Improving math fact acquisition of students with learning disabilities using the "Touch Math" method

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IMPROVING MATH FACT ACQUISITION OF STUDENTS WITH LEARNING DISABILITIES USING THE "TOUCH MATH" METHOD

by
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ABSTRACT

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This study examined the effects of "Touch Math" compared with a number grid for computation. The study also considered the effects of these interventions on the self-efficacy of students with learning disabilities towards mathematics.

Computation probes and math self-efficacy surveys were administered to the students prior to, and at the end of the intervention sessions. A quasi experimental alternating treatment design was utilized for interventions which lasted for ten days each. Probe and intervention practice sessions presented addition first then subtraction on separate worksheets. Seven elementary students with learning disabilities receiving specialized instruction through a pull-out program participated.

Significant difference was calculated using a t statistic and critical value for interventions and initial to final probe percentages. No significant difference was found in the accuracy of basic fact computations when the two interventions were compared. Results from initial to final probes indicated overall improvement in accuracy. For two students a significant improvement was found when comparing initial to final probe results. Neither intervention was seen as the key to the improvement. Survey results indicated a minimal relationship between perceived effectiveness, effort, and improved accuracy.

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Chapter I

Introduction

Students with learning disabilities often have difficulty when it comes to acquiring math fact fluency. These students often employ inefficient and inaccurate methods for computation such as using tick marks or tally marks and counting. They tend to commit more counting errors and use developmentally less mature procedures for computation than their non-disabled peers (Geary, 2004). They tend to be disorganized, have difficulty with sustained attention to tasks, and do not work carefully on mathematics tasks (Badian, Ghublikian, 1982). These students often experience a lower self concept with the realization that their peers do not share this problem (Zeleke, 2004). For older students it is assumed that they have already mastered these facts and committed them to memory for fast and accurate retrieval, however, this may not be the case (Gersten & Chard, 2001).

A secondary but no less debilitating effect is the embarrassment some students face knowing they cannot meet perceived expectations. This can lead to a lower self esteem in regard to math abilities.

Multi-sensory instruction has been an effective method for students with learning disabilities for strengthening concept development. By utilizing more than one sense modality, the student has a better chance of acquiring and building upon prior knowledge.

"Touch Math" (Bullock, 1989) is a multi-sensory, supplemental curriculum for teaching addition, subtraction, multiplication, and division. "Touch Math" was developed as a method to provide students with a critical means of transitioning from the concrete level of understanding to the representational or symbolic level. It is built upon the use of the visual, auditory, and tactile senses to enhance learning.

Standards Based Mathematics programs are increasingly being implemented in general education programs in districts throughout the United States. The design of standards based mathematics emphasizes self discovery of mathematical concepts, paired student activities, and whole group discussion of solutions where the students explain and compare answers. The No Child Left Behind Act has mandated that students identified as in need of special education be educated with their non-disabled peers to the greatest extent possible. According to Baxter, Woodward, and Olson (2001) students with learning disabilities tend to participate less in whole group discussions and are likely to be relegated to non mathematical aspects of tasks when working in small groups or paired practice activities. As a result, the student with learning disabilities may be participating in, but not gaining the benefits of the program.

As more students with special needs are educated in the general education classroom, students need to have available to them a method of computation that will allow them to make consistent and accurate computations, Older students, who may be more self conscious of their lack of math fluency, may need an efficient and inconspicuous method for computation while they continue to develop mathematical concepts. "Touch Math" may be the means to allow these students to access the benefits of conceptual development stressed in standards based math programs.

Statement of the Problem

Students with learning disabilities are being educated in the general education programs to a greater extent than ever before. Some students who have not yet mastered the memorization of basic math facts may need additional support that the "Touch Math" system for computation can provide. By providing students with an efficient and inconspicuous method of computation they will have an improved self concept regarding their mathematical ability and therefore be more willing to contribute to class discussions and become full participating members of this program type.

Thesis Question

Will providing students with learning disabilities with the "Touch Math" system for computation improve their math fact fluency and self confidence regarding mathematics when compared to using a number grid as utilized in the standards based Everyday Mathematics programs?

Hypothesis

Students who are taught the "Touch Math" system for computation will increase their speed and accuracy in math fact computation to a significant degree when compared to students who use the number grid used by the standards based mathematics program. The improved ability and confidence will show itself in an improved self concept regarding their abilities in mathematics.

Limitations of the Study

A small number of students were available for this study. At least one student had previously been taught the "Touch Math" system in a prior year.

Definition of Terms

Touch Math®: Mathematics program published by Innovative Learning Concepts Inc. A method of using touch points on numerals to assist with concept development of numerals and facts.

Standards Based Mathematics: Math programs that employ the constructivist theory for developing mathematics competency in grades K-6. Everyday Mathematics is the standards based program used in this study.

Number Grid: a hundreds chart used throughout the Everyday Mathematics program for addition, and subtraction of basic and extended math facts.

As a teacher of students with learning disabilities, the implications of this research are profound. If a VAT method such as Touch Math can provide a simple yet accurate means for students to access math facts it will open up the entire world of mathematics for them. Once the student has mastered the basic touch point system they can continue to work on memorization of facts, become more confident and competent learners, begin to focus on broader areas of mathematics, and become full participating members of the mathematics community.

Students with learning disabilities are increasingly being educated in general education classrooms. Standards based mathematics programs are used in most states in the United States today. Teachers and students need to have available methods for including these students as fully as possible in the programs being used. Students with learning disabilities need an accurate and inconspicuous means of computation in order to more fully gain the benefits of the standards based mathematics programs.

Chapter II

Literature Review

Introduction

A percentage of school age children will exhibit weaknesses in mathematical abilities to such a degree that specific, targeted, and intense instruction will be warranted. Research has found that approximately five to eight percent of children will be found to have some form of mathematics learning disability (MLD) (Garnett, 1998). Geary (2004) found that many of these same individuals had co-morbid disorders such as reading disability or attention deficit/hyperactivity disorder.

Characteristics of Students with a Math Learning Disability

Learning characteristics suggestive of a disability in mathematics include inversion or omission of numbers, confusion between right and left, a poor sense of direction, and difficulty with computation. In some cases these deficits will continue through adulthood (Geary, 2004).

Students with MLD commonly have a high frequency of procedural errors, difficulty representing and retrieving facts accurately, and may be unable to symbolically or visually represent numerical information for memory storage (Gersten & Chard, 1999).

An understanding of the underlying cognitive and neuropsychological behaviors that constitute mathematical disabilities is critical to professionals who are responsible for the assessment and identification of MLD and to those who seek to provide valid instructional techniques for addressing these disabilities (Bryant, Bryant & Hammil, 2000). Bryant, Bryant, and Hammill (2000) investigated specific behaviors that could be an indicator of a student with MLD. Using theoretical constructs and input from experts in the field of learning disabilities, a set of characteristic behaviors indicative of a math disability emerged. Nine behaviors were identified as significant to the identification of a student as having a mathematical learning disability. These include:

a. difficulty with multi-step problems
b. making regrouping errors in computation
c. inability to recall basic facts automatically
d. misspelling of number words
e. arriving at answers that are not "reasonable" (estimation and number sense)
f. making calculation errors when order of numbers is changed
g. inability to copy numbers accurately
h. ordering numbers and spaces inaccurately for multiplication and division.
i. and difficulty remembering number words or digits

Of those nine behaviors, five are relevant to the current study:

1) student cannot recall number facts automatically (unable to perform simple calculations)
2) reaches unreasonable answers (poor number sense)
3) calculates poorly when order of digit presentation is altered
4) cannot copy numbers accurately
5) does not remember number words or digits.(Bryant et al., 2000)

Additional causes for poor math performance could be poor matching of instruction to the student's learning needs, math anxiety, poor attitude towards math, or an inability to think abstractly (Hughes & Kolstad, 1994).

Prerequisite skills for developing the ability to add and subtract include one-to-one correspondence, stable order (word order for number naming is consistent), cardinality of numbers, abstraction of the concept of counting, and order irrelevance.

When observing a counting task, Baroody, Bajwa and Eiland (2009) found that a typically developing child will automatically notice when a double count occurs and the final tally is incorrect, whether the double count occurred at the beginning or end of the tally. However, students with learning disabilities only noted the discrepancy when the double count for a one to one correspondence occurred at the final count. This indicates that these students may have difficulty holding and using information in short term memory, an essential component for developing automaticity with number facts.

Young children begin to recognize cardinality of numbers through informal experiences such as learning nursery rhymes and practical counting of items such as blocks or toys. By attending to the final number stated or the exaggerated naming of the last item counted, the young child begins to develop a sense of the use and names for numbers. As they experience observing and listening to these activities they begin to act upon them, practicing counting and verbalizing number words. Feedback from parents and teachers reinforces the concepts and helps build number sense. If a child comes to school with a weak informal knowledge of number concepts, learning basic number facts can be seriously impeded. This could be caused by a lack of environmental experience or a learning disability (Gersten & Chard 2001).

Typically developing children tend to pass through three phases when mastering basic facts. Phase 1 utilizes counting strategies, either object or verbal counting to arrive at the answer. Count-all, counting from the first number, and counting from the larger number are the subcomponents of this phase. Phase 2 utilizes known facts and number relationships to deduce other number facts. For example, a student can use the basic fact 7+5=12 to reason that 70 + 50=120, or use doubles facts to include near doubles such as 6+6=12 and 6+7=13. Phase 3, or the mastery phase, is the ability to efficiently retrieve responses from a memory network. At this phase, fact knowledge is automatic and does not require conscious effort (Baroody, et al., 2009).

Students with MLD often do not progress spontaneously to phase two in the developmental sequence. They are prone to associative confusions and exhibit an unusual number of basic fact errors. Not only do students with learning disabilities in math fail to achieve math fact mastery on their own, they typically fail to achieve this even with extensive practice (Baroody, et. al., 2009). These students tend to continue to use developmentally less mature processes (such as the count all strategy) to arrive at their answers (Geary, 2004). It is for this reason that an alternative strategy may be necessary so that students with a math learning disability can accomplish computational tasks in a more efficient manner.

Instructional Strategies Shown to Improve Student Math Performance

Instruction for math facts should follow a specific sequence:

a. concrete examples of concept
b. concrete to semi-abstract (representational)
c. symbolic

d. abstract (Smith, & Geller, 2009)

Concrete examples of math facts could include the use of base ten blocks, using a ten frame mat to illustrate the relationships between numbers, or counting chips. Two sided color chips can be useful for developing the concept of number decomposition, which can later be useful for developing multiple means of arriving at the desired answer.

Initial instruction should include the use of manipulatives and follow the instructional sequence of teacher model, guided practice, and independent practice (Flores, 2009). This process can be repeated when progressing to the next step, the representation of the concept using numerals and symbols.

Willingham (2004) found that shorter periods of distributed practice over time (i.e. several years), was more beneficial in creating a long term stable and steady growth in math fact acquisition than one time intensive instruction.

Incremental review is a strategy whereby the student practices a number of known facts while adding only a few unknown facts at a time. This can improve not only accuracy but the speed of recall (Willingham, 2004).

Codding, Hilt-Panahon, Panahon, & Benson, (2009), examined simple and moderate intensity interventions for mathematics computation. Cover-copy-compare, student tracking of progress, individual goal setting, and class wide peer tutoring were found to have effect sizes ranging from moderate to large for math fact accuracy. They also found that the students continued to demonstrate maintenance of skills taught for up to 5 months after the intervention ceased.

Computer Assisted Instruction programs such as the Fluency and Automaticity Teaching with Technology, or FASTT, program appears to be effective in improving fact acquisition (Baroody et al., 2009). Verbalizing the problem as it is being solved also assisted students with developing the language of math facts. This aligns with the theory that cognitive connections are strengthened when more than one modality is involved.

Providing a multi-sensory program for reading has been shown to be effective in improving the skills of non-readers who need a strong phonemic awareness upon which to build decoding, in the area of reading. A similar need can be found for some students who cannot apply the basic skills of math fact acquisition (Gersten and Chard, 2001). Providing a student with the combined multisensory component for math fact acquisition may be helpful for these students who have difficulty in the math area.

Hands-on experience with concepts at the concrete level, frequent review opportunities, and mediated scaffolding are effective procedures for use with struggling students (Smith, K., & Geller, 2004).

Concrete instruction that is paired with the representational should provide students with the support needed to begin to develop meaningful memorization of math facts. The Touch Math® method pairs the concrete and representational components of both numerical recognition and math facts (Bullock, 1989). Baroody found that meaningful fact memorization, rather than the simple paired problem-response mode, reduced the amount of time and practice needed to achieve mastery and maintain efficiency (Baroody, et al. 2009) for struggling students.

Reducing the anxiety level when a student is struggling with concepts and skills related to math can also improve math performance. This can be accomplished through the use of untimed tests rather than timed tests (Wadlington, E. & Wadlington, P., 2008) and improving accuracy rate thereby improving self-confidence in math.

Instructional Practices

Instructional practices of the past placed a heavy emphasis on rote memorization of basic facts. This can be viewed as a passive method of strict problem-answer response (Baroody, et al. 2009). The theory behind the strong emphasis on rote memorization and quick retrieval of facts is that working memory space can then be allocated to more complex problems rather than laboring over counting procedures (Gersten & Chard, 2001). However, many students with learning disabilities had difficulty learning, maintaining, and generalizing the facts to other situations. Many students with a math learning disability had not mastered facts even at the middle school level (Garnett, 1998).

In some cases, a student may respond to repeated frustration of not meeting expectation for math fact mastery by avoidance or withdrawal of effort. A student may accurately or inaccurately perceive that they are not as proficient in math tasks as they would like to be, and the subsequent avoidance of continued practice can affect the student's ability to learn math or limit performance on math tests (Garnet, 1998; Wadlington, & Wadlington, 2008).

Academic Achievement and Self-Efficacy

Academic self-beliefs are beliefs about ones attributes and abilities as a learner and are closely related to student achievement. Bandura, as cited in Hailikari, Nevgi, & Komulainen, (2008) suggests that a person's beliefs about their ability to solve a task is a stronger indicator of behavioral performance even over skills and knowledge. The beliefs that the person holds moderate what the person will do with the skills and knowledge they possess. A negative self-belief can reduce engagement and motivation to perform a task. These effects have been found to be cumulative over time. A positive self-belief will allow an individual to attempt new tasks because they are confident that they will meet with success provided they persist.

Self-beliefs are comprised of three components. They are self-efficacy (which is context specific and reflects confidence in performing a task successfully; it is closely related to motivation and engagement), expectation of success, and self-perception, (which focuses on past performance). Expectation of success and self-efficacy are strongly correlated and academic self-beliefs are strongly related to student achievement (Hailikari et al., 2008).

Math self-efficacy, as defined by Bandura, is the perception of the individual that they possess the ability to utilize a strategy that will provide them with a correct response. Meltzer, Katzir-Cohen, Miller, & Roditi (2001), found that students both with and without learning disabilities regarded effort and successful strategy use to be the best predictor of academic achievement. It is vital, however, that the student view the strategy as one that is useful to him. When students use a strategy and they see the positive effects of the use of that strategy combined with their own efforts, they feel empowered to take more responsibility for their work, to value the strategy, and to continue to work hard. Effort and success often reinforce each other.

In order to successfully build self-efficacy, the task situation must be structured to ensure success. By providing students with a strategy that will assure positive results they begin to know that the skill is attainable to them, their confidence in their ability to perform the task improves, and they will be more inclined to work hard at that task. (Meltzer et al.2001). Guided mastery is a powerful means of instilling a robust sense of self-efficacy (Bandura, 1994). I hypothesize that "Touch Math" will provide the strategy to ensure accurate and positive responses thereby building the self-efficacy the student may need in order to gain confidence in their ability to perform computational tasks.

Zeleke (2004) studied the self-concept of normally achieving, high achieving, and LD students. Although general self-concept did not show significant differences, academic self-concept, specifically related to math revealed that the LD students had less favorable self-concept than the normally achieving group. Significant differences were found between the LD and the High Achieving groups.

Current Theory Regarding Math Instruction

Current Mathematics reform design was developed due to the realization that a percentage of students were exiting the school system without the needed skills, especially those required by a world that is highly technology oriented. Unfortunately, the National Report on Reform Mathematics did not look at how the paradigm shift in instruction would affect students with learning disabilities (Woodward & Montague, 2002).

The belief is that children develop informal math knowledge much sooner than was previously thought and that instruction needed to be a match to students developmentally. A variety of activities that use different types of manipulatives and game formats for developing a deeper construct of math principles while continuing to encourage higher order thinking skills are espoused to be a better fit for children. Skills are introduced, then extended spiral review is purported to be sufficient for developing strong conceptual understanding of math principles and skills. Concepts are introduced through a concrete example and are modeled by teachers. Students receive guided practice in the form of small group activities and game formats. Providing similar information from a variety of directions including relating numbers to money and degrees of temperature are thought to strengthen the conceptual connections providing flexibility in later applying the skills.

Strong emphasis in the lower grades is placed on relating number concepts including addition and subtraction to a hundreds chart number grid. Students count forward for addition and backward for subtraction. An integral part of the program is the ability to decompose numbers into related equivalent facts. The purpose is to show how a more complex problem faced later on can be handled by having the elements related to other equivalent and familiar facts. The role of the teacher is that of facilitator of students' own intuitive reasoning. Inductive reasoning and self discovery are stressed throughout reform math programs (Woodward & Montague, 2002 p. 92).

Many students with learning disabilities have difficulty "seeing" the big picture and do not automatically discover the concepts being taught. Heavy emphasis on the use of the hundreds chart number grid does provide a visual representation for facts; the facts will always be found in the same location on the grid, but students often have difficulty determining in which direction to count for addition and subtraction (Hickman, 2007). Add to that the difficulty of executive shift that many of these students experience (this would be required for addition of facts including the teen numbers) and the directionality issues often present for these children and using the number grid becomes problematic.

Proctor, Floyd & Shaver (2005) found that some students with math learning disabilities had deficits with directionality, attending to task, and accuracy while counting. With this in mind, such a heavy emphasis on using the number grid seems to be an inefficient means for these students to perform basic math fact practice.

Multi-Sensory Instruction

Multi-sensory learning is the process of learning new subject matter using two or more sense modalities. Multi-sensory input for concept development creates longer and stronger associations and memory (Rains, Kelly and Durham, 2008). Demonstrating a concept while verbally explaining the process provides the multi-sensory input some students need. In general, multi-sensory instruction involves the use of visual, tactile/kinesthetic, and auditory modalities.

According to Fleischmer and Manheimer (1997), the following sequence and principles should apply to mathematics instruction. Concrete representation includes using manipulatives when introducing a new concept, followed by pictorial representation of the underlying concepts, and finally progressing to the abstract conceptualization of the skill.

Concrete-representational-abstract instructional sequence incorporates explicit teacher modeling using manipulatives and verbal explanations as specific skills are introduced. The actions and explanations illustrate the key components of the skill or concept being taught. Flevares and Perry (2000) found that students performed better if a concept was both seen and heard simultaneously. Students should then be provided with opportunities to explore the concepts, develop examples and non-examples of the concept and explain or verbalize their understanding of the concept. Lively paced instruction, along with a minimum of three model sessions per concept prior to moving to the next level of instruction, is important.

In keeping with the recommendations from the National Council for the Teachers of Mathematics advisory panel, many reform based math programs embrace multiple exposures to different manipulatives in many different forms to build strong underlying understanding of basic concepts. The use of a large class-sized number grid provides a student with a semi-abstract representation of our number system. Thornton, Langrall and Jones (1997) found that a student with learning disabilities, while in a mainstreamed class, successfully utilized the chart to add two 2-digit numbers mentally. Prior instruction utilized finger movement on the number chart and the student was able to visualize the process including decomposing the second number into two smaller numbers to finally arrive at the correct response. The student was also able to explain the process she used in arriving at the answer. Another essential component in determining that a student understands and can utilize underlying information when solving more complex math problems is if the child can explain how they arrived at their answer.

The Multi-Sensory Basic Fact Program incorporates visual learning through picture, oral prompts, finger tapping, and tracing to build math fact knowledge (Rains, Kelly, and Durham, 2008).

To a significant degree, multi-sensory math instruction consists of using manipulative materials when introducing new mathematical concepts. Structural Arithmetic is a math program developed by Elizabeth Stern using specially designed manipulative materials which correlate number sense with representational and hands-on manipulatives. These materials are similar in design to Cusinaire Rods which also are physical representations of the numbers from one through ten. The design of Stern Arithmetic is based on the learning theory that students will strengthen underlying essential number concepts when presented with manipulatives that demonstrate number relationships. In the Structural Arithmetic approach, the children progress from activities and games with concrete materials that help them form basic concepts to the final steps of recording addition and subtraction facts with numerals. As the teacher utilizes the language of mathematics during instruction, understanding of the concepts is strengthened and the underlying number sense related to later fact retrieval is built.

Cusinaire Rods are a concrete manipulative tool which can be directly utilized to assist students with the concepts of number relationships, number building, creating examples and non-examples of simple basic math facts, extending number understanding to include addition of three or more numbers and the teen's facts. Virtual manipulatives are interactive computer-based materials that can be maneuvered much like concrete materials (Rains, Kelly, & Durham 2008). They can either be used individually at a computer station or through the use of smart board technology to address group work.

Orton-Gillingham multisensory math provides instructional techniques and describes strategies for the teaching of math. Manipulatives such as concrete materials are used to teach concepts, for example, popsicle sticks and rubber bands to create tens and ones, base ten blocks, or coins. Vocabulary related to the skills is directly taught. They also encourage verbalizing steps used when solving a problem, using diagrams, drawings to reinforce mathematical language, and highlighting or color coding essential information. Information is provided through workshops presenting the techniques used.

Touch Math® is a multi-sensory mathematics program that utilizes the configuration of numerals and touch points to enhance conceptual understanding of numbers (Bullock, 1989). It can be used as a supplement to the regular math program and therefore is transferable to any math program. The touch points follow a specified counting pattern and are consistently placed on each numeral from 1-9. Thee are no touch points on the numeral 0.

"Touch Math" was developed to assist students who had difficulty counting and performing basic math (Bullock, 1989). The points are strategically placed to assist students with understanding that the numeral represents a specific quantity. This system provides the student with a means of transitioning from the concrete to the representational aspects of numbers.

Through the consistent use of tactile and verbal counting, math concepts are reinforced linking the representational to the abstract components of math facts.

Prerequisite skills are the ability to count in sequence from 1-50 forward for basic addition, and from 20-0 backward for subtraction. Program training information from the company suggests that students should first be introduced to the individual touch points and practice them until they can use the counting procedure independently (Bullock, 1989). Students may construct their own pattern of touch points if they remember them more accurately than the points suggested by the program.

By placing the touch points on the numerals themselves, the student performing the task directly relates the abstract nature of number to the representational numeral. The student also gains the advantage of not having to avert his/her attention away from the problem to a number line or number grid before calculating the solution. The practice is portable, (once the student has memorized the touch points they can be drawn on any math problem encountered in other classes), it is virtually invisible and therefore older students are not embarrassed by either the inability to perform basic facts or the need to draw and count tally marks or use a number grid.

Scott, (1992) studied the effects of Touch Math to determine the effectiveness of the technique for students with mild disabilities. A multiple probe design was used for the study. The study included an initial probe, Touch Point training, three interventions with follow up probes after each intervention, and two maintenance probes. The total number of sessions for the study was 30. Subjects of the study were three fourth-grade students receiving instructional support in a resource setting. Initial training focused on the placement of touch points on numerals. The students practiced until they reached 100% accuracy on the counting touch points. Each student received instruction for 15-30 minutes per day. Probe conditions were untimed.

The Intervention phase for individual skills with the method then focused on one of the target skills, either column addition, two-digit subtraction, or three-digit subtraction. Students were reinforced by receiving praise for correct responses. Intervention conditions lasted an average of five days and continued until the student reached 85% mastery without touch points for two consecutive days. Follow-up maintenance probes found that all subjects maintained and generalized all target skills which included addition, single digit subtraction and subtraction with regrouping. Although limited by the number of subjects included in the study, Scott has added to the research supporting multi-sensory instruction regarding math skills.

Cihak and Foust (2008) compared the use of a number line to Touch Math for addition of basic facts. This study included three elementary students identified with severe to moderate autism and moderate mental retardation. The study utilized an alternating treatment design. An adapted model-lead-test procedure was used for each intervention. Both strategies were administered semi-randomly, separated by a 20 minute time span. Students were then presented with one worksheet per session. Students received verbal praise for correct responses. The strategy that allowed students to reach criterion, 100% correct responses on the worksheet, was then replicated using content from the non-preferred strategy. They found the touch points were preferred to the number line and was functionally more effective than the number line when strategies were compared. All students acquired single-digit addition skills more quickly by using the touch points (Cihak, & Foust, 2008 p. 135).

Students identified as having a learning disability are being educated in general education settings to a greater extent than in the past. Research has shown that a percentage of these students will be developmentally lagging behind their peers in the attainment of basic math fact fluency. Research has also shown that students who have a strategy they believe will allow them to meet with success will increase their effort at a task and continue to build on prior knowledge.

Two possible strategies that can meet the developmental level of students while allowing them to continue to learn math in the general education setting are examined in this study; they are the use of a hundreds chart and "Touch Math". A secondary aspect of the study will be to examine the students' current beliefs of their abilities and compare that with any changes which may occur as a result of these strategy interventions.

Chapter III

Methodology

Introduction

The current study compared students' addition and subtraction accuracy prior to and after providing two intervention strategies; using the number grid and Touch Math®. Additional assessment included assessing students' self-efficacy related to basic fact knowledge. Intervention strategies were provided using an alternating treatment design. Accuracy rates from pre-intervention to post-intervention were compared. Finally, the same self-efficacy rating scale was re-administered to determine whether either treatment design had a significant effect on the students' beliefs about math fact capability.

Student Profiles

Seven elementary school students receiving special education services through the pull out resource program participated in the study. Three of the students are female, four are male. The age range is from seven years ten months through 10 years five months. Three students are white, three students are African American and one student is Hispanic. All students have Individualized Educational Plans and were eligible for special education services under the category of Specific Learning Disability, Communications Impaired, Other Health Impaired, or Multiple Disabilities. Six of the seven students received additional pull out instruction for language arts.

Table 1 defines the student information for those participating in the study.

Table 1:

Student Information

Disability Type	Gender	Race	Age	Grade	LAL Pull-out	Subject
Communications Impaired	Female	African American	10 yrs 5 mos.	Fourth	yes	A
Multiple Disabilities (OHI/ SLD)	Male	White	9 yrs 9 mos.	Fourth	yes	B
S.L.D.	Female	White	9 yrs 5 mos.	Third	yes	C
S.L.D.	Male	White	9 yrs 4 mos.	Fourth	yes	D
Communications Impaired	Female	Hispanic	9 yrs 1 mo.	Third	no	E
Communications Impaired	Female	African American	8 yrs 1 mo.	Second	yes	F
Other Health Impaired	Male	African American	7 yrs 10 mos.	Second	yes	G

Pre requisite skills for participation in the study were the ability to count with one to one correspondence from 1 through 50 and oral counting from one through 50 with no omissions. Additionally, the student must be able to write all the numbers from 0-50 without error. For subtraction, the student must demonstrate the ability to count backwards from 20 to zero in sequence, with no omissions. Additional prerequisite for subtraction is the ability to count backwards from numbers other than twenty and stop at different numbers without omissions.

Materials

The researcher developed a self-efficacy scale related to math based on Schwarzer and Matthias's self-efficacy scale. The scale consisted of statements regarding beliefs about math facts. Each statement had a forced choice, Likert type response. The response choices were Always, Most of the time, Not too often, and Never.

For the initial intervention, an eight and a half by eleven sized hundreds chart, (number grid from the Everyday Math Teacher resource kit) was used for modeling the procedure. Student sized number grids, also from the Everyday Math resource kit, were used for treatment sessions and practice sessions. Small number grids were affixed to the students' desks and four by six inch charts were also made available.

For the second intervention, a large, class-sized poster showing Touch points related to the Touch Math method was used to demonstrate the touch points and counting procedures. Students used individual number cards with touch points for practice. Desk sized student reference number charts with touch points were affixed to desks. Additional numeral charts without touch points were also used to practice proper placement and counting of touch points.

Initial baseline computation probe consisted of two basic math fact worksheets obtained from the Silver Burdett &Ginn mathematics series. One worksheet contained 60 addition facts, the second contained 60 subtraction facts.

Dependent and Independent Variables

The dependent variables include the number of correct responses on worksheets under the ten minute mark. Two forms were developed with approximately equivalent difficulty levels on each form.

The number of problems correctly completed independently divided by the total number presented is used to calculate the percentage of correct problems per session. The independent variables are the treatments. An alternating intervention treatment plan was used to examine the differential effects using the number grid vs. the touch math touch point system. During the initial intervention, students were taught to add and subtract using the number grid for a total of 10 sessions. The second (alternate) treatment was to teach the touch points. Initial instruction included teaching the proper placement and counting process on each of the nine numerals. This lasted for four days in accordance with the "Touch Math" training video.

Procedures

Initial testing consisted of having students demonstrate pre-requisite skills in a one to one situation with the examiner. Once this was established the students were administered the self-efficacy survey to determine students' current attitudes and self-efficacy regarding math computation. The examiner read the statements to the students and they responded either verbally or by checking the box that represented their beliefs. This was also done in a one-to-one setting apart from the regular classroom. Students completed the probe worksheet containing 60 basic addition and subtraction computation problems. The problems were obtained from the Silver Burdett & Ginn Mathematics program laboratory activities book.

Instruction consisted of a model-lead-test design for each intervention. Students were grouped according to home room scheduling. Interventions occurred over a ten day period and took place in the resource room at the beginning of the math period each day. Baseline assessment was established using the lab activity masters #5 and #6 from the Silver Burdett mathematics series.

The students applied the intervention strategy on two daily fact practice worksheets. 30 addition and 30 subtraction problems were on each separate worksheet and practiced following intervention.

Initial intervention (Treatment #1)

Experimental procedures: for number grid –students sat with the teacher at the instructional table. The teacher used the model, lead test procedure for implementing the use of the number grid for addition. Initial instructional focused on addition, counting forward. Subsequent instruction targeted the procedure for subtraction, counting backward using the number grid. These instructions were presented prior to all intervention practice sessions.

Second intervention (Treatment #2)

Treatment design introduced the touch points. Initial instruction focused on training students on the placement of touch points on numerals one through nine. Instructional design followed guidelines as presented in Touch Math instructional video. Individual number touch points were modeled, students practiced on numerals on which the touch points are already present. Students were considered at mastery when they consistently placed the touch points on unlabeled numerals for a total of five consecutive trials.

Procedures for instruction followed the same model-lead-test design. Initial addition instruction consisted of counting on both numerals to obtain a sum. Additionally, students had modeled for them to name the larger number and count back to subtract. Additional instruction for those who demonstrate 100% mastery with this strategy consisted of naming the larger number then counting on for the remaining smaller number. In a similar way to the first intervention, each student completed a practice worksheet for addition and subtraction following each day's instruction. Each worksheet consisted of 30 addition and 30 subtraction basic facts.

At the conclusion of the study, students were given a post assessment using the alternate form of the initial assessment worksheets. This was compared with the initial probe results. Additionally, the students repeated the self-efficacy questionnaire to determine whether either strategy provided the desired results, an increase in the belief that the student could accurately answer basic facts.

Chapter IV

Results

Introduction

This study was conducted to determine the effectiveness of "Touch Math" for basic fact accuracy versus using a number grid, with students identified as having a learning disability. The secondary aspect of the study was to determine whether a student's perception of usefulness of a particular strategy affected accuracy with regard to basic facts.

Math fact accuracy is a critical skill for all students. Since the passage of the No Child Left Behind Act and the reauthorization of IDEA, students identified as in need of specialized educational services are being educated in the general education classroom to a greater extent than ever before. Some students may benefit from a strategy that allows them greater participation in the mainstream classroom while allowing them to continue to master basic facts. Since many students with learning disabilities tend to utilize less mature methods for computation, an alternative method, such as "Touch Math" may be a strategy that the student finds useful and easily adaptable to the general education setting. The results of the quasi-experimental method follow. All subjects were given an initial probe to establish a baseline. Subjects received both interventions through an alternating treatment design. A final probe similar to the initial baseline data probe was administered and the results were compared.

Description of Data

Initial probe results for all subjects were analyzed as a mean of accuracy; for addition and subtraction, and collectively for all facts presented. Students were instructed to use any method to find the correct answers. The researcher stressed the importance of accuracy. Initial probes were subject to a ten minute time limit and students were presented with 60 addition and 60 subtraction facts. Table two presents the percent of accuracy during the initial probe for all subjects.

Table 2:

Mean Percent Accuracy at Initial Probe for all Subjects

	Addition	Subtraction	Total
Subject A	98.33	95.00	96.67
Subject B	53.33	65.00	59.17
Subject C	78.33	71.67	75.00
Subject D	93.33	81.67	90.00
Subject E	91.67	78.33	85.00
Subject F	53.33	51.67	52.50
Subject G	75.00	78.33	76.67
Overall Mean	78.33%	74.52	76.43

Intervention practice sessions followed instruction. The students were instructed using a model, lead, test format. All students were instructed in the method for addition and subtraction using a number grid. Practice session worksheets were randomly generated and consisted of 30 addition and 30 subtraction facts. All worksheets presented addition facts first and subtraction facts second.

Table 3:

Mean Percent Accuracy for Intervention One: Number Grid

	Addition	Subtraction	Total
Subject A	100	97.62	98.81
Subject B	98.99	99.32	99.155
Subject C	94.37	92.52	93.445
Subject D	97.96	96.28	97.12
Subject E	98.95	98.23	98.59
Subject F	99.12	98.68	98.9
Subject G	97.79	95.85	96.82
Overall Mean	98.17	96.93	97.55

For intervention two, "Touch Math", the worksheets had touch points placed on the worksheets and were obtained from the Upper Grades Computation Kit. For the final two days, the touch points were not placed on the worksheets but a touch point reference strip was available if needed. Practice session worksheets contained 30 each of addition and subtraction facts and were presented with addition first and subtraction second. Instruction consisted of learning the placement of touch points on individual numerals prior to practice sessions. The same model, lead, test procedure was followed for intervention two.

Table 4:

Mean Percent Accuracy for Intervention Two: Touch Math

	Addition	Subtraction	Total
Subject A	98.95	100	99.47
Subject B	100	100	100
Subject C	97.71	98.11	97.91
Subject D	95.55	96.6	96.08
Subject E	95.57	92.24	93.91
Subject F	97.62	96.58	97.1
Subject G	98.3	93.62	95.96
Overall Mean	97.67	96.74	97.20

The mean accuracy for the first intervention, number grid instruction for addition, was 98.17%. For intervention two, "Touch Math" the mean accuracy was 97.67%.For subtraction the mean accuracy for the first intervention, the number grid, was 96.93%. For the second intervention, Touch Math, the mean percent accuracy was 97.74%.

For addition, the t statistic result is -0.533. Results are significant at the 0.06 level. The critical value is 2.178. There is only a 40% probability that the change is due to the interventions. We reject the H_0 (Null Hypothesis) if the t statistic is $\geq$2.178, we reject H_1 if the t statistic is $\leq$ -2.178. Since the t statistic falls within the range of the critical value, the null hypothesis is supported, therefore, any change that is found cannot be attributed to the intervention instruction.

For subtraction, the t statistic is 0.135. The probability that the result is due to chance is the alpha level ($p<0.9$). The critical value is 2.178. We reject the null hypothesis if $t \geq 2.178$. The t statistic falls within the range of critical value. The null hypothesis is supported. Since the alpha level is 0.9 the probability that any change was due to chance is 90%. There was no significant difference between the two interventions. So the hypothesis that using "Touch Math" would increase accuracy for basic facts is not supported by the comparisons of the intervention sessions.

For the final probe session, students were presented with an alternate form of the initial probe worksheets. Students had both intervention references available and were instructed to add and subtract as accurately as possible. They could use known facts or either of the two intervention methods. Students were given ten minutes to complete the final probe. Final probe results are illustrated in table five.

Table 5:

Mean Percent Accuracy at Final Probe for all Subjects:

	Addition	Subtraction	Total
Subject A	100	100	100
Subject B	98.33	100	99.17
Subject C	100	93.33	96.67
Subject D	100	100	100
Subject E	85	83.33	84.17
Subject F	100	61.67	80.83
Subject G	95.00	96.67	95.83
Overall Mean	96.90	90.71	93.81

From the initial probe to the final probe, the mean percent of accuracy for addition increased from 77.61% to 96.9%. The mean percent for subtraction increased from 74.52% to 90.71%. The overall mean percent accuracy increased from 76.16% to 93.81%. There was an overall increase of 17.20% from initial to final probes.

The t statistic for addition from initial to final probe is -2.444 ($p=0.03$). The critical value is 2.178. There is a 97% probability that the change was not due to chance. We reject the null hypothesis if $t \geq 2.178$, or if $t \leq -2.178$. -2.444 is less than -2.178, therefore we reject the null hypothesis and state that there is a significant difference from beginning to end in accuracy for addition. The change is likely due to the interventions.

The t statistic for subtraction from initial to final probe is -2.178. The critical value is 2.178. The t statistic is equal to the critical value so the null hypothesis is rejected ($p= 0.05$). There is a 95% likelihood that the change was not due to chance, the change can be attributed to the interventions.

Figures One and Two represent the individual student accuracy for initial and final probes. Side by side comparison shows that for some individual students, there was minimal to no change in accuracy, whereas for other students there was significant difference from the beginning of the study to the end.

Figure 1:

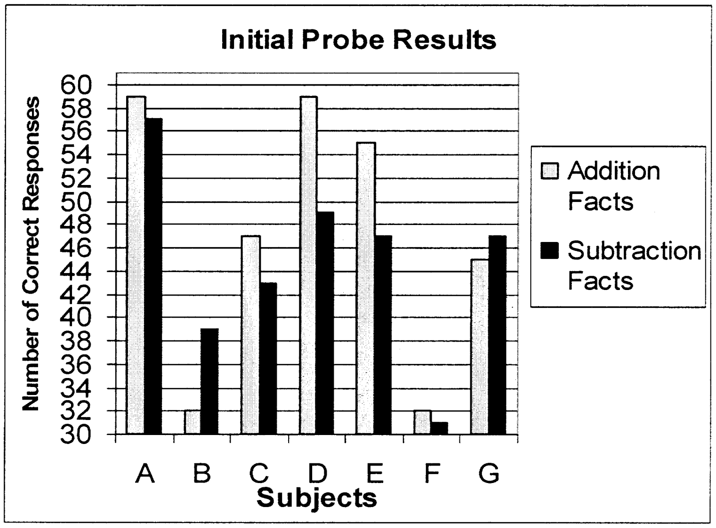
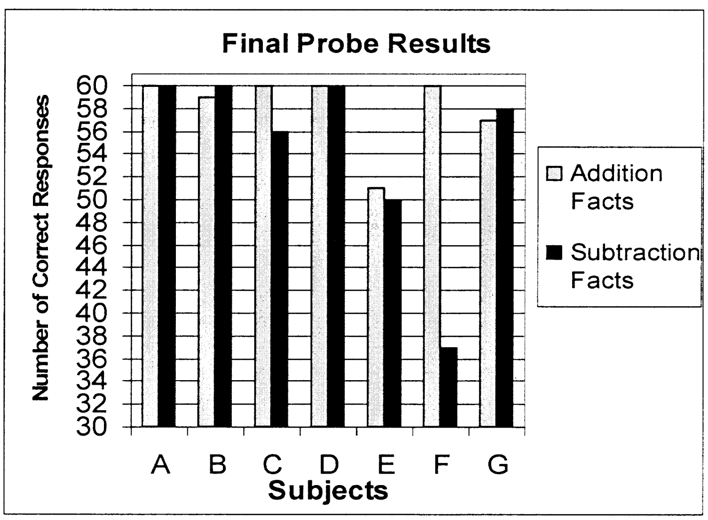
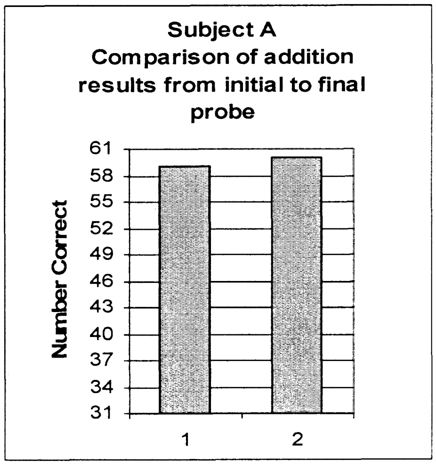


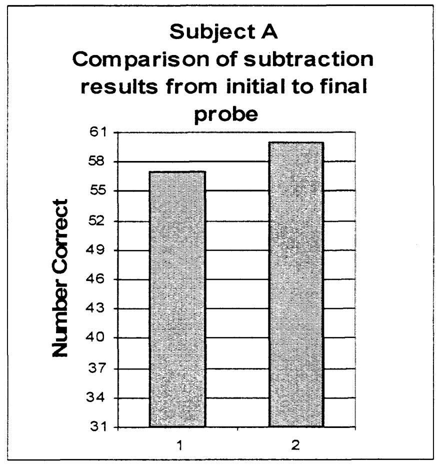
Figure 2:



For individual subjects, the following graphs indicate change from initial to final probes.

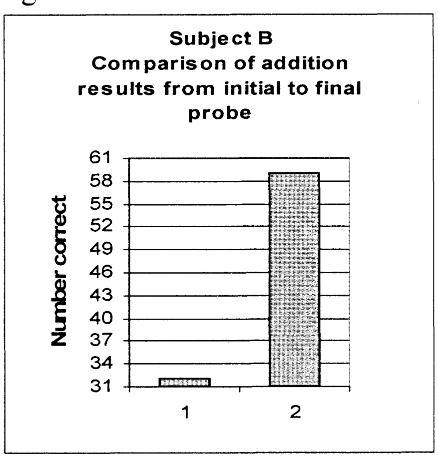
Figures 3 and 4:

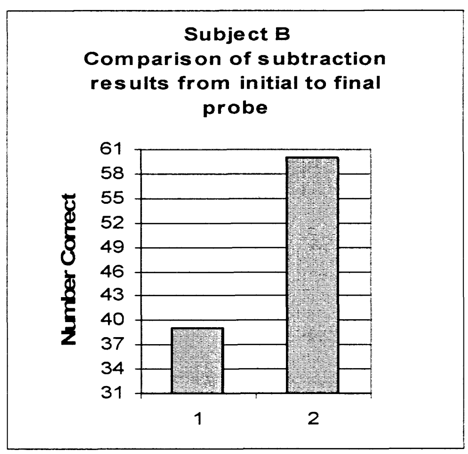




For Subject A, the rate of change for addition was 2.06%, for subtraction, 4%. There was no significant increase or decrease in accuracy for either addition or subtraction.

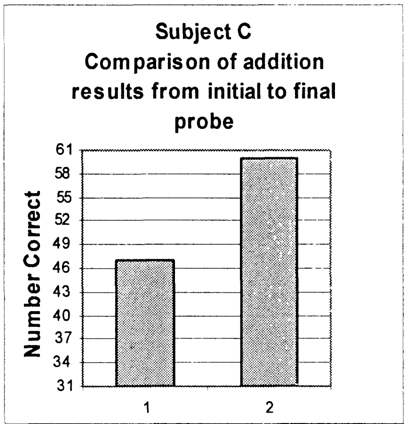
Figures 5 and 6:

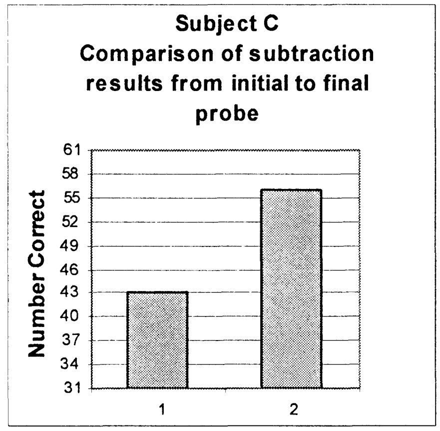




Subject B demonstrated a significant improvement in accuracy for both addition and subtraction from initial to final probe conditions. For addition, Subject B improved from 32 to 59 correct responses out of a possible 60. For subtraction, subject B improved from 38 to 59 correct responses out of a possible 60. In percentage terms, the initial to final probe change for addition indicated improved accuracy rate of 84%. For subtraction, the change indicated a 54% improvement in accuracy. Subject B demonstrated significant improvement in accuracy from initial to final probe.

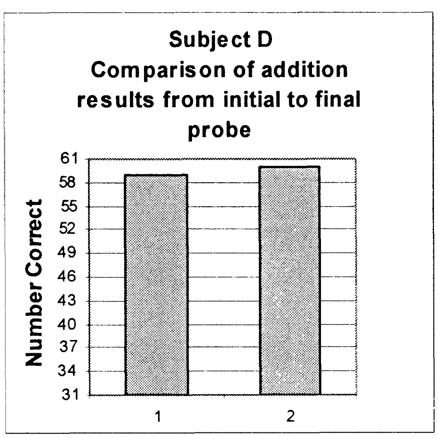
Figures 7 and 8:

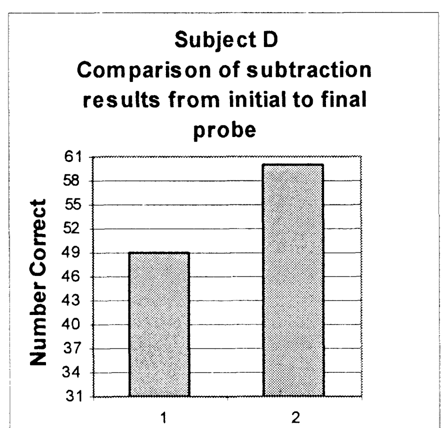




Subject C demonstrated significant improvement in both addition and subtraction accuracy from initial to final probes. Subject C improved from 47 to 60 correct out of a possible 60 correct responses for addition, and for from 43 to 56 out of a possible 60 subtraction facts presented. Initial to final probe percentage change was an increase in 40% for addition and 41% for subtraction.

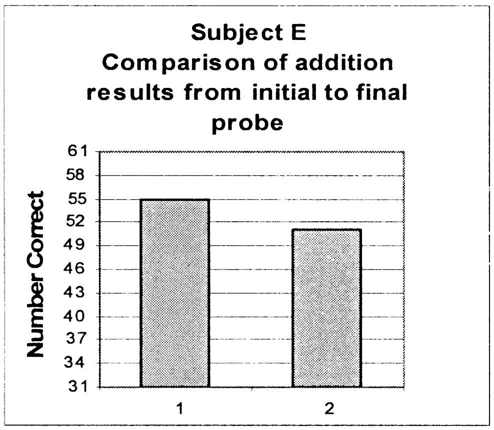
Figures 9 and 10:

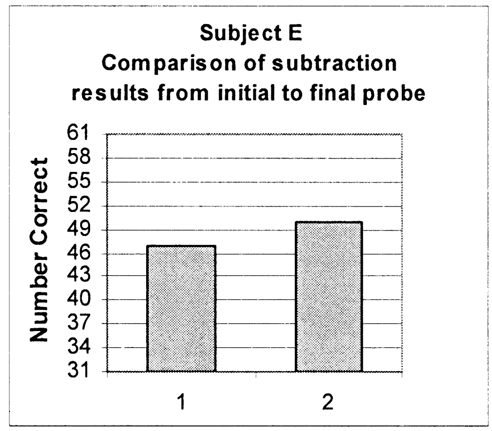




Subject D demonstrated a minimal increase in accuracy for addition with a change in percent from 97.94% to 100 % for addition and 81.34% to 100% for subtraction. Although there was no significant increase in accuracy for addition there was a significant increase in percent of accuracy for subtraction.

Figures 11 and 12:

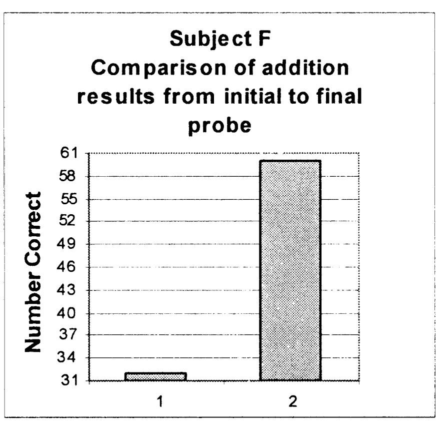


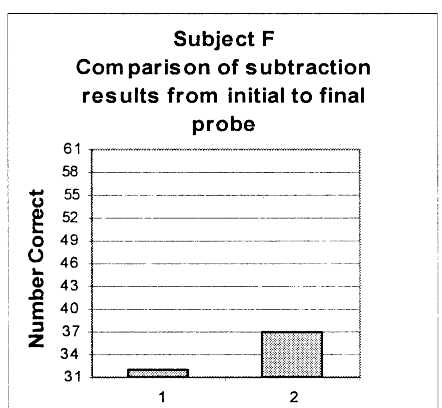


Subject E demonstrated a decrease in accuracy from initial to final probe with an initial 91.30 % accuracy rate for addition to 84.66% final accuracy

For subtraction, a minimal increase in accuracy was found from78.02% at initial probe to 83.00% at the final probe. That is a 5% change from beginning to end.

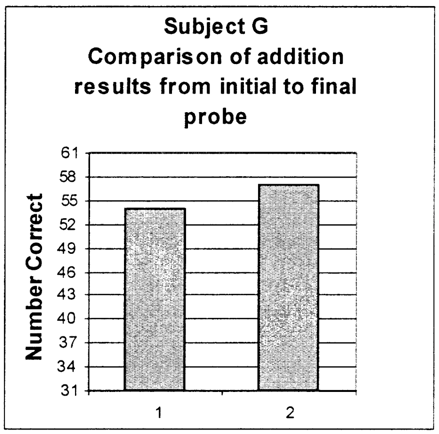
Figures 13 and 14:

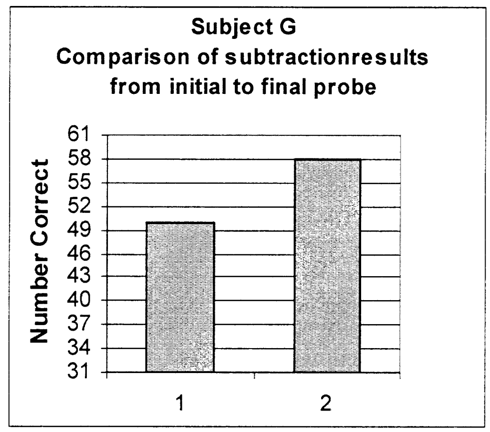




Subject F showed a significant increase in accuracy from initial to final probe for addition. For addition the increase went from 32 out of 60 possible correct responses to 60 out of a possible 60 correct responses. In percentage terms the increase went from 53% to 100%which is an 86% increase in accuracy. For subtraction there was an increase from 53.12% to 61.42 % which is an increase in accuracy of 15%.

Figures 15 and 16:





Subject G demonstrated some increase in accuracy from initial to final probe for both addition and subtraction. In terms of mean percent accuracy, the increase went from 87.98% to 94.62% for addition and 83.00 to96.28% for subtraction that is an increase of 6.64% for addition and 13.28% for subtraction.

The secondary area of study was to determine whether the student's perception of the usefulness of a particular strategy affected their self-efficacy and translated into an increase in accuracy related to basic facts.

Each student was administered a self-efficacy survey prior to intervention instruction and at the end of the study. The survey used statements obtained from the Schwarzer and Jerusalem self-efficacy scale with additional questions relating specifically to the interventions being studied. The researcher read the statements to the students individually and the student marked the appropriate box to indicate the level of their feelings regarding mathematics. A sample survey can be found in the appendix section. Students indicated their level on a forced choice, four point Likert scale. No additional coding was required. Scores were obtained as a sum of points. The initial score was compared with the final survey score in total points. Each subject's scores were isolated as related to the number grid intervention or "Touch Math". The mean score for number grid prior to interventions was 19.71. The mean for number grid after interventions was 21.14. There was a slight increase in perceived self-efficacy related to the use of the number grid.

The initial mean score for "Touch Math" prior to interventions was 18.85. The mean for "Touch Math" after interventions was 21.43. For the number grid intervention the increase was 1.43 points and for touch math the increase was 2.58 points. Table Six compares the initial and final survey results related to the two interventions by individual subject.

Table 6: Survey Results by Point Value

Touch Math	15	22	12	21	21	24	24	22	22	20	17	24	20	17
Number Grid	18	21	15	20	19	23	23	21	24	23	18	22	21	18
	init	final	init	final	init	final	init	final	init	final	init	final	init	final

Subjects: A B C D E F G

There was a slight increase in perceived self efficacy for both interventions, however, the relationship from self-efficacy to increased accuracy was found only for subject B. Subject B increased in accuracy to a significant degree as measured by the change from initial to final probe, and shifted reported self-efficacy in point value form

12 to 21 in favor of a positive result toward "Touch Math". A single specific relationship cannot be stated however, due to the increase in the apparent usefulness of both interventions. A similar argument can be made for Subject F. Although Subject F did show a significant improvement in fact acquisition when measured from initial to final probe, perceived usefulness of both strategies increased as per the survey results. No single intervention appears to have been the cause of the improvement.

Chapter V

Summary, Conclusions and Discussion

Introduction

The purpose of the study was to determine whether one type of intervention, using a number grid, or a second intervention, using the "Touch Math" system for computation, would significantly improve students' basic fact accuracy. A secondary purpose was to determine whether a student's self-efficacy affected the outcome; that being an increase in fact accuracy.

It was hypothesized that students who were taught the "Touch Math" method for addition and subtraction would improve their fact accuracy to a significantly greater extent when compared to a 100's chart number grid.

Pre-requisite skills were assessed individually prior to administration of the initial probe and survey. Students were individually asked questions relating to self-efficacy toward math fact accuracy and responses were documented on the student form. Students were administered an initial probe which consisted of one worksheet of 60 addition facts and one worksheet of 60 subtraction facts. Students received intervention one, number grid, for ten days. For "Touch Math", students practiced until they met mastery of applying the correct number "taps" without the aid of a guide. Intervention two lasted for ten days. The final probe was administered along with a repeat of the survey questions. All instruction followed the teacher model, lead, test format. All students received the same interventions in groups of two or three depending on daily schedules.

The findings of the study indicate that there was no significant overall difference using the "Touch Math" method versus the number grid. Student self-efficacy did not change with the interventions but stayed consistent with the individual student's perceptions. One student, who had previously stated a perceived usefulness for "Touch Math", was observed using extraordinary effort in order to achieve improved accuracy during the number grid intervention. The student was observed using the known strategy of sub-vocalizing, to maintain short term memory information. An extraordinary amount of effort was expended to maintain this strategy. Apparently, some students will go to great lengths to succeed.

Students' perceptions of usefulness of a strategy did not necessarily translate into improved accuracy; however, significant fact improvement was evident for two subjects. These students improved in accuracy level and significantly improved in decreased time to complete the task when initial results are compared to final probe results. If we are looking for ways for students identified with learning disabilities to improve not only fact accuracy but fluency, these methods may be beneficial.

Discussion

For the students involved with the study, one intervention may not have been the critical factor in the improvement they attained. The increase in accuracy may have been the result of intensive daily practice and routine rather than a specific strategy. According to Willingham (2004), the distinguishing feature of expertise is practice over and above that which offers understanding. This may account for the significant improvement that several of the students attained.

The number of students and amount of time available for this study was limited. In addition, several of the students had previously been introduced to and/or taught the "Touch Math" procedures. Further research could include younger students and/or older students who are struggling and have never been exposed to the concept of touch points on numerals. Including a larger group of students may provide clearer results.

Additional research may evaluate the improvement of students as they incorporate touch math and follow up with meaningful fact memorization. Baroody, et al. (2009) stated that improvement in fact acquisition will be stronger when meaningful memorization is used rather than the simple paired stimulus response. A longer period of time if available may contribute to the knowledge that fact acquisition occurs over time, sometimes considerable, extended time.

In terms of self-efficacy, it is somewhat difficult to ascertain what a younger student perceives as useful. For example, one student in the study was equally comfortable with the two interventions and for the final probe utilized both types. Although not specific to one intervention, she did improve in her ability to complete more problems in less time, thereby increasing fluency. This too, is an important mathematical skill.

Alternative experimental design may provide additional information as to the usefulness of "Touch Math" or the number grid to aid students as they become proficient in basic math fact acquisition.

Finally, it may not be the specific method that is the key to helping students achieve accuracy, but rather the continued and consistent meaningful practice to mastery and finding the method that aligns with the student's learning comfort level that may be the key.

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APPENDIX A

Self-efficacy Survey

Mathematics computation self-efficacy questionnaire

Read each question. Choose the statement that best matches your feelings about basic facts.

	Always	Most of the time	Not too often	Never
I can always find the correct answer for addition and subtraction using my fingers.				
I can always find the correct answer for addition and subtraction using the number grid.				
I can always find the correct answer for addition and subtraction using Touch Math.				
If someone else gets a different answer I can prove my answer is correct.				
I am confident that I can handle unexpected math problems.				
I can solve most math problems if I try hard.				
I can stay calm when confronted with a difficult math problem.				
If I get stuck I can think of more than one way to arrive at my answer.				
I can handle any addition or subtraction problem that comes my way.				
I would be willing to do extra math problems using the number grid.				
I would be willing to do extra math problems using touch math.				