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Research Article

Effectiveness of the Touch Math Technique in Teaching Basic Addition to Children with Autism

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Abstract

This study aims to reveal whether the touch math technique is effective in teaching basic addition to children with autism. The dependent variable of this study is the children's skills to solve addition problems correctly, whereas teaching with the touch math technique is the independent variable. Among the single-subject research models, A multiple probe design with probe conditions across subjects was used in the study. Three male students aged 8 to 10 years, diagnosed with autism, and exhibiting the prerequisite skills participated in the study. The findings revealed that the touch math technique was effective in teaching basic addition to each participant. All three participants were found to be successful at the end of the teaching session, compared to the baseline. In other words, there is a positive difference between the data obtained in the first and last teaching sessions for each child. Moreover, the generalization and maintenance findings also support the effectiveness of this technique.

Keywords

Touch math technique • Math skills • Children with Autism

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Teaching independent life skills to individuals with special needs, including children with autism, is the common purpose of the education services provided to them. In general, independent living skills are those necessary for the individuals to sustain their lives independently without help from others (Mannix, 2009). A significant part of these skills follows a progressive path from the stages of childhood to adulthood. The skills necessary for independent living are social skills, communication skills, self-care skills, daily life skills, occupational skills, and functional academic skills.

Functional academic skills such as reading, writing, and mathematical skills have an important place among independent living skills (Kırcaali-İftar, Ergenekon, & Uysal, 2008). Math skills are complicated for children with autism as for many other children with poor learning skills (Scott, 1993). Math skills proceed from the simple to the complex. Basic math skills include number recognition, simple addition, subtraction, multiplication, division, problem solving, knowledge of money, and time units. This also holds true for addition skills. Adding single-digit numbers and finding a two-digit sum is considered the first step of addition (Dağseven, 2001; Gürsel, 2010; Cawley, Hayes, & Foley, 2008).

To ensure the success of children with autism in teaching math skills, educational arrangements involve considering the characteristics of mathematics and those of children with autism. This means that children are required to meet the consecutiveness criteria in mathematical operations. In other words, acquisition of a mathematical concept or skill necessarily depends on applying previously learned concepts or skills. Therefore, the prerequisite relationship between the concepts, skills, or operations is taken into consideration when teaching them (Dağseven, 2001; Yıkmış, 1999, 2005). Furthermore, it is known that children with disabilities are different from each other during the learning process (Fletcher, Boon, & Cihak, 2010). Children with autism are included with those who need different arrangements (Sucuoğlu, 2009). On the other hand, not all children with autism are good at math; however, it is possible for most of them to acquire math skills when the appropriate conditions are met (Adkins & Larkey, 2013). In other words, it is an important fact that children with autism, like other children with disabilities, have specific learning needs (Heward, 2009). Therefore, trying different teaching techniques is necessary to ensure their success in math classes (Miller & Hudson, 2007). As they are unable to focus their attention and be occupied with an activity for a long time, children with autism require special instructional arrangements during the process of learning academic skills (Kroesbergen & Van Luit, 2003). A review of educational approaches to children with autism shows that object and visual stimuli are more effective in children with autism than the traditional stimuli (Berry, 2007; Birkan, 2009; Simon & Hanrahan, 2004). Some studies reveal that children with autism have basic math skills and are especially able to perform addition, subtraction, division, and

multiplication operations (Berry, 2007; Çalık & Kargin, 2010; Mykleburst, 1995; Simon & Hanrahan, 2004). Moreover, the use of objects and visual clues in teaching various skills to children with autism accelerates their learning process (Heward, 2009). Therefore, it is considered that teaching basic addition to children with autism through the use of visual clues will facilitate permanent learning.

The studies show that methods such as direct instruction, errorless learning, and interaction unit are frequently used in teaching basic addition to individuals with special needs, including children with autism. All of these methods are teacher-centered, making the teacher more effective at the beginning, but aiming to progressively move the children toward being independent (Dağseven, 2001; Gürsel, 2010; Kırcaali-İftar et al., 2008; Morton & Flynt, 1997; Yıkıncı, 1999). There are also different techniques available in teaching basic math skills such as the number line technique, finger counting technique, schema-based technique, and touch math technique (Berry, 2007; Cihak & Foust, 2008; Rockwell, Griffin, & Jones, 2011).

The review of the approaches to teaching math skills to children with autism shows that the number of studies on this topic is limited, and the existing studies focus on different techniques and strategies.

Kasap (2015) aimed to determine the effectiveness of the scheme approach for acquisition and generalization of verbal math problems to children with Autism Spectrum Disorder (ASD). The verbal math problems with unknown final sum benchmarking type were used in this study. In addition to this, Kasap's study aimed to determine: (a) the effectiveness of the maintenance level of the children for learning verbal math problems after the completion of the intervention, and (b) the generalization of these skills to different kinds of math problems. Furthermore, the mothers' and teachers' opinions on the social validity of the study were evaluated. Three children with ASD at the ages of 9, 11, and 14 participated in this study. Among the single-subject research models, multiple-probe design with probe trials across subjects was used in the study. The effectiveness of the scheme approach on verbal math problems was diagnosed via graphical analysis. According to the findings of this study, teaching with the scheme approach increased the performance levels of the children on solving verbal math problems. This increase resumed following the first, third, and fifth weeks after the intervention was completed. In addition, two children generalized solving verbal math problems from an unknown final sum benchmarking type to an unknown gap sum benchmarking type. By examining the social validity findings obtained from the mothers and teachers of the children, it was observed that each group noted positive opinions on the use of the scheme approach to teach verbal math problems.

The study by Burton, Anderson, Prater, and Dyches (2013) examined the effectiveness of video self-modeling in teaching functional math skills to students

with autism. They used a multiple-baseline across participants design, which is a type of a single-subject design. The participants were four adolescent male students with autism. The study aimed to teach problem solving skills in estimating a certain amount of money using iPads. The findings of the study showed that video modeling is effective in problem solving skill acquisition of students with autism in estimating a certain amount of money.

In a study by [Rockwell et al. \(2011\)](#) aiming to determine the effectiveness of the schema-based strategy in teaching addition and subtraction word problem solving to a fourth grade student with autism, a multiple-probes across behavior design was used. The student with autism was taught to use three types of schematic diagrams in solving addition and subtraction problems. The strategy was found to be effective in solving all single-digit addition and subtraction problems. Moreover, the improvement of the student in problem solving was also generalized to problems with unknowns and was maintained over time.

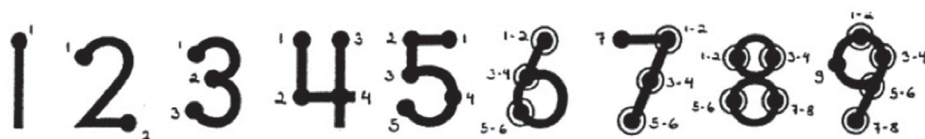
The study by [Whitby \(2009\)](#) examined the effectiveness and efficiency of a modified “Solve It!” strategy on the multiple-step mathematical word problem solving ability of middle school students with autism or Asperger’s syndrome. The participants of the study were three middle school students aged from 12 to 14, two of whom had Asperger’s syndrome and one of whom was diagnosed with autism. The study used a multiple-baseline design across subjects. The findings showed that the percentage of correct answers ranged from 20% during baseline to 100% at the end of the training. Besides that, the students maintained the strategies that they learned. The study showed that the use of a modified “Solve It!” strategy together with cue cards and computers is effective in the multiple-step mathematical word problem solving ability of students both with autism and Asperger’s syndrome. No performance difference was observed between two of the three students. However, one student fell behind the others in terms of the percentage of correct answers when the cue cards were used. The students were able to generalize their problem solving performance throughout the classroom.

Another technique that can be used in teaching math skills to children with autism is the touch math technique. It was developed by Janet Bullock in 1975 for children with math learning disabilities to help them to overcome their difficulties. This technique is based on the concrete-to-abstract instruction principle in mathematics teaching and learning. It is a student-oriented technique that provides easier computation by means of the concrete learning of numbers as well as quicker counting without the use of fingers ([Berry, 2007](#); [Bullock, 2009](#)).

The touch math technique is based on counting by placing touch points (dots) on numbers. This approach is of a multisensory nature, combining visual, auditory, and tactile

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

In the study by [Bullock, Pierce, and McClelland \(1989\)](#), the touch math technique was incorporated in a program where word problems are solved. Their study also takes the same points as reference.



The study carried out by [Carpenter and Moser \(1984\)](#) on children without disabilities is an important study in the literature. It examines what type of strategies students use when solving addition problems and reveals that they employ three different strategies. One of them is the use of a “count-all” strategy. For example, when solving the problem $3 + 5$, the student holds up three fingers on the one hand while counting to three, then holds up five fingers on the other hand while counting to five, and then finds the solution. This strategy is limited in that the student has difficulty in adding numbers greater than 10.

Another strategy for learning addition skills is the “count-on” strategy. This strategy involves saying the first addend of the addition problem and then counting on from that number. For example, in solving the problem $3 + 5$, the student first says three and then adds five. This strategy helps to save time in solving addition problems.

Another strategy identified in the study involves “storing and later retrieving the addition facts from the long-term memory.” The researchers reveal that repeated practice helps students memorize the basic addition facts and retrieve them from memory when needed ([Cihak & Foust, 2008](#); [Çalık & Kargin, 2010](#); [Jitendra, Star, Rodriguez, Lindell, & Someki, 2011](#)).

When the studies conducted on this strategy are examined according to the disability groups, it can be seen that people with intellectual disabilities comprise one

of these groups. Fletcher et al. (2010) studied individuals with moderate intellectual disabilities. Their study compared the touch math program and a number line strategy to teach addition facts to middle school students with moderate intellectual disabilities. An alternating-treatments design across participants was used in the study. The participants were one female and two male students aged between 13 and 14 years. The findings demonstrated that the touch math technique was more effective compared to the use of the number line.

When the studies on the touch math technique are examined, it can be seen that some of them were conducted with children having intellectual disabilities (Çalık & Kargin, 2010; Eliçin, Dağseven-Emecen, & Yıkılmış, 2013; Fletcher et al., 2010), while the others were conducted with children having learning disabilities (Simon & Hanrahan, 2004), on children without disabilities (Bullock et al., 1989; Carpenter & Moser, 1984), on kindergarten students (Velasco, 2009), on children with physical disabilities (Avant & Heller, 2011), and on children with special needs (Wisniewski & Smith, 2002).

The literature review shows that there is limited number of studies available on improving the math skills of students with autism through the use of touch math.

Berry (2007) studied the effectiveness of the touch math curriculum to teach addition and subtraction to elementary school aged students identified with autism. In the study, the fact sheets including examples covering 1's facts (for example, $1 + 1 =$, $1 + 2 =$, $1 + 3 =$) were used. The participants were ten students diagnosed as autistic. The findings of the study showed that eight out of ten students were able to learn to add and subtract fluently; however, two students were not able to do so, although they also learned the use of touch points. All of the students first learned addition and then subtraction.

Cihak and Foust (2008) conducted a study in which they compared number lines and touch points to teach addition facts to students with autism. An alternating-treatments design was used in their study. A total of three students (two females and one male) aged seven to eight participated. The findings of the study indicated that the touch math technique is more effective than the number line method in teaching additional skills to all three students. One of the students even showed no progress as a result of teaching with the number line technique.

In a study on three middle school students with autism with different levels of intellectual disability aged 13 to 14, Fletcher et al. (2010) compared the effectiveness of the touch math program and the number line strategy. The students were taught how to solve single-digit mathematics problems using touch math and a number line. Comparison of the single-digit addition skills of the three students by using touch math and a number line showed that they solved the problems correctly and more quickly when they used the touch math technique.

Although the touch math technique has been known for approximately 30 years, and studies have been conducted on its effectiveness in teaching math skills to children with certain disabilities, there are few studies on its effectiveness in teaching addition skills to children with autism (Berry, 2007; Cihak & Foust, 2008). Therefore, the need for further studies on the effectiveness of this technique for children with autism is one of the reasons for this study. Moreover, no study has been conducted in Turkey on teaching addition skills to children with autism. Therefore, this study is the first to reveal the effectiveness of touch math on addition skills, which can be considered as another reason for this study.

This study primarily aims to determine whether the touch math technique is effective or not in teaching basic addition skills to children with autism. In line with this purpose, answers will be sought to the following questions: (a) Is the touch math technique effective in teaching basic addition skills to children with autism? (b) Is the effectiveness maintained for one, two, and three weeks after the skills have been learned? (c) Can students with autism generalize the skills they have learned to other settings?

Method

Participants

The participants of the study were three male children diagnosed with autism attending a special education and rehabilitation center in a province in the Black Sea Region that provides education to children with developmental disabilities. The prerequisite skills were determined based on the steps of addition with the touch math technique. The children were expected to have certain prerequisite skills such as (a) the ability to follow instructions such as do, show, write, count, look at the sheet, examine the problem, and add. (b) fine motor skills, (c) the ability to recognize numbers between 1 and 10, (d) the ability to count rhythmically up to 10, (e) the ability to direct attention to the activity for 10 minutes.

During the selection of participants, pre-interviews were conducted with the instructors and information about the prerequisite skills of the children was obtained. The participants were also observed separately during a class to determine if they had the prerequisite skills or not. At the end of the observation period, each child was interviewed in an empty room and asked to count from 1 to 10, say the name of the numbers 1 to 10, and write that number on a piece of paper. Three children out of six who met these skills were involved in the study. Prior to the study, the parents of the participants were provided with information about it and written consent was signed by the parents. Moreover, the instructors and parents of the participants were asked not to teach the skill included within the scope of this study. Pseudonyms were used for the participants involved in the study.

Emrah is an eight-year-old male student diagnosed with autism and does not have any other disability. Before going to the special education center, he received preschool education as an inclusive student. He is also a first grade inclusive student. Emrah has all the prerequisite skills required for the study. In other words, he can focus his attention for a long time, verbally count 1 to 10, write the numbers, and say the name of an indicated number. He can also follow instructions such as look, tell, and write.

Doruk is a nine-year-old male student diagnosed with autism and does not have any other disability. Before going to the special education center, he received preschool education as an inclusive student and still continues to receive inclusive education in a primary school. Doruk has all the prerequisite skills required for the study. In other words, he can focus his attention for a long time, verbally count from 1 to 10, write the numbers, and say the name of an indicated number. He can also follow instructions such as look, tell, and write.

Seyit is a ten-year-old male student diagnosed with autism and does not have any other disability. Before going to the special education center, he received preschool education as an inclusive student, and still continues to receive inclusive education in a primary school. Seyit has all the prerequisite skills required for the study. In other words, he can focus his attention for a long time, verbally count from 1 to 10, write the numbers, and say the name of an indicated number. He can also follow instructions such as look, tell, and write.

Table 1
Demographic Features of the Participants

Participants	Sex	Age	Period of Attendance at the Special Education Center	Diagnosis
Emrah	M	8	1	Autism
Doruk	M	9	1	Autism
Seyit	M	10	1	Autism

Researcher. The researcher has a bachelor's, master's, and PhD degree in Special Education as well as experience as an instructor in various primary special education schools. He teaches the course of "Teaching Math to Students with Intellectual Disabilities" at the undergraduate level and the course of "Teaching Academic Skills" at the graduate level. In addition, he researches the teaching of mathematical concepts and skills to groups of people with various disabilities. He incorporates his research on teaching with the touch math technique into the undergraduate and graduate courses. Moreover, he has published studies on teaching math skills to children with disabilities by using touch math as well as served as an advisor to master's level studies. The researcher has carried out the entire process of this study, from its planning stages to its reporting. Only the experimental phase was conducted by the practitioner. However, consultations were held with the practitioner throughout all the phases, before, and after each teaching session.

Practitioner. The practitioner has a master's degree in Special Education and is in a PhD program in the same field. She has worked as an instructor for a year in a foundation institution in Istanbul that provides education to children with autism. Moreover, she has previously used the touch math technique to teach math skills to students with intellectual disabilities and presented it as a research paper.

Observer. Reliability data on dependent and interdependent variables (interobserver reliability and intervention reliability data) were obtained by two special education experts holding bachelor's and master's degrees in education of the mentally disabled. In a two-hour training prior to the experimental study, the observers were provided with information about the study and about teaching with the touch math technique.

Environment

The probe, teaching, and maintenance sessions of the study were held in an individualized education classroom. The individualized education classroom is 4 x 3 meters in size. The classroom was furnished with a table, two chairs, a board, and a bookshelf. During the teaching session, there was no other person in the classroom other than the practitioner and the child. Generalization sessions were held in another classroom. During the teaching session, the practitioner and the child sat face-to-face at the table. A camera was also installed in the classroom to record the data.

Materials

A video camera was used to record the teaching and assessment processes. In addition, teaching and assessment worksheets based on the touch math technique were used during the teaching session. An assessment worksheet covering ten addition facts was developed to be used in the assessment sessions. In each session, the order in which the facts were presented in the assessment worksheet was changed. During the teaching session, a teaching worksheet covering ten addition facts was used. The addition facts in the teaching, assessment, and generalization worksheets were determined by random assignment.

Previously determined reinforcers were made available to reinforce the correct responses of the participants. To establish the appropriate reinforcers, the instructors of the participants were interviewed, a reinforcer establishment form was prepared, and the parents were asked to fill out that form. The reinforcer establishment form included the favorite food and beverages of the child (chocolate, biscuits, wafers, chips), objects (ball, toy car, teddy bear), activities (watching TV, riding on a swing, playing in the park) and compliments and touches as well as the response categories of "likes a lot, likes, hates" to be filled out by the parents. Appropriate reinforcers for the participants were determined based on this form, and they were given to the participants after every correct response during the teaching session.

This study involves teaching to solve basic addition problems that have a single-digit sum. Therefore, dots were placed on all numbers from top to bottom on a teaching worksheet that included ten addition facts. The number of dots represented the number itself. For example, for the problem $2 + 1 = ?$, the corresponding number of dots was placed on both 1 and 2. The generalization worksheets prepared for the generalization sessions and also included ten addition facts. However, dots were placed on only one of the addends in the addition facts. For example, for the problem $5 + 3 = ?$, the dots on the first addend were removed and those on the second addend were left. During the generalization sessions, the dots on the first addend were faded to allow the participants to generalize the addition facts.

Variables

Dependent variable. The dependent variable of this study is the process of adding two single-digit numbers and finding a single-digit sum. Basic addition is a process of making a whole with at least two parts. In other words, it involves combining at least two numbers to obtain a third one. The dependent variable is considered significant as it constitutes a prerequisite for the subsequent mathematical operations and concepts.

Prior to the experimental study, the researcher analyzed both the order of addition steps and the dependent variable, i.e., the addition operation. Table 2 shows the top five addition steps from easy to difficult.

Table 2

Addition Steps and Examples

Steps	Examples
1. Adding two single-digit numbers and finding a single-digit sum	$3 + 2 =$, $5 + 4 =$
2. Adding two single-digit numbers and finding a two-digit sum	$9 + 7 =$, $6 + 5 =$
3. Adding a two-digit number to a single-digit number and finding a two-digit sum (without carrying)	$36 + 3 =$, $63 + 4 =$
4. Adding a two-digit number to a single-digit number and finding a two-digit sum (with carrying)	$32 + 9 =$, $48 + 8 =$
5. Adding two two-digit numbers and finding a two-digit sum	$25 + 65 =$, $45 + 36 =$
6. Adding three single-digit numbers and finding a single-digit sum	$1 + 3 + 2 =$, $3 + 2 + 2 =$
7. Adding three single-digit numbers and finding a two-digit sum.	$4 + 8 + 3 =$, $3 + 9 + 5 =$

The target skill within the scope of this study was analyzed using the touch math technique and the steps were determined. The skill analysis for the targeted behavior includes eight steps. Each step was studied based on the total task procedure. Table 3 shows the skill steps for adding two single-digit numbers and finding a single-digit number.

Table 3
Skill Steps for Adding Two Single-Digit Numbers and Finding a Single-Digit Number

1. Says that he/she will perform addition.
2. Identifies the large number.
3. Counts the dots on the large number.
4. Identifies the small number.
5. Counts the dots on the small number.
6. Says that the small number will be added to the large number by counting the dots.
7. Remembers the large number and counts the dots on the small number and adds to the large number.
8. Identifies the sum.

Independent variable. The independent variable of this study is teaching through the use of touch math.

Possible participant responses. Possible participant responses that need to be considered when teaching basic addition using the touch math technique are divided into three parts: correct response, no response, and incorrect response. Answering the question in each instruction of basic addition steps within ten seconds was determined as a correct response, while answering the question incorrectly (answering after ten seconds or giving no answer) were considered incorrect responses.

Design

Among the single-subject research models, the multiple-probe design with probe conditions across subjects was used in the study to test the effectiveness of the touch math technique on teaching *Addition of Two Single-Digit Numbers and Finding a Single-Digit Sum*. The multiple-probe design with probe conditions across subjects is an experimental design model used to test the effectiveness of a method on a skill across multiple subjects (Gast, 2010; Kircaali-İftar & Tekin, 1997; Tekin-İftar, 2012).

In the multiple-probe design with probe conditions across subjects, two or three independent participants that can learn a skill through the use of same method are chosen. The multiple-probe design with probe conditions across subjects, like the other multiple-probe models, comprises two phases: baseline (A) and intervention phase (B). During the baseline stage, measurements are simultaneously conducted on all subjects in the same environment till they reach stability in the data. After achieving stability in all subjects during the baseline phase, intervention was introduced for the first subject. Once stability was achieved during the intervention phase, probe data was collected across three sessions for all subjects. The intervention was then introduced for the second participant. Once stability was achieved during the intervention phase, probe data was collected across three sessions for all subjects. Finally, the intervention was introduced to the third participant. Once stability was achieved during the intervention phase, probe data for the third participant was collected across three sessions for all subjects (Gast, 2010; Kircaali-İftar & Tekin, 1997).

In studies using multiple-probe designs with probe conditions across subjects, the experimental control is based on a change in the data only on the participant upon whom the independent variable is introduced, not on changes in the data on the participants upon whom the independent variable is not introduced. However, the similar changes in the data gradually occur along with the introduction of the variable (Gast, 2010; Kırcaali-İftar & Tekin, 1997).

Main Study

The main study includes the practitioner training, baseline sessions, teaching sessions, daily probe sessions, full probe sessions, generalization sessions, and maintenance sessions.

Practitioner training. The practitioner took the course of “Teaching Academic Skills” within the scope of the master’s program and attended the course of “Teaching Math to Students with Intellectual Disabilities” given by the researcher as a scientific preparation for students. During both courses, the practitioner was provided with necessary information and skills for the touch math technique by the researcher as well as other methods and techniques. Moreover, the practitioner also attended four hours of training (one hour daily) given by the researcher in which she was provided with theoretical knowledge, information, and skills regarding the use of the technique. During the first hour of training, the touch math technique was introduced. In the second training session, the practitioner watched sample videos in a foreign language and was provided with explanations of the important points. The third session covered teaching with the touch math technique using examples of addition. Furthermore, a 15-minute video including ten samples (each taking 1.5 minutes) was used. The practitioner also performed a teaching practice session on another child with autism during one session. The practitioner watched the video recording of this session and was provided with feedback from the researcher. The practitioner’s office was used for the training.

Probe Sessions

Baseline probe sessions. Prior to the teaching session, baseline data was collected for each subject during three consecutive days (one session per day) to determine the performance levels of the participants. Baseline data was collected on a one-to-one basis through assessment worksheets including examples different from those used in the teaching environment. At the beginning of the implementation, it was ensured that the participant directed his/her attention to the study. For the evaluation, there were ten basic additions on a worksheet where children would enter the results. Each session took about 10 to 15 minutes. In the assessment of performances, the single opportunity procedure was used. During the baseline probe sessions, a “+” (plus sign) was recorded for the

correct responses and a “-” (minus sign) was recorded for the steps skipped or performed incorrectly, and the assessment ended with the first step for which “-” was recorded.

Daily probe sessions. Daily probe session data was collected on a one-to-one basis in the teaching environment at the end of each session. Data collection was conducted about 15 minutes later and each session took about 10 to 15 minutes. In this session, the presentation order of the examples used in the teaching session was changed. A total of ten addition facts were presented to the participants. The same process as in baseline probe sessions was followed in the daily probe sessions.

Full probe sessions. As in the baseline session, the data was collected for each participant during three consecutive days (one session per day). During these full probe sessions, the data was collected in the teaching environment through the assessment worksheet used in the baseline session. Each session took about 10 to 15 minutes. A total of ten addition facts were presented to the participants. The same process as in baseline probe sessions was followed in the full probe sessions.

Teaching sessions. During the teaching sessions, addition facts (for example, $4 + 4 = ?$) prepared using the touch math technique were presented to the students. The sessions were held three days a week on an individual basis and were arranged as two sessions per day. In the teaching sessions, as in the baseline and probe sessions, the participant’s attention was directed to the activity. In each session, ten addition facts were presented to each student. All sessions were held on a one-to-one basis.

Prior to the beginning of the session, the practitioner said “Now we will solve an addition problem. If you perform the addition verbally, you can have a reinforcer. Are you ready?” “Let’s get started on addition,” to draw the attention of the participant towards the activity. The practitioner then presented the addition fact by following each step. The student was also asked to perform each step of addition. During this process, the practitioner, after drawing the participant’s attention to the worksheet, provided some stimuli for the addition fact in the worksheet, such as “This is the large number, this is the small number. I am adding the small number to the large one and counting the dots on the number while adding.” The practitioner then encouraged the student to perform the operation by giving instructions for each step. During each operation, correct responses of the student were reinforced. The teaching session ended when the participant performed the addition.

During the collection of data on effectiveness, correct and incorrect responses of the participants were recorded and a correct response percentage was calculated. Data was also collected on ten addition facts in the worksheet prepared during the assessment of basic addition skills. In the assessment phase, the single opportunity procedure was used. During the assessment, a “+” (plus sign) was recorded for the

correct responses, a “-” (minus sign) was recorded for the steps skipped or performed incorrectly, and the assessment ended at the first step for which “-” was recorded. The teaching session ended with the student achieving or exceeding the targeted performance value of 80% (8 correct operations out of 10) and full probe sessions were initiated. The percentage of correct responses in the record charts was calculated and the data obtained was incorporated into the chart as the teaching session data.

Maintenance sessions. Maintenance sessions were held on a one-to-one basis in the teaching environment as in the baseline and full probe sessions. Maintenance sessions were held for all participants on the 7th, 14th, and 21st days after teaching. During the maintenance sessions, a pre-prepared assessment worksheet was used as in the baseline and full probe sessions. Each session took about 10 to 15 minutes. A total of ten addition facts were presented to the participants. The same process used in the baseline probe sessions was followed in the maintenance sessions.

Generalization sessions. The pre-test session was immediately held after the baseline probe sessions, and the post-test session was held following the teaching session after the criteria were met. Generalization session data (one session per participant) was collected in a different environment from the teaching classroom prior to teaching and one week after teaching. A total of ten addition facts were presented to the participants. Each session took about 10 to 15 minutes. In the generalization sessions, differently from the worksheet sets used in assessment and teaching, the dots on the first addends in the addition facts were removed.

Reliability

Data collection included two different types of reliability data: Interobserver reliability and intervention reliability data. The reliability data were obtained from all phases of the study. To do so, a random assignment table was used, and the chosen sessions were followed. Interobserver reliability and intervention reliability data was collected in 20% of all sessions held throughout the study.

Interobserver reliability. Interobserver reliability data was collected by two observers independently. Each observer watched the video recordings of the sessions and recorded data on the data record forms. Interobserver reliability was calculated as follows: $[(\text{agreement}) / (\text{agreement} + \text{disagreement})] \times 100$. Reliability data was collected from all phases of the experimental study. In calculating reliability, 80% interobserver reliability is sufficient. Reliability above 90% is considered the desirable reliability (Gast, 2010). In this study, the interobserver reliability was found to be 97%.

Intervention reliability. Intervention reliability data was collected to assess the intervention process. To do this, a data record form for intervention reliability was

prepared. The data record form included practitioner behaviors such as drawing the attention of the student, applying skill steps for the target behavior, and giving corrective feedback that includes reinforcers. The interventionist behaviors consisted of interventionist's directing the attention of the child by saying "Let's do some addition!," placing the calculation in front of the child, modeling the calculation by doing it on his/her own, including the calculation process, doing the calculation with the child, letting the child do the calculation by him/herself, and providing reinforcers after each correct response of the child. Intervention reliability was calculated as follows: (observed practitioner behavior/planned practitioner behavior) X 100. Randomly selected 20% of all sessions held throughout the study were analyzed by an expert in the field. The intervention reliability of the study was found to be 100%.

Results

Figure 1 shows the correct responses of the participants in the baseline, intervention, and maintenance sessions, throughout which the skill performance levels of the participants were measured for adding two single-digit numbers and finding a single-digit sum.

As shown in Figure 1, the success rate of the first participant, Emrah, is between 0% and 100%. His success rate increased from 0% (during the baseline) to 100% at the end of the 12 teaching sessions. It can also be seen that stability (at the end of the 14th session) was maintained. The maintenance data for Emrah shows that his success rate was still 100% on the 7th, 14th, and 21st days. In addition, as shown in Figure 2, his success rate was 0% during the generalization pre-test session, which increased to 90% in the generalization post-test session. Given the findings, we can say that teaching with the touch math technique was effective for Emrah.

The second participant, Doruk, has a success rate between 50% and 100%. His success rate increased from 0% (during the baseline) to 100% at the end of four teaching sessions, and stability (at the end of the sixth session) was maintained. The maintenance data for Doruk also show that his success rate was still 100% on the 7th, 14th, and 21st days. Furthermore, as shown in Figure 2, his success rate was 0% during the generalization pre-test session, which increased up to 90% in the generalization post-test session. Given the findings, we can say that teaching by the touch math technique was effective for Doruk.

The third participant, Seyit, has a success rate between 50% and 100%. His success rate increased from 0% (during the baseline) to 100% at the end of six teaching sessions, and stability (at the end of the eighth session) was maintained. Moreover, as shown in Figure 2, his success rate was 0% during the generalization pre-test session, which increased up to 90% in the generalization post-test session. Given the findings, we can say that teaching with the touch math technique was effective for Seyit.

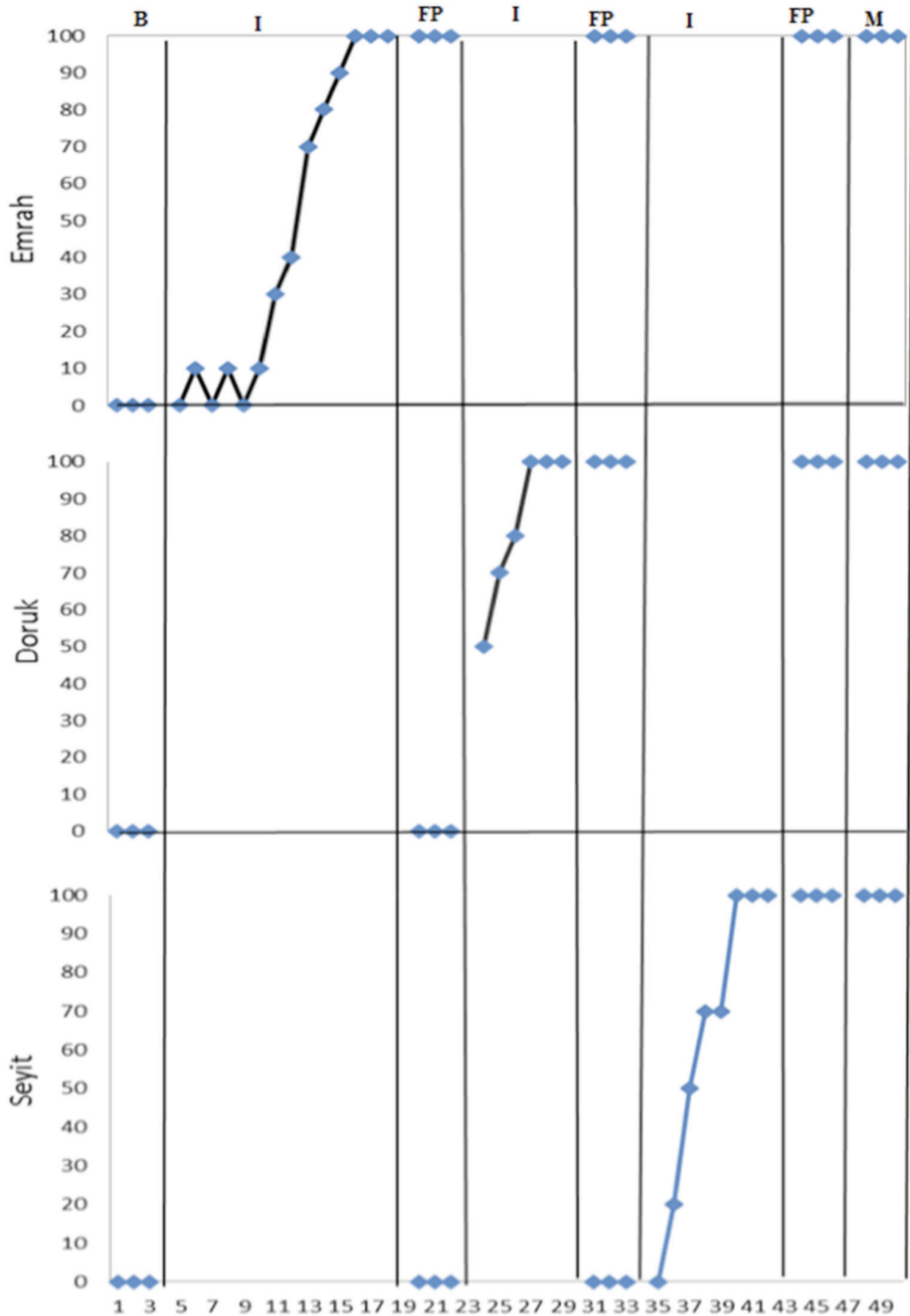


Figure 1. Skill performance levels of the participants measured for adding two single-digit numbers and finding a single-digit sum during the baseline (B), intervention (I), full probe (FP), and maintenance (M) sessions.

Given the findings obtained at the end of the study, we can say that the use of touch math in teaching basic addition skills is effective for all three participants in the teaching, maintenance, and generalization sessions.

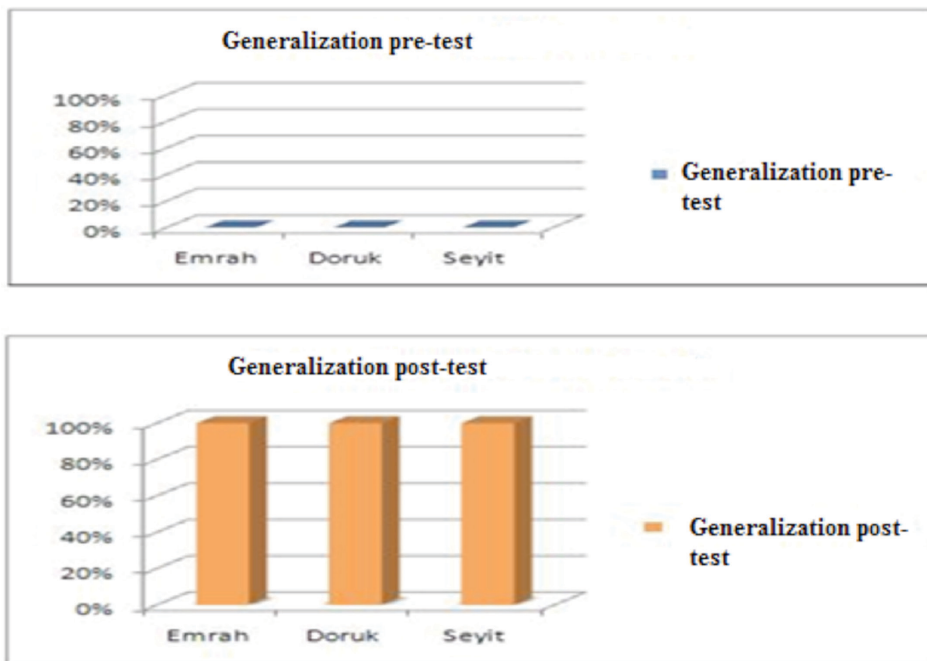


Figure 2. Success rates of the participants measured for adding two single-digit numbers and finding a single-digit sum during the generalization pre-test and post-test sessions.

Discussion

This study aimed to determine whether the touch math technique is effective in teaching basic addition skills to children with autism. For this purpose, the multiple-probe design with probe conditions across subjects, which is a type of single-subject design, was used. Through the use of touch math, basic addition skills (adding two single-digit numbers and finding a single-digit sum) were taught to three children with autism who fulfilled the prerequisite skills. The findings of the study show that the touch math technique is effective in teaching the skill of adding two single-digit numbers and finding a single-digit sum.

The data on the effectiveness of touch math indicates that the first participant could not achieve the skill of adding two single-digit numbers and finding a single-digit sum during the baseline. However, he acquired 100% success at the end of the 12th teaching session. The second participant could not achieve the skill of adding two single-digit numbers and finding a single-digit sum during the baseline, but could reach 100% success at the end of the fourth teaching session. Finally, the third participant again could not achieve the skill of adding two single-digit numbers and finding a single-digit sum during the baseline, but could reach 100% success at the end of the sixth teaching session. Additionally, the data on all of the participants reflected stability during three consecutive sessions, and the maintenance session data show that the participants' skills were maintained. According to the generalization session data, all three participants achieved success in generalization.

It can be seen that the number of sessions that the first participant attended is greater compared to the other two participants. This might be the result of different learning rates between the individuals. However, the technique was still effective despite the differences in the number of sessions. The findings on the effectiveness of touch math obtained in this study are in conformity with the findings of some previous studies. [Cihak and Foust \(2008\)](#) conducted a study in which they compared number lines and touch points to teach addition facts to three students with autism and reported that the touch math technique was more efficient and effective than using number lines. The findings on the effectiveness of touch math obtained in their study conform with the findings of this study. Moreover, [Fletcher et al. \(2010\)](#) also compared the touch math program and a number line strategy to teach single-digit addition skills to three children with autism and intellectual disabilities (one of the children was diagnosed with autism) and reported that the touch math technique was more efficient and effective than the number line strategy. Their findings show the effectiveness of the touch math technique. The findings on the effectiveness of touch math obtained in the study by [Fletcher et al. \(2010\)](#) conform with the findings of this study.

In a study conducted on the effectiveness of the touch math curriculum to teach basic addition to ten children with autism, [Berry \(2007\)](#) reported that the technique was effective in eight children, but not effective in two. The effectiveness of touch math observed in eight children conforms with the effectiveness, maintenance, and generalization findings of this study. However, the lack of effectiveness in two children does not conform with the findings of this study.

There are also studies conducted on the effectiveness of touch math in children with disabilities that include children with autism. [Simon and Hanrahan \(2004\)](#) conducted a study on the effectiveness of touch math in children with intellectual disabilities. They reported that children with autism could learn the touch math technique. The findings of this study are also in conformity with those of other studies on teaching math skills with the touch math technique in terms of effectiveness, maintenance, and generalization ([Berry, 2007](#); [Cihak & Foust, 2008](#); [Çalık & Kargin, 2010](#); [Eliçin et al., 2013](#); [Fletcher et al., 2010](#); [Simon & Hanrahan, 2004](#); [Velasco, 2009](#)).

The touch math technique adopts a multisensory approach. Therefore, the technique involves the use of a concrete to abstract instruction principle in teaching math skills. [Bullock et al. \(1989\)](#) suggest that the touch math technique helps children with math learning disabilities to overcome their difficulties. Their argument conforms with the findings of this study.

The children participated in the experimental phase of this study willingly and voluntarily. They even asked the practitioner if they would solve addition problems again after the teaching sessions ended, which indicated the children's willingness. Moreover, their mothers stated that the children really liked working with the

interventionist, which was another indication of their willingness. The willingness of the children indicates that touch math is probably an attractive technique to them.

As a result, the touch math technique was effective on children who participated in this study to learn basic addition skills. Furthermore, this effect resumed for the maintenance data. While generalization data was diagnosed, it was seen that children with autism were able to generalize the basic addition skills.

According to the findings of this study, the touch math technique can be said to be applicable in teaching addition skills to children with autism. The findings of this study show that touch math is an effective technique in the acquisition of addition skills, and the findings are in conformity with others obtained in a limited number of studies in the literature. Therefore, this study sets an example for future studies in this field. Moreover, other potential contributions to the effectiveness of the touch math technique may be the practitioner's previous experience in teaching children with autism as well as the information and skills provided to the practitioner by the researcher during the training sessions.

Future studies may examine the effectiveness of the touch math technique in teaching different basic math skills. Moreover, new studies may be conducted to evaluate this technique's efficiency, in addition to its effectiveness. Instructors can use the touch math technique in teaching basic addition skills. Furthermore, they can teach subtraction, multiplication, and division skills through the use of this technique. Practitioners could be trained so that they are able to use touch math in teaching.

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