2nd grade students using the NWEA MAP, which created dissimilar comparisons across grade levels in the comparison group. Thus, 2nd grade cases were removed from the sample, while closer grade-level treatment and comparison groups were retained. A similar situation occurred in the remaining schools, which use iReady. Second grade cases were removed from the sample. The final analytic sample consisted of 150 cases as shown below in Table 2, which provides a breakdown for the retained analytic samples and their respective groups. A complete breakdown of the demographic data for this analytic sample can be found in Appendix A.

Table 2. Analytic sample: group assignment and outcomes assessment

Assessment	Grade	Treatment *n*	Comparison *n*	Total
NWEA MAP	Kindergarten	54	0	54
	1st	0	59	59
iReady	1st	11	26	37
Total		65	85	150

Note: The 37 students for whom iReady data is available come from two schools. The first school includes all 26 students in the comparison group, and 3 students in the intervention group. The second school includes the other 8 intervention group students.

Outcome Measures

Outcomes of math achievement were calculated using the scale scores of a school's respective standardized math assessment at the beginning, middle, and end of school year. Growth variables also were produced to examine differences in rates of change over the year between the treatment and comparison groups. These were generated by subtracting beginning of year from end of year scores to obtain score differences. The differences were divided by beginning of year scores to obtain a proportion of growth from the beginning to the end of year. Any cases missing in either beginning or end-of-year test scores were excluded from analysis. The standardized math tests used were iReady and the NWEA MAP.

Analytic Strategy

The analytic samples cases included the two different math assessments and separate analyses were conducted to examine the outcomes on the two different assessments. Means of beginning and end of year assessment scores were calculated to capture change in student performance throughout the school year for both the treatment and comparison group. Evaluators further calculated the mean proportion of score change between the beginning and end of year for both treatment and comparison students. T-tests were conducted for means comparisons of differences between beginning and end of year assessment score change and proportion of change between the treatment and control groups.

The approach to test comparisons of changes and proportion of changes from beginning to end of year was selected to account for pre-test and overall score differences. This approach was chosen because pre-test scores for students selected for the treatment group were below school selected cut-off assignment criteria (for treatment and control groups), which leads to lower overall scores among the treatment group. These procedures will reveal differences in the standardized math assessment scores and growth from first to last testing associated with the treatment and comparison groups.

Findings

Results for the means comparisons t-tests for both the NWEA MAP and iReady can be found in Table 3. Complete math assessment score and growth means are in Appendix B, and math assessment score means by intervention and comparison groups are in Appendix C. Overall, the results show that students in the treatment group showed more change on the NWEA MAP and iReady than the comparison group. Furthermore, the proportion of change on NWEA MAP and iReady performance from beginning to end of school year also was higher for treatment students as shown in Table 3**.** However, the results for treatment and control group students on the iReady were not statistically significant.

Table 3. NWEA MAP and iReady mean comparisons by treatment and control groups

Assessment	Comparison	Group	n	M	SD	$t_{(df)}$
NWEA MAP	Score Change from Beginning to End	Treatment	51	17.12	9.29	$2.12_{(96)}$*
		Comparison	47	13.85	5.26	
	% Change from Beginning to End	Treatment	51	12.02	6.87	$3.03_{(96)}$**
		Comparison	47	8.64	3.46	
iReady	Score Change from Beginning to End	Treatment	10	38.40	20.88	$0.53_{(34)}$
		Comparison	26	34.73	17.54	
	% Change from Beginning to End	Treatment	10	11.81	7.25	$1.20_{(34)}$
		Comparison	26	9.32	4.80	

Note: * Significant at $p < 0.05$; ** Significant at $p < 0.01$

McREL TouchMath Study Screening for WWC Review

The Significance of WWC

ESSA, the recertification of the Elementary and Secondary Education Act, signed into law in 2015, provides a framework for understanding the level of evidence for programs', practices', strategies', and interventions' effectiveness at addressing a specific outcome. This framework helps state education agencies (SEAs) and local education agencies (LEAs) to use evidence-based programs, practices, strategies, and interventions in schools. These evidence tiers include Tier 1 (strong evidence), Tier 2 (moderate evidence), Tier 3 (promising evidence), or Tier 4 (demonstrates a rationale).[3] The tiers align to the WWC standards, and only studies that meet WWC standards are eligible to meet Tier 1 or Tier 2.

The WWC provides the structure to review and assess studies and assign a rating that guides educators in determining the strength of the efficacy evidence for programs, practices, strategies, and

[3] IES. ESSA Tiers of Evidence: What you need to know. https://ies.ed.gov/ncee/edlabs/regions/midwest/pdf/blogs/RELMW-ESSA-Tiers-Video-Handout-508.pdf

interventions. The WWC offers three overarching rating levels: *Meets WWC Standards Without Reservations*, *Meets WWC Standards With Reservations*, or *Does Not Meet WWC Standards*.[4]

TouchMath Study Screening

TouchMath submitted 28 national and international efficacy studies for McREL evaluators to screen using WWC criteria. The McREL evaluation team includes individuals certified by the Institute of Education Science (IES) to screen studies against the WWC group design standards. These team members also are experienced in assigning the appropriate tier of evidence to strategies and outcomes based on the existing evidence. The team aligned WWC criteria to its screening of the 28 efficacy studies provided by TouchMath. Table 4 defines the screening criteria used to determine which studies may be eligible for full review by the WWC.

Table 4. Study screening criteria and descriptions

Screening Criteria	Description
Study	Does it meet the WWC definition of a study ("examination of the effect of an intervention on a single group of participants"), WWC, 2022, p. 19.
Primary Analysis	Did the study authors define the primary analysis conducted?
Geographic Alignment	Was the study conducted in the U.S. or a predominantly English-speaking OECD country?
Timeframe	Was the study conducted within the previous 20 years? Studies limited to those published during or after 2002.
Relevant Outcome Domain	Do the findings fit within a WWC-specified outcome domain? In this case, *Mathematics Achievement, Numbers and Operations*
Age/Grade Range	Was the study conducted with an elementary, secondary, or postsecondary student population?
Setting	Was the study conducted in an educational setting such as a classroom or school?

Study Screening Findings

McREL identified eight studies eligible for WWC review with the potential to meet WWC SCD or group design standards. The citations, findings, study designs, and review recommendations are included in Table 5. The analysis of all studies submitted by TouchMath are found in Appendix D.

[4] To meet the highest rating level, a study must include a well-implemented research design that demonstrates confidence that the outcome is clearly attributed to the intervention. The second highest rating level is assigned for studies that do not statistically rule out variables that contribute to the effects. Oftentimes, this occurs because of the limitations that occur in the natural environment in which the study is situated. The lowest rating level is assigned for studies that do not provide sufficient evidence to demonstrate the effect occurred because of the intervention. WWC reviewers further consider effect sizes (magnitude), sample size, setting (single vs. multiple), and the lack of negative effects to determine rating levels for each outcome domain the study addresses (WWC, 2022). Moreover, WWC reviewers assess individual studies, intervention reports and practice guide to recommend evidence ratings.

Table 5. TouchMath studies recommended for WWC review

Citation	Findings	Study Design	Review
Avant, M.J.T., & Heller, K.W. (2011). Examining the effectiveness of TouchMath with students with physical disabilities. *Remedial and Special Education, 32*(4), 309-321. https://doi.org/10.1177/0741932510362198	*From the abstract:* "…fundamental math skills for students to learn is basic computational skills … A multiprobe, multiple baseline, across-participants design was used in this study to investigate the use of TouchMath with students with physical disabilities … to solve basic addition problems with sums to 20 All students were successful in reaching the criterion, with high percentages of correct responses using the TouchMath strategy to answer simple addition problems," (p. 309).	Single-case design	Further, specialized SCD review required
Cihak, D.F., & Foust, J.L. (2008). Comparing number lines and touch points to teach addition facts to students with autism. *Focus on Autism and Other Developmental Disabilities, 23*(3), 131-137. https://psycnet.apa.org/doi/10.1177/1088357608318950	*From the abstract:* "The results indicated that the touch-point strategy was more effective in teaching single-digit addition digit schools. The touch-point strategy was then replicated using the nonpreferred strategy's content, improving all students' addition skills," *(p. 131)*	Single-case design	Further, specialized SCD review required
Fletcher, D., Boon, R., & Cihak, D. (2010). Effects of the TouchMath program compared to a number line strategy to teach addition facts to middle school students with moderate intellectual disabilities. *Education and Training in Autism and Developmental Disabilities, 45*(3), 449-458. http://www.jstor.org/stable/23880117	*From the abstract*: "Results indicated that the TouchMath strategy was more effective and efficient in teaching students' single-digit addition problems compared to the use of the number line," (p. 449).	Single-case design	Further, specialized SCD review required

Citation	Findings	Study Design	Review
Nelson, J. (2019). An investigation of the effectiveness of TouchMath on mathematics achievement for students with the most significant cognitive disabilities. http://hdl.handle.net/2097/39495	*From the abstract:* "… investigate the use of the TouchMath strategy with students with the most significant cognitive disabilities in school settings … 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," (p. 2).	Single-case design	Further, specialized SCD review required
Park, J., Bassette, L., & Bouck, E. (2021). Using TouchMath to teach money identification to students with autism spectrum disorders: A brief report. *International Journal of Disability, Development and Education.* [*https://doi.org/10.1080/1034912X.2021.1882665*](https://doi.org/10.1080/1034912X.2021.1882665)	*From the abstract:* "Results of the study demonstrated that two students showed intervention effects. Yet, the students struggled to generalize the skill. The third student demonstrated varied intervention effects, but the intervention was ended due to his challenging behavior at the end of the school year," (p. 1).	Single-case design	Further, specialized SCD review required
Simon, R., & Hanaran, J. (2007). An evaluation of the TouchMath methods for teaching addition to students with learning disabilities in mathematics. *European Journal of Needs Education, 19*(2), 191-209. https://doi.org/10.1080/08856250410001678487	*From the abstract:* "Results indicate that the three subjects were able to learn and apply the dot-notation method successfully, and to retain the methods from one-and-a-half to four-and-a-half months after completing instruction," (p. 191).	Single-case design	Further, specialized SCD review required
Uzomah, S. (2012). Teaching mathematics to kindergarten students through a multisensory approach. http://www.proquest.com/en-US/products/dissertations/individuals.shtml.	*From the abstract*: "An independent-samples t test was used to test whether there was a significant difference between instructional strategies and mathematical achievement. Results of the statistical test demonstrated significantly higher gain store in mathematics achievement for those who were taught using the TouchMath program," (p. 3).	Quasi-experimental design	Review to meet WWC group design standards with reservations
Waters, H.E., & Boon, R.T. (2011). Teaching money computation skills to high school students with mild intellectual abilities via the TouchMath program: A multi-sensory approach. *Education and Training in Autism and Developmental Disabilities*, *46*(4), 544-555.	*From the abstract:* "The results revealed the TouchMath© program improved all three of the students' ability to subtract 3-digit mathematics operations using money applications; however, maintenance results were mixed, as the students exhibited difficulty with maintaining the necessary skills once the intervention was withdrawn," (p. 544).	Single-case design	Further, specialized SCD review required

Conclusions, Discussion, and Recommendations

The results demonstrate statistically significantly higher increases in NWEA MAP scores from beginning to end of year, as well as significantly greater proportion of growth from beginning to end of year for the students in the treatment group. It is possible that differences in score increases, and proportion of increases are due to exposure to the intervention. However, comparisons were made across grade levels with kindergarten students in the treatment group and first graders included in the comparison group. Differences in NWEA MAP growth may reflect grade level differences in growth rather than a true difference between students in the treatment and control groups. The NWEA MAP normed growth rates for kindergarten and 1st grade shows that growth from fall to spring is expected to decrease as grade level increases.[5] However, this difference appears smaller between kindergarten (M = 17.54, SD = 6.63) and 1st grade (M = 16.35, SD = 6.81) than between grade levels that follow in the normed sample, and this difference appears smaller than the difference between kindergarteners and 1st grade students in the present sample. It also is worth noting that the 2015–2020 NWEA MAP sample norms are derived from a student population prior to, or only just experiencing, the impact of the COVID-19 pandemic, which we suggest urges caution in applying the typical growth rates to current student populations.

iReady results indicated larger increases in scores and growth rates for students in the treatment group than their peers in the comparison group. However, the differences were not statistically significant for this sample. Evaluators identified possible explanations for this finding. Students in the treatment group (n = 3) at one school were briefly exposed to TouchMath at the onset of the school year. The teacher who used TouchMath resigned, which affected continued implementation. Therefore, it is not surprising that the difference between the treatment (n = 3) and comparison groups (n = 26) was not statistically significant. Moreover, the student population characteristics within the schools differed from one another, which reduced the sample size because the groups could not be matched using statistical tools such as propensity score matching.

Although study results showed that students in the treatment group showed greater change in math performance than the students in the comparison group, the study design and sampling was insufficient in demonstrating TouchMath efficacy. This was partly due to the study limitations.

1. **TouchMath implementation was inconsistent across study sites.**

   School leaders agreed to participate in the study. However, the demands of a changing education landscape exacerbated by a global pandemic created more challenges for educators committed to meeting student needs. As indicated by NAEP 2022 results, all students need accelerated interventions to perform at grade level. Teachers recognize the urgency in providing students with what they need, academically. Therefore, they assigned students to the TouchMath treatment group based on their emerging rather than assessed needs. While the research design required a specific strategy to assign students to treatment and comparison groups, needs that arise in the classroom trump the needs of the research design under the current conditions educators experience.

   Recommendation

   The external evaluation team in collaboration with TouchMath and the district central office could co-create a monitoring plan prior to the study's onset to address this challenging issue.

2. **The teacher implementation survey was insufficient for capturing fidelity throughout the school year.**

   McREL evaluators designed an implementation survey (data in Appendix E) that asked teachers to indicate how frequently they used specific TouchMath tools in the classroom based on what they learned during their professional development sessions. The survey was

[5] From: NWEA (2020) The 2015-2020 normed sample.
https://teach.mapnwea.org/impl/MAPGrowthNormativeDataOverview.pdf

administered three times during the school year and teachers' responses declined precipitously (from 108 respondents at the beginning of the year to 15 respondents at the end of the year). One explanation for this rests with the competing priorities teachers experience in their daily professional lives. Their priority is to ensure they are serving students' needs, which is now more demanding due to lingering pandemic effects. Among the respondents in the end-of-year survey, only 13% reported having used the implementation fidelity checklist supplied by TouchMath (Appendix F). Lacking sufficient implementation data, the study team could not determine whether TouchMath was ready for an efficacy study with this population of schools.

<u>**Recommendation**</u>

Consider different methods to assess implementation. While surveys are efficient and less expensive than observation data collection strategies, teachers are reluctant to respond due to competing priorities. Rather than overburdening teachers with an implementation survey administered three times during the school year, enlist the TouchMath coaching support team to use the implementation checklist as the foundation for an observational tool to capture implementation. The checklist as a foundational tool could generate more useful implementation data than the survey.

3. **Data provided by the schools was inconsistent across sites.**

   Student data collection was managed directly through school rather than district central offices, which led to changes in creating the analytic sample. The lack of a sufficient set of student data disrupted the opportunity for the external evaluators to demonstrate the efficacy of TouchMath in improving student math performance.

   <u>**Recommendation**</u>

   Establish an agreement (MOU/DSA) between the district central office and the external evaluator. District data analysts can access all the student data needed for efficacy studies and will provide usable data with minimal issues, in a timely manner, and without disrupting school staff.

4. **Eight efficacy studies conducted by TouchMath are eligible for WWC review.**

   The studies TouchMath shared with external evaluators were published in national and international peer-reviewed academic journals. An early analysis of the publications could provide information about gaps in the literature related to program efficacy. When external evaluators screened the studies, they learned some meet the ESSA evidence requirements. These studies could be submitted to the WWC for review, which could provide TouchMath the evidence necessary to support their continued work in schools.

   <u>**Recommendation**</u>

   Continue to screen published efficacy studies about TouchMath using WWC review criteria and follow the protocol for submitting them for review.

Appendix A

Table 6. Analytic sample demographics (n = 150)

Categories	Subcategories	Treatment	Comparison	Totals
Location	WA. D.C.	3	26	**29**
	Kentucky	8	0	**8**
	New Jersey	54	59	**113**
Grade	Kindergarten	54	0	**54**
	1st	11	85	**96**
Race	Asian	1	5	**6**
	Hispanic	11	7	**18**
	Black	10	10	**20**
	White	36	57	**93**
	Hawaiian Native/ Pacific Islander	0	1	**1**
	Two or More Races	7	5	**12**
Gender	Female	32	42	**74**
	Male	33	43	**76**
Free/Reduced Lunch Eligibility[1]	Yes	16	15	**31**
	No	46	44	**90**
IEP Status[2]	Yes	8	3	**11**
	No	0	26	**26**
EL Status	Yes	5	3	**8**
	No	60	82	**142**

Note: [1] 29 cases did not report Free/Reduced Lunch Eligibility; [2] 113 cases did not report IEP Status information.

Appendix B

Table 7. Math assessment score and growth means for all students

Assessment	Time	*n*	*M*	*SD*	Min.	Max.
NWEA MAP	Beginning of Year	98	152.55	13.59	127.00	187.00
	Middle of Year	102	159.51	13.92	131.00	196.00
	End of Year	113	168.68	13.97	129.00	197.00
	Score Change from Beginning to End	98	15.55	7.76	-8.00	39.00
	% Change from Beginning to End	98	10.40	5.74	-5.00	30.00
iReady	Beginning of Year	37	362.92	27.88	291.00	416.00
	Middle of Year	37	382.54	26.10	328.00	430.00
	End of Year	36	399.89	27.39	328.00	443.00
	Score Change from Beginning to End	36	35.75	18.29	-6.00	79.00
	% Change from Beginning to End	36	10.01	5.59	-2.00	26.00

Appendix C

Table 8. Math assessment score means between treatment and comparison groups (n = 150)

Assessment	Time	*n*	*M*	*SD*	Min.	Max.
Treatment NWEA MAP	Beginning of Year	51	144.55	10.94	127.00	179.00
	Middle of Year	50	152.70	11.85	132.00	179.00
	End of Year	54	161.87	13.06	129.00	191.00
Comparison NWEA MAP	Beginning of Year	47	161.23	10.55	129.00	187.00
	Middle of Year	52	166.06	12.63	131.00	196.00
	End of Year	59	174.92	11.77	141.00	197.00
Treatment iReady	Beginning of Year	11	333.91	25.65	291.00	377.99
	Middle of Year	11	357.82	19.90	328.00	386.00
	End of Year	10	373.80	21.18	328.00	398.00
Comparison iReady	Beginning of Year	26	375.19	18.15	345.00	416.00
	Middle of Year	26	393.00	20.97	333.00	430.00
	End of Year	26	409.92	22.63	360.00	443.00

Note: Scores for beginning, middle, and end of year for both the NWEA MAP and the iReady are higher in the comparison group due to schools using pre-test scores to place students below a pre-determined cut-off in the intervention group, and all those above in the comparison group.

Appendix D.

Table 9. TouchMath studies: Screening findings

Citation	Study	Primary Analysis	Eligible Design	Geographic Alignment	Timeframe	Relevant Outcome Domain	Age / Grade range	Setting	Review Outcome
Avant, M.J.T., & Heller, K.W. (2011). Examining the effectiveness of TouchMath with students with physical disabilities. *Remedial and Special Education, 32*(4), 309-321. https://doi.org/10.1177/0741932510362198	Y	Y	SCD	Y	Y	Y	Y	Y	Further, specialized SCD review required
Aydemir, T. (2014). A review of the articles about TouchMath. *Procedia Social and Behavioral Sciences, 174*(12), 1812-1819. https://doi.org/10.1016/j.sbspro.2015.01.842	Y	N							Tier 4 (demonstrates a rationale) for included outcomes
Calik, N.C., & Kargin, T. (2010). Effectiveness of the TouchMath technique in teaching addition skills to students with intellectual disabilities. *International Journal of Special Education, 25*(1),195-204	Y	Y	SCD	N	Y				Not eligible for WWC review (provides Tier 4, potentially Tier 3 evidence for included outcomes)
Abdou, R. A. E. (2020). The effect of TouchMath multi-sensory program on teaching basic computation skills to young children identified as at risk for the acquisition of computation skills. *Amazonia Investiga, 9*(27), 149-156. http://dx.doi.org/10.34069/AI/2020.27.03.15	Y	Y	GDS	N	Y	Y	Y	Y	Not eligible for WWC review (provides Tier 4, potentially Tier 3 evidence for included outcomes)
Ellingsen, R., & Clinton, E. (2017). Using the TouchMath program to teach mathematical computation to at-risk students and students with disabilities. *Educational Research Quarterly, 41*(1), 15-42.	Y	N							Tier 4 (demonstrates a rationale) for included outcomes

TouchMath studies: Screening findings 2

Citation	Study	Primary Analysis	Eligible Design	Geographic Alignment	Timeframe	Relevant Outcome Domain	Age / Grade range	Setting	Review Outcome
Fletcher, D., Boon, R., & Cihak, D. (2010). Effects of the TouchMath program compared to a number line strategy to teach addition facts to middle school students with moderate intellectual disabilities. *Education and Training in Autism and Developmental Disabilities, 45*(3), 449-458. http://www.jstor.org/stable/23880117	Y	Y	SCD	Y	Y	Y	Y	Y	Further, specialized SCD review required
Green, N.D. (2009). The effectiveness of the TouchMath program with fourth- and fifth-grade special education students. ERIC Number: ED507708.	Y	Y	N						Not eligible for WWC review
Kot, M., Sönmez, S., Yikmis, A., Ince, N.C. (2016). The effectiveness of the TouchMath technique to teach in-hand addition to students with hearing impaired. *Current Research in Education,* 2(1), 17-28.	Y	Y	SCD	N	Y				Not eligible for WWC review (provides Tier 4, potentially Tier 3 evidence for included outcomes)
Kot, M., Terzioğlu, N., Aktas, B., & Yikmis, A. (2018). Effectiveness of TouchMath technique: Meta-analysis. *European Journal of Special Education,* 3(4), 100-110. 10.5281/zenodo.1326894	Y	N							Tier 4 (demonstrates a rationale) for included outcomes
Nelson, J. (2019). An investigation of the effectiveness of TouchMath on mathematics achievement for students with the most significant cognitive disabilities. http://hdl.handle.net/2097/39495	Y	Y	SCD	Y	Y	Y	Y	Y	Further, specialized SCD review required
Park, J., Bassette, L., & Bouck, E. (2021). Using TouchMath to teach money identification to students with autism spectrum disorders: A brief report. *International Journal of Disability, Development and Education.* *https://doi.org/10.1080/1034912X.2021.1882665*	Y	Y	SCD	Y	Y	Y	Y	Y	Further, specialized SCD review required

TouchMath studies: Screening findings 3

Citation	Study	Primary Analysis	Eligible Design	Geographic Alignment	Timeframe	Relevant Outcome Domain	Age / Grade range	Setting	Review Outcome
Taneja, K.K. & Sankhian, A. (2019). Effect of multi-sensory approach on performance in mathematics at primary level. *The Educational Beacon, 8,* 2582-3515.	Y	Y	GDS	N	Y	Y	Y	Y	Not eligible for WWC review (provides Tier 4, potentially Tier 3 evidence for included outcomes)
Urton, K., Grunke, N., & Boon, R.T. (2022). Using a TouchPoint instructional package to teach subtraction skills to German elementary students at-risk for LD. *International Electronic Journal of Elementary Education, 14*(3), 405-416. 10.26822/iejee.2022.252	Y	Y	SCD	N	Y	Y	Y	Y	Not eligible for WWC review (provides Tier 4, potentially Tier 3 evidence for included outcomes)
Uzomah, S. (2012). Teaching mathematics to kindergarten students through a multisensory approach. http://www.proquest.com/en-US/products/dissertations/individuals.shtml	Y	Y	GDS	Y	Y	Y	Y	Y	Pending certification from the WWC, meets requirements for Tier 3 evidence of TouchMath for Mathematics outcome.
Vinson, B.M. (2004). A foundational research base for the TouchMath program. https://www.touchmath.com/wp-content/uploads/2019/08/TouchMathResearchBase.pdf	Y	N							Tier 4 (demonstrates a rationale) for included outcomes
Wakeman, S., Karvonen, M., & Ahumada, A. (2013). Changing instruction to increase achievement for students with moderate to severe intellectual disabilities. *Teaching Exceptional Children, 46*(2), 6-13. https://doi.org/10.1177/004005991304600201	N								Tier 4 (demonstrates a rationale) for included outcomes

TouchMath studies: Screening findings 4

Citation	Study	Primary Analysis	Eligible Design	Geographic Alignment	Timeframe	Relevant Outcome Domain	Age / Grade range	Setting	Review Outcome
Waters, H.E., & Boon, R.T. (2011). Teaching money computation skills to high school students with mild intellectual abilities via the TouchMath program: A multi-sensory approach. *Education and Training in Autism and Developmental Disabilities*, *46*(4), 544-555.	Y	Y	SCD	Y	Y	Y	Y	Y	Further, specialized SCD review required
Wisniewski, Z.G., & Smith, D. (2002). How effective is TouchMath for improving students with special needs academic achievement on math addition mad minute timed tests? ERIC Number: ED469445	Y	Y	N						Not eligible for WWC review
Yikmis, A. (2016). Effectiveness of TouchMath technique in teaching basic addition to children with autism. *Educational Sciences: Theory & Practice*, *16*(3), 1005-1025. https://doi.org/10.12738/estp.2016.3.2057	Y	Y	SCD	N	Y				Not eligible for WWC review (provides Tier 4, potentially Tier 3 evidence for included outcomes)
Waters, H.E. (2014). The effects of TouchMath on students with mild intellectual disabilities. https://getd.libs.uga.edu/pdfs/waters_hugh_e_201005_phd.pdf	Y	Y	SCD	Y	Y	Y	Y	Y	Further, specialized SCD review required
Valesco, V. (2009). Effectiveness of TouchMath İn teaching addition to kindergarten students. https://www.proquest.com/openview/f87fabfea35f57c35bbc97c08f6f1669/1?pq-origsite=gscholar&cbl=18750	Y	Y	GDS*	Y	Y	Y	Y	Y	Eligible for WWC review, but will not meet standards due to over alignment of outcome measure
Rudolph, A.C. (2008). Using TouchMath to improve computations.	Y	Y	N**						

TouchMath studies: Screening findings 5

Citation	Study	Primary Analysis	Eligible Design	Geographic Alignment	Timeframe	Relevant Outcome Domain	Age / Grade range	Setting	Review Outcome
Kim, S. A., Bryant, D. P., Bryant, B. R., Shin, M., & Ok, M. W. (2022). A multilevel meta-analysis of whole number computation Interventions for students with learning disabilities. *Remedial and Special Education*, 1-16. https://doi.org/10.1177/07419325221117293	Y	N							Not eligible for WWC review
Dueker, S.A., Day J.M. (2022). Using standardized assessment to identify and teach prerequisite numeracy skills to learners with disabilities using video modelling. *Psychology in the Schools, 59*, 1001– 1014. https://doi.org/10.1002/pits.22473	Y	Y	SCD	Y	Y	Y	Y	Y	Further, specialized SCD review required
Valenzuela, V.A., Guitierrez, G., & Lambros, K.M. (2014). Response to intervention: Using single-case design to examine the impact of tier 2 mathematics interventions. *School Psychology Forum: Research in Practice, 8*(3), 144-155.	Y	Y	SCD	Y	Y	Y	Y	Y	Further, specialized SCD review required. However, intervention was the use of TM and AIMSweb, so would not contribute to findings
Cihak, D.F., & Foust, J.L. (2008). Comparing number lines and touch points to teach addition facts to students with autism. *Focus on Autism and Other Developmental Disabilities, 23*(3), 131-137. https://psycnet.apa.org/doi/10.1177/1088357608318950	Y	Y	SCD	Y	Y	Y	Y	Y	Further, specialized SCD review required
Simon, R., & Hanaran, J. (2007). An evaluation of the TouchMath methods for teaching addition to students with learning disabilities in mathematics. *European Journal of Needs Education, 19*(2), 191-209. https://doi.org/10.1080/08856250410001678487	Y	Y	SCD	Y	Y	Y	Y	Y	Further, specialized SCD review required

*Study will not meet standards; **No comparison group; ***Meta analysis

Appendix E. Implementation Survey Data from August 3, 2022, Report

Table 10. Teacher implementation survey: Beginning of year and end of year respondents' characteristics

Teacher Current Role and Experience	Beginning of Year (BOY) Survey		End of Year (EOY) Survey	
	#	%	#	%
General education teacher	28	26%	2	40%
Special education teacher	72	67%	3	60%
Intervention specialist/teacher	4	4%	NA	NA
Building instructional coach	NA	NA	NA	NA
Other	4	4%	NA	NA
Average number of years teaching math	8.2		7	

Table 11. Teacher-reported confidence in teaching mathematics to students

Teacher Confidence	Beginning of Year (BOY) Survey		End of Year (EOY) Survey	
	#	%	#	%
Use multiple tools to identify student needs	107	98%	15	100%
Engage students regardless of math ability	102	98%	15	100%
Improve math performance for students who struggle	102	98%	15	100%
Apply evidence-based instructional strategies to improve learning	98	90%	15	100%

Note: On a 4-point scale of strongly disagree to strongly agree, teachers were asked to what extent they agreed with each of the following statements that started with I am confident that I can… The above table presents teachers who selected agree and strongly agree.

Table 12. End of year survey: Percentage of teachers who ...

Percentage of Teachers who …	
	%
participated in TouchMath formal professional development (n = 13)	87%
participated in Live office hours at least 1-2 times (n = 5)	33%
participated in Live office hours at least 1-2 times (n = 5)	33%
said they are able to apply knowledge from TouchMath PD and support in practice (n =10)	71%
said TouchMath training and support enhanced understanding and ability about teaching students who struggle with math (n = 11)	79%
used the implementation fidelity checklist (n = 2)	13%
said it is easy to use TouchMath with my students (n = 13)	93%
said it is easy to use TouchMath pro to support my math instruction (n = 19)	64%
said they are able to apply knowledge from TouchMath PD and support in practice (n = 8)	62%

Table 13. End of year survey: Teacher's agreement with the benefits of adopting TouchMath

As a result of adopting TouchMath …	Percent Agreement
My students are more engaged in math lessons (n=12)	86%
I have enhanced my ability to improve student math performance (n=11)	79%
I can see students mastering new skills (n=10)	71%

Appendix F. Teacher and Administrator Checklist for Implementation

These "look fors" provide evidence that TouchMath is being implemented with fidelity. *From: TouchMath*

<u>Classroom Setup</u>

- Resources are readily available. This may include manipulatives, workbooks, activity sheets, handheld devices, software, and access to digital platforms.
- TouchPoint Posters, Primary/Upper Skip Counting Posters, and Computation Step Posters are fixed on the walls at student eye level.
- Desktop TouchLines and Student Number Cards are readily available to the students.
- Unit or lesson objective is displayed.
- All manipulatives are labeled and stored where they are readily accessible.

<u>Planning & Preparation</u>

- Download and review the TouchMath Implementation Guide to ensure familiarity with materials and resources. The Implementation Guide is available on the Teacher Tools page of the TouchMath website: www2.touchmath.com/teacher-tools
- Visual schedules and evidence of regularly scheduled math time and a predictable routine.
- The length of structured activities is determined based on the teacher's knowledge of student needs.
- Lesson plans should evidence a systematic focus on teaching math, and include a connection to previous and future lessons that is explicitly shared with students during the lesson.
- Links to IEP goals/objectives and/or personalized learning plans from TouchMath PRO are indicated.

<u>Teaching the Lesson</u>

- Multisensory teaching and learning is used in each lesson.
- Differentiation is evident in each lesson. Modified instructional goals, content, and strategies may be needed for special needs students.
- Use of teaching aids is evident. This could include specific lesson-related worksheets, manipulatives, Desktop TouchLines, Student Number Cards, Domino Cards, posters, etc.
- Checks for prior understanding are done.
- The teacher and students use mathematical language and vocabulary words.
- Questioning incorporates targeted vocabulary, number concepts, and number operations.
- All students have the opportunity to respond individually.
- Evidence of multiple methods of frequent response to maintain engagement. Students demonstrate understanding by holding up fingers, using response cards, eye gaze, pointing and touching, choral practice, think, pair, share, thumbs up, thumbs down, whiteboards, etc.

  Identified student mode of communication is known by all staff as evidenced by active prompting for student responses throughout the lesson.

  In lower grades use a book(s) from the literature connections with skill and vocabulary being introduced embedded with the storyline, asking students questions about adding, subtracting, skip counting, multiplying, or dividing.

- The teacher models the skill with TouchMath manipulatives as part of the lesson or when students need additional work with concrete models of the mathematics.
- The teacher provides explicit instruction with TouchPoints and students respond by touching TouchPoints as needed.
- Fluency is developed through short 1–5-minute timed activities with Student Number Cards, TouchCards, or activity sheets.
- Visual and auditory cues are provided.
- Students may continue to demonstrate kinesthetic learning. This could include using hands-on learning aids (TouchShapes, TouchNumerals, 3-D Numerals, Student Number Cards), Desktop TouchLines, and TouchCards as a means of demonstrating knowledge.
- There is evidence that students have learned and are practicing the step-by-step verbal rehearsal as
- appropriate, using physical or mathematical output.
- Evidence of skills practiced throughout the day when there is a natural need for math such as the calendar, money, time, distance and size.
- Use of various evidence-based instructional strategies:
- Modeling, guided practice, independent practice also known as model, lead, test (or I do, we do, you do).
- Constant time delay.
- Draw, Write, Share: Students apply learning and share with a partner.
- Multiple representations of the math concept with variety of concrete, pictorial and abstract
- representations during activities. Think build, draw, write.
- Word problems are evident, differentiated based on student need, and used to help students apply content just learned.

Assessment & Progress Monitoring

- Formative and summative assessments used to determine progress and next steps in instruction,
- planning, goal setting, IEPs, etc.
- Progress monitoring records are accessible and maintained for evidence. They may include work samples and pre- and posttests.
- IEP goals/objectives are matched to skills that are taught and those that are mastered.

Home & School Communication

- Parent/guardian communication letters should be sent home after each module.
- Share TouchMath procedures with parents/guardians via website or meetings.
- Independent work used as homework to practice skills may be sent home 2 to 4 times per week.

Professional Learning

- TouchMath University provides numerous training and support opportunities for teachers and administrators.

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