Live Oak Education Center

San Bernardino, California

The Effectiveness of the TouchMath Curriculum to Teach Addition and Subtraction to Elementary Aged Students Identified with Autism

Presented by

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Abstract

This study examines the effects of Touchmath (a concrete psychomotor designed) math curriculum on ten children labeled autistic. These children were served in a special day class setting in the West End region of San Bernardino County, California. The influence of the curriculum is viewed longitudinally over two school years. Pre and post teacher tests and a variety of gathered work samples detailed student progress. During the second year of study the number of students involved dropped to eight due to student mobility and a variety of other uncontrollable factors. The research question this study posed was: Is TouchMath an effective math curriculum for children diagnosed with autism? The results indicate TouchMath lead to an increase of math fluency with the students averaging a three year gain in addition and subtraction skills, these results were significant ($p<.05$). A theoretical finding from the study indicates that children with autism may learn in a whole-part-whole sequence. The TouchMath curriculum uses dots on the numbers to indicate the quantity each number represents. This modification may have supported this need for whole-part-whole instruction providing an explanation of the three year gain in the students math skills during the two years of the study.

Introduction

The unprecedented rise in the population of students identified as autistic and the high rate of these students involved with due process proceedings provide a large incentive to generate information regarding effective curriculums for students with autism. The outcomes of this study add to the knowledge base needed by districts and teachers that serve and teach children with autism. This study was done to facilitate those needs and enable teachers and districts to work from a research base of effective curriculums. The results are encouraging and similar studies should be done to establish the replicability of these findings across a broader base of children with special needs.

Review of the literature

Henschen (1925) first used the term dyscalculia in relating to mathematical disabilities to dysfunctions of the brain. Myklebust and Boshes (1969) found that many learning disabled children have difficulty with calculations and Cohn (1971) held that dyscalculia was a disturbance that often persisted into adulthood. Dyscalculia has subtypes relating to number identification, arithmetic problems and sequencing abilities (Badian, 1983). It is important to note that reading numbers and reading the names of numbers involves two different processes and thus two different abilities. Sugishita, Iwata, Toyokura, Yoshiala and Yamada showed that digits differ from numbers and that phonographic aspects of numbers differ from the visual representation (1978). Hemispheric involvement studied by Gazzaniga and Smylie (1984), demonstrated that the left hemisphere is involved in the process of calculation and the right hemisphere identifies numbers.

In autistic children some are able to perform arithmetic functions such as addition, subtraction and even multiplication, but their performance is often ritualistic involving little conceptualization of quantitative amounts (Mykleburst, 1995). It is important to understand the complex nature of ability to calculate. Caramazza and McCloskey (1987) state there are three basic cognitive functions that must be operational in order for a student to perform math problems. They are: (1) ability to process numerical symbols and the arithmetic processes to be performed; (2) ability to retrieve needed operations from memory; (3) ability to execute the operations. Some high functioning individuals with autism may have dyscalculia as an additional disability, lower functioning individuals with autism may simply not have the cognitive ability to do math. This difference needs to be noted by teachers in order to best serve the students and the families that they serve.

The stability of cognitive functioning according to Freeman et. al. (1991) in their follow up study of autistic children twelve years after initial testing showed that a little more than 20% had progressed. However they concluded "... even though cognitive scores increased or remained relatively stable, patients in all IQ groups still exhibited significant social deficits (p. 481)". Regarding the ability to perform arithmetic functions, educators should view the Freeman research in light that math ability once gained will remain relatively stable throughout the life of the individual. This stability of functioning justifies the teaching of math to autistic children as the ability should be maintained throughout the life of the individual and better conceptualization may be gained at a later date.

Teaching Math to Individuals with Disabilities

Teaching math to students with disabilities is quite challenging. There are a variety of cognitive precursors needed in order for the instruction to be effective (Caramazza & McCloskey 1987). Some of these precursors include recognition of numbers and one to one correspondence. Without these precursors, the ability to learn math is diminished. Early research found that students with mental retardation lagged considerably behind their average achieving peers in their ability to differentiate relevant and non relevant information from needed arithmetic facts, computation, in problem identification, and in each of the four basic arithmetic fundamental operations (Cruickshank, 1948a, 1948b, 1948c). Thurstone's (1960) research confirmed these findings and added that students with mental retardation also score lower on tests of arithmetic reasoning. Recent research has measured the students with mental retardation against students with learning disabilities and again the performance of the students with mental retardation show the most difficulties when doing math.

Palmer, Cawley, and Miller (1994) found that fourteen year old students with mental retardation were unable to achieve the basic math concepts scores of identified eight year old students with learning disabilities. Mastropieri, Bakken, and Scruggs' (1991) review of the literature relating to math interventions used for students with mental retardation confirms a paucity of research in this area during those twenty-three reviewed years. In twenty-three years only twenty-five studies were found. The bulk of the findings support the idea of using a task analysis approach to teaching math to students with mental retardation. Limited methodology has been available relating to teaching mathematics to students with mental retardation (Morin, & Miller, 1998). However, Mastropieri et al.'s (1991) work support good direct teaching methods which include modeling, prompting and feedback.

The literature in the area of best mathematic teaching practices for learning disabled students is being applied to teaching math to students with mental retardation. One of the best practices for students with learning disabilities is the use of the concrete-representational-abstract (CRA) sequence. The use of this CRA sequence to teach math to students with learning disabilities has shown promise. Particularly in teaching these students to solve basic math facts (Harris, Miller, & Mercer, 1995; Mercer, & Miller, 1992; Miller, & Mercer, 1993; Miller, Mercer, & Dillon, 1992). This is important as across the board, students with behavior disorders, learning disabilities, mental retardation and other conditions typically score below their same aged peers on measurements of mathematic achievement (Scruggs & Mastropieri, 1986, Zentall & Smith, 1993). Concrete level instruction involves the use of objects as manipulative devices to promote conceptual understanding of the math skill being instructed. From student mastery at the concrete level the instruction moves to the representational level. This level of instruction often includes the use of drawings and/or tallies. The numbers written are displayed with a pictured number amount next to them. The number of items next to the numbers reflects the quantity related to the written number. This allows the student to count the number of items shown if they need assistance. The representational level allows the students to focus on the most important concept in the lesson which is actually determining the function to apply to the numbers, addition or subtraction. They are already able to count, the lesson is in learning to subtract, multiply or to add.

Additional research has demonstrated the specific need to understand how a student thinks when learning new skills. This research thrusts the need for cognitive strategy instruction when teaching students mathematics (Hutchinson, 1993; Mastropieri, Scruggs, & Shah, 1991; Montague, 1992; Montague, Appellate, & Marquard, 1993; Monatgue, & Boss, 1966). Again this body of literature stems from students with learning disabilities, but when warranted is applied to students with mental retardation (Morin, & Miller, 1998). Cognitive strategy instruction emphasizes how a student processes information when working to solve a problem. This type of instruction often uses mnemonic devices to help students organize their thoughts and to solve a problem in a systematic way.

The CRA sequence and strategy instruction has resulted in better math skills for both general and learning disabled special education students (Harris et al., 1995). Morin and Miller (1998) further this research with students with mental retardation. They found that the CRA sequence and strategy instruction is also beneficial for students with mental retardation. In their study they measured the effectiveness of CRA instruction on one 15 and two 16 year old students with retardation (mean WISC-R score: 58). They used CRA techniques to teach multiplication facts. They found the students made excellent progress, "...experienced much success and motivation was high (p. 34)." The results were particularly encouraging in light of the importance multiplication skills. It is Morin and Millers opinion that continued research on effective math instructional techniques will benefit not only special needs students, but also general education populations.

In an analysis of eight curriculums identified by Vaughn, Bos, & Schumm (1997) as helpful for students that are having difficulty learning math four offered unique instructional strategies. One was through direct instruction in a highly sequential fashion. This program named the DISTAR Arithmetic Program stresses direct instruction and immediate feedback to the students (Englemann & Carnine, 1972, 1975, 1976). The second unique strategy involved using computer programs to teach problem solving strategies to children in fourth grade and up whom have been unsuccessful in learning problem solving skills. Instructional computer games can improve basic math skills and improve the recollection of math facts for children with learning disabilities (Vaughn, Bos, & Schumm, 1997). This computer program is called Milliken Wordmath. Structural Arithmetic is designed for kindergarten through third grade with an emphasis on the use of materials to enable the child to make and discover math facts and concepts (Stern, 1965). This discovery mode is difficult for students with any type of severe disability and this program would not have been appropriate for a classroom with students with moderate to severe disabilities such as autism. The fourth unique strategy was TouchMath (Bullock, 1991). TouchMath offers the unique touchpoints idea, counting up for addition and down for subtraction. It has been shown to help students with mild disabilities learn math (Scott, 1993).

Touchpoints are dots placed systematically on the numbers to represent the value of the number. Each touchpoint is placed in key points on the numbers. The numbers 6 through 9 have touchpoints surrounded by a concentric circle. These are referred to as double points and the child touches and count these unique points twice. Students touch each point in a logical pattern as they count out loud, providing a natural repeating multi-sensory reinforcement of their newly acquired number recognition skills (Bullock, 1991). TouchMath estimates that in a general education classroom 1st graders may learn the touchpoints in a week. It might take 3rd graders as little as one math session

Participants

This study consisted of 10 children identified as autistic. All instructional materials were purchased through TouchMath. TouchMath is a pen and pencil approach to basic computation. The students are taught to count forward for addition and backward for subtraction. The materials used were number identification sheets, addition and subtraction math facts sheets, and addition and subtraction worksheets. The math facts sheets varied from the worksheets with respect to the variety of problems presented. Fact sheets covered 1's then 2's and then 3's and so on. For example, the 1's fact sheet had the problems 1+1, 1+2, 1+3, 1+4 . . . up to 1+9. The 2's fact sheet would contain just the two's facts. Work sheets would mix the different fact problems and contain a variety of addition or subtraction work. The worksheets would vary in difficulty starting from single digit addition or subtraction moving on to larger numbers and then adding carrying or borrowing.

Settings and Procedures

All instruction took place in the classroom settings with instruction beginning in the one-to one training areas. The students review previously learned skills in the independent area.

Entry criteria to the study was the ability to recognize and name numbers up to ten. One to one correspondence was mastered at a 70% level by the majority of the participants. All participating students had the ability to count by ones to at least ten. The ability to count by twos would prove helpful in later stages of this study, but the lack of this ability did not preclude someone from participating.

The instructional steps were as follows:

1. understanding the TouchMath numbers -touching the touchpoints
2. Adding numbers 1-5 (in a math facts flash card form)
3. Adding numbers 1-10 (in a math facts flash card form)
4. Adding the numbers one column, two, or more column no carrying (paper work)
5. Adding the numbers with carrying (paper work)
6. Subtracting numbers 1-5 (paper work skipping fact cards)
7. Subtracting numbers 1-10 (paper work)
8. Subtracting numbers two or more columns no borrowing
9. Subtracting numbers with borrowing

Once the students acquired mastery of the stage staff would work on drill and practice with the students to reinforce the learning. Once the facts were learned at an 80% correct level the students moved on to independent work, redone by the student if the accuracy levels dropped below the 80% level.

MODIFICATIONS OF MATERIALS AND INSTRUCTION

The paper lessons were first presented without the use of manipulatives or modifications. The students would then start the lesson and as quickly as possible move to guided practice with intermittent checking. The TouchMath program is sequentially laid out moving from addition to addition with carrying and then to subtraction.

Some modifications were made to facilitate three students who could not write or state their answers. The teachers cut out a series of individual numbers 1 through 10, laminated them and placed velcro on the back of them. These number pieces were then available to students to use solve the problem by placing the correct number piece in the answer spot. This adaptation allowed for a clear understanding of whether the child knew the answer, there was no interpretation of messy written numerals or difficult speech patterns. This adaptation also allowed for the work to be done independently, something not afforded if someone needs to work with the child to hear their answers.

One other modification was a deletion of a recommended instructional technique. TouchMath recommends the children count the touchpoints aloud during group instruction, while learning the touchsystem. All participatory oral instructional techniques were not used during the instruction due to the fact instruction was done individually and language is one of the primary areas of deficit for children with autism.

The 10 students were divided into four naturally forming groups based on the initial baseline data of initial skills. The baselines of skills for these students were as follows:

1. the top two students, both boys, could add single digits with counters;
2. the next tier of students, two other boys, could count by ones to 100;
3. this next and largest group had four students, two could count to ten by ones, one could count to thirteen and a boy who could count to twenty;
4. the last group of two had no baseline as they were untestable at the time

The results of the two years of TouchMath instruction show significant progress for all of the children. The first group of two could add with counters, both can now add and subtract two to four digit numbers with borrowing and carrying. Both can add columns of four or five with the numbers ranging in size from single to quadruple digit numbers. One student in this group is moving into single digit multiplication problems.

Table 1

Baseline of Initial Math Skills ( ) = # of students	*Ending skills of students*
Group 1 - (2) - Simple addition with counters	(2)- 5 digit addition and subtraction with regrouping
Group 2 - (2) - Orally rote count to 100	(1)- single digit addition
	(1)- two digit addition, single digit subtraction
Group 3 - (4) - Orally rote count to 10 (2), 13, and 20	(1) - 4 digit addition and subtraction with regrouping
	(2)- 4 digit addition and subtraction no regrouping
	(1)- not successful with TouchMath
Group 4 - (2) -No reliable baseline data	(1)- 1 digit addition
	(1)- not successful with TouchMath

In the second group of students that could orally rote count to 100, one can now add numbers up to ten and is starting with two digit numbers. This first child has also as an ancillary benefit gained by the TouchMath system, an improvement in the legibility of his handwriting. This was most likely facilitated through the constant writing of his numbers in the answer boxes that are on the TouchMath papers. This particular child focused on staying within the box when writing his numbers and this TouchMath work has helped his fine motor skills. The second child in this group can add double digit numbers without carrying, and do subtraction facts 1- 10. This child seems to be leveling out and is having difficulty subtracting numbers over ten and carrying.

The third group of four children despite the lessor initial baseline abilities improved more than those in group two. One child in this group was unable to understand the double dots, and did not make significant progress with the TouchMath system. He was taught to use a calculator in the second year and now can add and subtract using a calculator up to four digits numbers with accuracy.

In the fourth group (the one in which no baseline was achieved) the child using the TouchMath for one year, was able to learn to use the touchpoints and work math facts up to 10. This child liked the dots and would get into self stimulatory behavior on the dots when engaging in TouchMath work. This self stimulatory behavior was shown by the student continually touching and counting the numbers while working the problems more than necessary to do the work. The other student in this group was unsuccessful with TouchMath.

Eight of the ten students were able to learn touchpoints and make significant progress towards early math fluency. Two of the ten children were unable to learn the touchpoints and had to learn to add and subtract via a calculator and counters. Despite the varied levels of achievement the data show that the use of the touchpoints helped most of the students become successful adding and subtracting numbers.

All of the children learned addition first and then subtraction. As the TouchMath lessons progress the dots on the numbers are dropped, but students would still go to the exact points they would have been when counting. Over time the students would simply know the answer to single digit addition or subtraction facts. However, when stuck the strategy employed by the students would be to start touching the touchpoints on the numbers and counting forward for addition or backwards for subtraction. The strategy of putting dots on the numbers to represent the quantity of the number enabled these students to learn math.

Conclusion

The results of the TouchMath program on these two groups of individuals diagnosed with autism are both encouraging and significant. It is important to give students exposure to best curriculums to give opportunity for successful academic gains. The TouchMath system proved helpful for these students. An alternate curriculum may have also proven successful, however it should be noted that TouchMath is the only alternate system that uses the touchpoints, and it is the use of the touchpoints that proved to be the key to this group of students' success. Other curriculums were used by the teacher prior to the use of TouchMath without corresponding student gains. This curriculum may prove to be the best way to teach basic math computation to children identified as autistic, additional research is needed.

The significance of the TouchMath system is its use of touchpoints. The touchpoints allowed the students to focus on the number and work math problems without looking away from the paper. Touchpoints on the numbers pictorially represent the quantity of each number. Due to this the students were able to look at the whole concept at a glance. They could stare at the numbers and without lifting their gaze or attention, input in one chunk of information both the number (abstract) and the number amount (concrete).

This study concludes that teachers of children with autism need to be aware of the potential effectiveness of TouchMath and use it as the primary curriculum for teaching simple addition and subtraction. Children with autism are best served using Touchmath as it has been proven an effective curriculum for this population.

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