

**EFFECTIVENESS OF THE TOUCH MATH TECHNIQUE IN TEACHING ADDITION SKILLS TO STUDENTS WITH INTELLECTUAL DISABILITIES****Nuray Can Calik**

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*The aim of this study was to investigate the effectiveness, generalizability, and the permanency of the instruction with the touch math technique. Direct instruction was used to the instruction of the basic summation skills of the students with mild intellectual disabilities. A multiple probe design across the subjects was used in this study. The participants included three students with mild intellectual disabilities in inclusive classrooms. They were second grader and their ages were 7-8 years old. The results of the study show that the use of touch math technique, based on direct instruction approach is effective in teaching the basic summation skills to the students with mild intellectual disabilities. The social validity results demonstrated that all the teachers have positive views towards the touch math technique and express that they would use this technique in their classes.*

Mathematics is developmental in nature and should be taught through sequential cases. Although the sequences are previously determined, the students' development is individualistic. Adaptations in accordance with the students' needs are required in education so as to ensure effective teaching. These adaptations include course planning, differentiation of teaching methods, arrangement of content, and arrangement of evaluation (Spencer, 1998; Wood, 1992).

In general education classrooms, adaptations and arrangements are required in teaching mathematics not only for the students with special needs but for all the students. Lock (1996) stated that minor changes made by mathematics teachers in the presentation of mathematical concepts would not only increase the number of correct answers given by the students, but also help them to understand the process more clearly.

When teachers express the goals explicitly, provide instructions, and make simple adaptations, the students' success and interest increase. Furthermore, goals reflect the learning expectations, which have a close effect on the students' success. In their studies on successful teaching, Porter and Brophy (1988) stated that successful teachers clearly express their expectations as well as the course objectives. While introducing the objectives, successful teachers also explain in detail what the student has to do to be successful, and what he/she will learn through the study (Christenson, Ysseldyke, & Thurlow, 1989).

Although there are only a few researches on how students with special needs learn addition, there are several researches in the field concerning how students without disabilities gain addition skills (Groen & Parkman, 1972; Hughes, 1986). Perhaps, the most outstanding study has been the one by Carpenter and Moser (1984), who examined the different strategies that students use when performing addition problems at different stages of learning. They identified three strategies that students without disabilities employ for solving addition problems. The first one of these strategies is the use of a *count-all* strategy that consists of counting, with the use of fingers or other objects, each addend in an addition problem starting at 1, until all the numbers have been counted. For example, when solving the problem  $4 + 5$ , the student begins by holding up four fingers on the one hand while counting to 4, and then holding up five fingers on the other hand while counting to 5, and finally, the student counts all the fingers that are held up to find the solution, 9. The count-all strategy is limited, in that the student can only easily add to 10 using his/her fingers and will experience considerable difficulty when adding

numbers greater than 10. However, the count-all strategy is used by most learners at the early stages of learning.

Once the *count-all strategy* is learnt, students generally need to move to another strategy for solving addition problems. This strategy, called the *count-on* strategy, involves saying the first addend of the addition problem and then counting on from that number (Carpenter & Moser, 1984; Secada, Fuson, & Hall, 1983). For example, a student would solve the problem  $4 + 5$  by saying the first number, in this case 4, and then counting on from 4. Through this strategy, students eventually learn to begin the count with the largest addend, thus saving time.

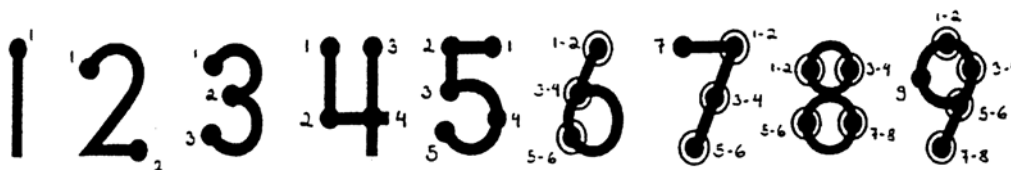
The final stage of addition learning identified by Carpenter and Moser (1984) involves *storing and later retrieving* the addition facts from the long-term memory. With repeated practice and reinforcement, students memorize the basic addition facts and retrieve them from memory when needed. For example, in time, students memorize the addition problem  $4 + 5 = 9$ . In addition to the research mentioned earlier, there are some researches in the literature on how students with intellectual disabilities learn to make additions. In a research on addition skills by Hanrahan, Rapagna, and Poth (1993), a group of students with intellectual disabilities was found to use the same three strategies as their non-disabled counterparts when learning to solve addition problems.

The use of *count-all* and *count-on* strategies may not be preferred by many students. Especially students with special needs may be embarrassed to count their fingers when they see their peers without disabilities making additions rapidly and using their memory. That is why many students with special needs may not prefer using finger-counting strategies that can be detected either by their classmates or teachers, thus revealing their incompetency. One way to overcome these drawbacks is by using a dot-notation method, whereby dots are associated with each number from 1 to 9 according to a specified pattern. By using such a technique, the students count the dots on the numbers rather than fingers or blocks and, in time, learn to count the positions of the dots, and the dots are subsequently removed from the numbers.

*Dot notation method (touch math)* involves visual, auditory, and tactile learning. The students mark the touch dots (dots on the numbers and dots in circles) while looking at the number (visual) and counting the number (auditory) with their pencils (tactile). The students are taught to count the touch dots on each number so as to help them in addition, subtraction, multiplication, and division. While the students count forward in addition, they count backward in subtraction. For multiplication and division, they align the sums (Bullock, Pierce, and McClelland, 1989). *Touch Math* is a multisensory method for teaching addition by breaking down the task of adding into small, logical steps without requiring the storage of arithmetic facts in memory. Furthermore, it is a silent method helping students with special needs in a classroom to solve addition problems without using methods such as finger counting that can be easily seen by other students; thus, preventing them from being labeled by their peers (Scott, 1993).

When using the *Touch Math* technique, the students begin by learning the positions of the dots on each number from 1 to 9 according to the specified pattern. Once this task has been mastered, the instruction begins with the most basic type of addition problems, single-digit pairs. Students are taught to begin with the first number, count all the dots on that number, and then continue counting the dots on the second number until all the dots have been counted. For example, when adding  $4 + 5$ , the students are taught first to count the dots on the number 4 and then to continue counting the dots on the number 5, until all the nine dots have been touched and counted. Students are also encouraged to repeat the problem and its solution verbally once it has been solved. When students successfully master this task, the dots are removed from the largest number, and they are then taught to add by identifying the largest number, mention it verbally, and continue to count-on from that number to find the solution. Once the students learn this step, all dots are removed and they are taught to continue to count-on from the largest number and then count the dots removed from all the other numbers.

When the touch dots are removed from the papers, the students still can *touch the dots* with their pencils using their memories. While reading the mathematical problems, the students are encouraged to read both the problem and the solution verbally so as to facilitate their memorization.



The *Touch Math technique* appears to teach addition according to the same strategies that students naturally develop to solve addition problems. The system offers a method for teaching addition that involves *count-all* and *count-on* strategies, but does not require the *retrieval of stored facts from memory*, an area of difficulty for many students with intellectual disabilities. Students are encouraged to repeat their answers to problems aloud when using the Touch Math technique; it is expected that addition facts will gradually be stored in a student's long-term memory. A study conducted by Marsh and Coke in 1996 proved that the repetition of visual materials aided retrieval from the memory. The Touch Math technique also has the advantage of being a multisensory method, as it involves the use of auditory, visual, and tactile information. The use of multisensory approaches in teaching the basic concepts of mathematics has been supported by many researchers (Scott, 1993; Thornton, Jones, and Toohey, 1983). Furthermore, the technique assumes less prior knowledge of arithmetic on behalf of the learner. This knowledge involves remembering and counting numbers from 1 to 20, and to count-on from the largest number when adding and to count-down when subtracting.

Pupo (1994) investigated the utility of this technique with three students with intellectual disabilities. Before the research, the students were unable to solve addition problems correctly; however, after the teaching of Touch Math, they managed to solve addition problems correctly. Similarly, in a study by Newman (1994), a group of students with Down's syndrome successfully learnt and applied the Touch Math technique to solve the single-digit addition problems.

Looking at the literature in the light of this conclusion, Touch Math technique has a clear impact on teaching addition skills to students. Nonetheless, direct studies in the framework of remedial education services using single subject patterns concerning addition skills of students with special needs in general education classrooms appear to be limited. Therefore, the aim of this study is to investigate the effectiveness, generalizability, and the permanency of the instruction with the touch math technique. In this research following questions is answered: a) Is the Touch Math technique effective in teaching basic addition skills to students with mild intellectual disabilities attending second grade?, b) Can the students with mild intellectual disabilities, attending second grade, generalize the skills they have learnt to the classroom environment and to addition problems consisting of the combinations of the same numbers when they learn addition skills through teaching provided in accordance with the Touch Math technique?, c) Can the students with mild intellectual disabilities in second grade sustain the skills they have learnt after 10 or 20 working days, when they learn addition skills through teaching provided in accordance with the Touch Math technique?, d) What are the opinions of primary school teachers who have been working in primary schools in Turkey for at least 5 years, concerning the teaching provided in accordance with the Touch Math technique to the students with intellectual disabilities (social validity)?

## Method

### *Participants*

The research was conducted in a Primary School located in Ankara, Turkey. Two girls and one boy are attending this study. Prior of the study, parents of targeted students were informed about the research and signed an agreement on the terms and conditions of the study. Seven pre-requisites were considered and met in the selection of the participants. To determine the participants' levels of the pre-requisites, checklists developed by the researchers were used and in addition to that, the teacher provided information concerning the participants' performance to this pre-requisites skills, such as: (a) following written and oral instructions, (b) counting rhythmically one by one and two by two up to 20, (c) matching and writing numbers between 1 and 20, (d) recognizing the addition sign, (e) counting pictures of objects using count-all strategy and telling the total, (f) count-all from the largest number, and (g) having the skills to count the dots on the numbers prepared in accordance with Touch Math, and draw the dots on the sample without dots.

*The first participant, A,* was an 8-year-old girl with borderline mental capabilities (IQ score 73- ), *second participant, B,* was an 8-year-old girl with mild mental disabilities (IQ score 68), and *third participant, C,* was an 8-year-old boy with borderline mental capabilities (IQ score 75). IQ scores were

obtained from WISC- R. All participants didn't receive any formal preschool education and they all are second grader, second semester in their school. Based on the information provided by the teachers, all of participants were seen to perform quite lower than the average in the classroom concerning issues, such as maintaining their attention for a long time, carrying out the four mathematical operations and literacy skills, and they had difficulty in comprehending participants in social lessons such as social studies. Thus, all the three students were observed to fulfill the pre-requisites and they were included in the research based on the results of the related evaluation.

#### *Settings and Materials*

The research was conducted in a room in the participants' school. In this room there was a study table and two chairs (one for staff and one for student). A camera system was installed in order to keep reliability and intervention data. Keeping a record for the participants' performance, some worksheets on a variety of addition operation sets and data collection forms were used in the study.

#### *Design*

Multiple probe design across the subjects was used. In multiple probe design across the subjects, the change in the subjects' performance can be explained as follows: the change only occurs for the subjects to whom the independent variable is applied and no significant change occurs for those to whom independent variable is not applied; and this effect recurs consecutively for all the subjects (Tekin-Iftar and Kircaali-Iftar, 2004).

#### *Dependent and Independent Variable*

The dependent variable of this research was *basic addition* skill in mathematics, and the independent variable was the teaching program delivered in line with Touch Math technique based on direct teaching approach. The possible participant responses considered in the assessment of this skill are; a) correct response: in 10 seconds after directive, answering the question given in the directive independently. b) Incorrect responses: after giving directive related to skill, answering question incorrectly or deficiently. c) No response: the participant doesn't answer the question. In this condition, after a ten second waiting, staff passes to the next step.

#### *Independent Variable*

*Pilot study.* In order to predetermine the possible problems in the research process and provide the necessary modifications, a pilot study had been conducted with another participant apart from the three participants. The pilot study was applied following procedures of main study. Pilot study was also video-recorded. After the application of pilot study, all the records were watched and necessary modifications were decided (e.g., the duration of the session period and processing) for main study.

*Main study.* In the main study, the procedures included the baseline sessions, the probe sessions, the training sessions, the maintenance sessions, and the generalization sessions. All the sessions were carried out in the room, Monday through Friday, twice in a day. For the mathematics lessons, the participants were taken individually from their classroom to the room.

*Probe sessions (Baseline/Probe Sessions).* During this phase, before the teaching application, the basic addition skill baseline data were gathered for each student prior to instruction in order to determine participants' basic addition skill levels. Probe sessions were held in order to determine the levels of every related skill of all participants after the teaching sessions. These sessions were held immediately after the teaching sessions to calculate the percentages of correctly solved problems without receiving clues like dots, as the participants were continuously presented with dots as clues up to a certain level during teaching with the Touch Math technique. These success criteria in these quiz instruments were determined as 100 % independent correct reactions in at least three successive sessions.

#### *Teaching Sessions by the Touch Math Technique*

Teaching sessions were held in accordance with the implementation plan prepared for the teaching of the related skills, in the room designed as the source room at the primary school regularly attended by the participants.

During the teaching sessions, the participant and researcher sat face-to-face around a table. In the teaching session with the first participant, the teaching commenced with the use of small numbers with dots and large numbers without dots and during each trial within the first session, the participant was aided through modeling and by guided practice, and was constantly reinforced via verbal reinforcement in line with the reinforcement plan.

After the first session, until the teaching sessions where the dots were removed, the participant was aided through modeling in the event of incorrect reactions, and was verbally reinforced for the correct reactions in line with the reinforcement plan. After the first teaching session, once the participant reached 100% success, the dots on the numbers were removed and teaching continued using numbers without dots.

During the teaching sessions using numbers without dots, the participant was aided through modeling in the event of incorrect reactions, and in the case of correct reactions, the participant was reinforced verbally in line with the flexible rate reinforcement plan. The participant's attention towards the study, cooperativeness, and participation was verbally reinforced through fixed rate reinforcement plan (e.g., through saying ... *you did what I said, you solved the problems etc.*).

The participant's incorrect reactions were corrected. The incorrect reactions were recorded as incorrect and the participant was presented again with the skill instructions and aided through modeling so that the problem could be solved correctly; however, the reaction was recorded as incorrect. Both the correct and incorrect reactions were recorded and collected, and the percentage of correct reactions was calculated. Data collected at the end of the research were analyzed through graphical analysis.

#### *Maintenance Sessions*

*Maintenance sessions.* Maintenance sessions were arranged 10 and 20 days after meeting the criteria for the target behavior. In maintenance sessions, the same process was followed as in the probe sessions.

#### *Generalization Sessions*

To examine the generalizability of the skill taught under the scope of the research to the classroom environment, pre-testing was applied to all the participants in the classroom, one day before the baseline sessions were held, and post-test was applied to all the students as well as the participants one day after the research had been finalized and the final collective probe session had been held. For the purposes of this research, only the percentages of the correct reactions given by the three participants in the post-test were calculated. Thereby, estimations were made concerning whether they could generalize the skills they had learnt to the classroom environment.

#### *Social Validation*

The social validity aspect of the study was analyzed with a view to determine the significance of the research aims, the teaching practices used to meet these aims, and the research findings. Social validation questionnaires developed by the researcher were used for the collection of social validity data. The related questionnaires were filled in by previously selected five primary school teachers having a minimum experience of 5 years as a primary school teacher. The frequencies and percentages for the data collected through social validity data collection instrument were calculated and the related data were also evaluated qualitatively.

#### *Reliability*

Two different reliability data were collected: (1) dependent variable reliability, (2) independent variable reliability (treatment integrity). *Dependent variable reliability* and *treatment reliability* data were collected in at least 35% of the sessions held throughout the study. In the determined sessions, both dependent variable reliability data and independent variable reliability (treatment integrity) data were collected and analyzed by using inter-coder reliability procedures.

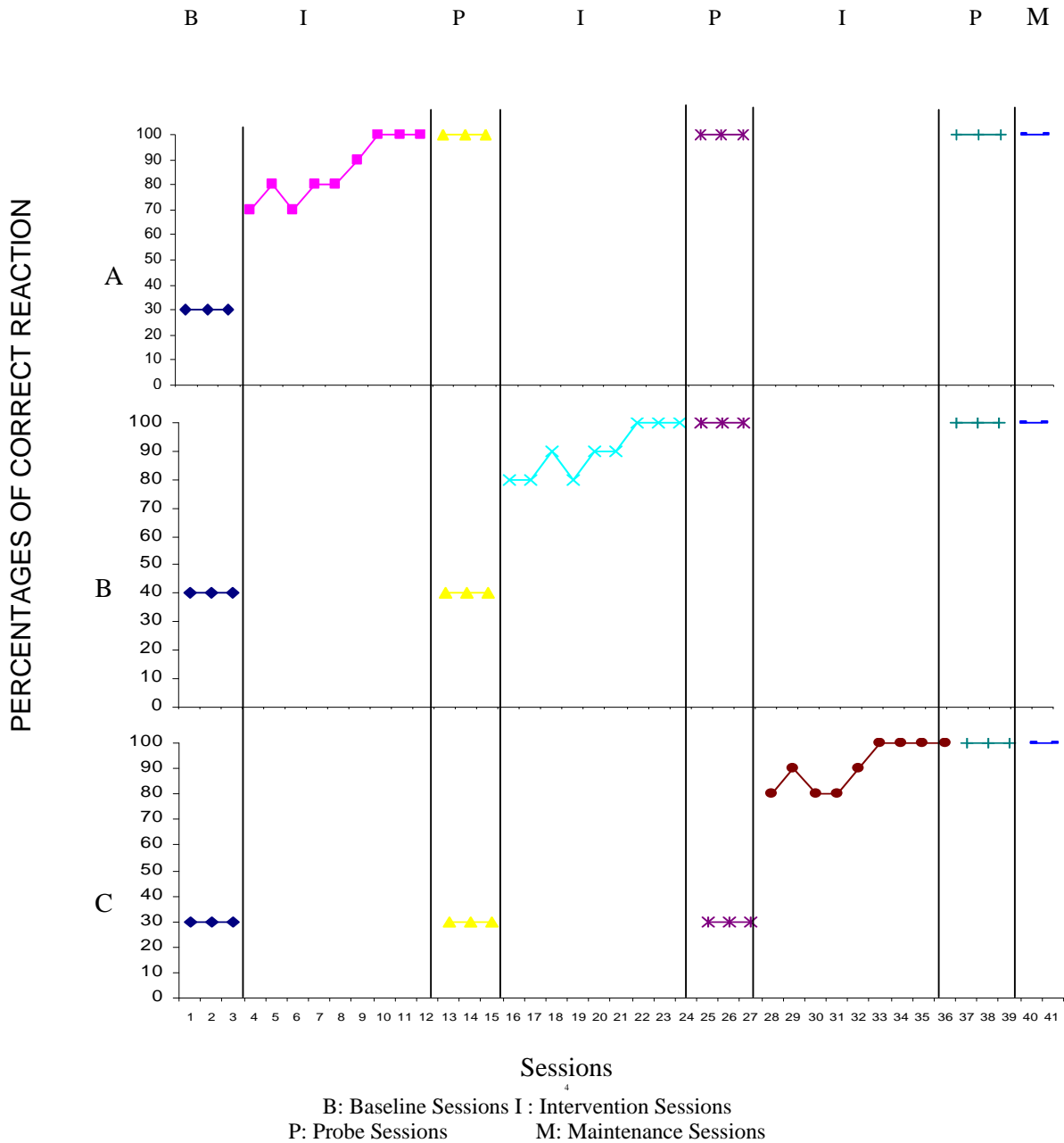
In order to collect and analyze dependent reliability data, two independent observers watched the video recording of the sessions of the students selected randomly and recorded their observations on the data record form. Dependent variable reliability was calculated by dividing the number of agreements by the number of agreements plus the number of disagreements and multiplying by 100 (Tekin-Iftar & Kırcaali-Iftar, 2006). Dependent reliability data for A, B and C indicated 100% agreement for basic addition skills during the baseline, intervention, maintenance, and probe sessions.

In order to collect and analyze independent variable reliability (treatment integrity) data, two independent observers watched the video recordings of the selected sessions of each student and recorded their observations on the record form. Later, independent variable reliability was calculated by dividing the number of observed teacher behaviors by the number of planned teacher behaviors and multiplying by 100 (Tekin-Iftar & Kırcaali-Iftar, 2006). Independent reliability for A, B, and C indicated 99.99% agreements during all the sessions.

**Results**

*Effectiveness on Acquisition and Maintenance*

The first subject, A, met the criteria through increasing her basic addition skills success rate from 30% to 100% after 9 teaching sessions were delivered in line with the Touch Math technique based on a direct teaching approach, and sustained her success afterwards, during the probe sessions and maintenance sessions held 10 and 20 days after all the probe sessions had been finalized. Accordingly, the teaching sessions provided in line with the Touch Math technique based on a direct teaching approach may be considered as effective for subject A's learning and sustainment of basic addition skills (Figure 1).

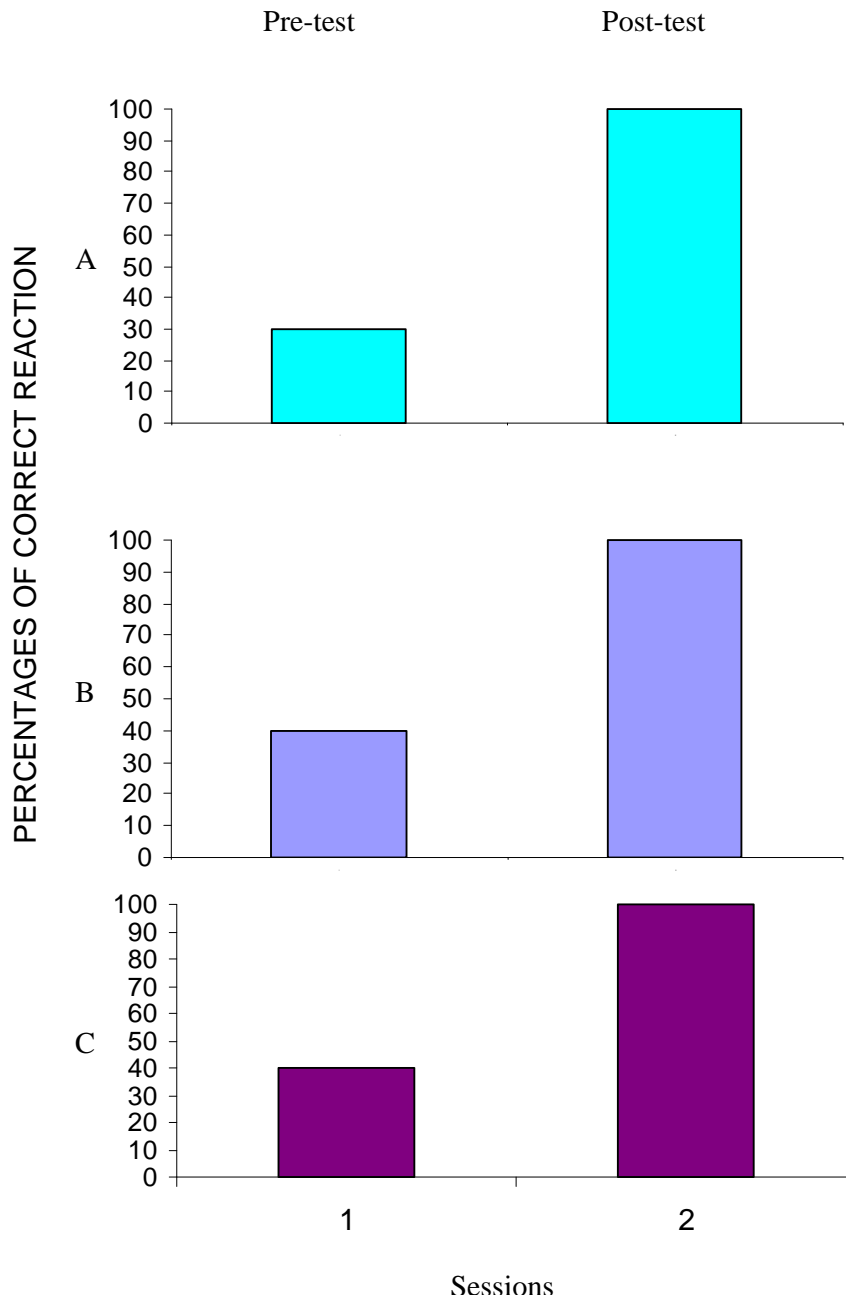


**Figure 1.**  
**Basic Addition Skills Performance by the first subject A, the second subject B, and the third subject C in Baseline, Intervention, Probe, and Maintenance Sessions**

The second subject, B, met the criteria through increasing her basic addition skills success rate from 40% to 100% after 9 teaching sessions were delivered in line with the Touch Math technique based on

a direct teaching approach, and sustained her success afterwards, during the probe sessions and maintenance sessions held 10 and 20 days after all the probe sessions had been finalized. Accordingly, the teaching sessions provided in line with the Touch Math technique based on a direct teaching approach may be considered as an effective tool for subject B's learning and sustainment of basic addition skills (Figure 1 above).

The third subject, C, met the criteria through increasing his basic addition skills success rate from 30% to 100% after 8 teaching sessions were delivered in line with the Touch Math technique based on a direct teaching approach and sustained his success afterwards, during the probe sessions and maintenance sessions held 10 and 20 days after all the probe sessions had been finalized. Accordingly, the teaching sessions provided in line with the Touch Math technique based on a direct teaching approach may be considered as an effective tool for subject C's learning and sustainment of basic addition skills (Figure 1 above).



**Figure 2:**  
Basic addition skills performance levels of the first subject A, the second subject B, and the third subject C in Generalization Sessions.

*Effectiveness on Generalization*

While the first subject, A, had correctly answered 3 out of 10 questions and scored 30% success in the pre-test, after the teaching sessions were held, she scored 100% success in the post-test, by correctly answering 10 out of 10 questions.

While the second subject, B, had correctly answered 4 out of 10 questions and scored 40% success in the pre-test, after the teaching sessions were held, she scored 100% success in the post-test, by correctly answering 10 out of 10 questions.

Lastly, while the third subject, C, had correctly answered 4 out of 10 questions and scored 40% success in the pre-test, after the teaching sessions were held, he scored 100% success in the post-test, by correctly answering 10 out of 10 questions.

Finally, in the light of the data presented earlier and as observed in the post-test results, all the three subjects scored 100% success in the generalization of the skills that they had learnt in an individual environment to the classroom environment and to the addition problems comprising same number combinations (Figure 2 above).

*Social Validation*

The *social validation questionnaire* developed for the determination of social validity of this research was distributed to the teachers at the end of the teaching sessions. After analyzing the questionnaires, the teachers' views concerning this research and its results can be summarized as follows (Table 1):

**Table 1**  
**The Distribution and the Percentages of Answers given by Primary School Teachers to the Closed Questions in the Social Validation Questionnaire.**

Questions	<u>Yes</u>	<u>No</u>	<u>Indecisive</u>
	n %	n %	n %
1. Did you use the Touch Math technique during the activities you had with students with special needs who had Intellectual disabilities or are in a risk group?	5 100%	0	0
2. Do you think the Touch Maths technique is practical (applicable) in teaching mathematics (arithmetic)?	5 100%	0	0
3. Would you prefer integrating the Touch Math technique into the content of arithmetic lessons?	5 100%	0	0
4. Would you recommend the Touch Math technique to Primary School teachers working with students with special needs who Have intellectual disabilities or are in a risk group?	5 100%	0	0
5. Do you agree that the skills taught through the Touch Math approach have a higher possibility of generalization?	4 80%	0	1 20%
6. Do you agree that there is no need for large-scale changes in the classroom for activities based on the Touch Math approach?	5 100%	0	0
7. Do you agree that it is appropriate to use teaching provided in line with the Touch Math technique based on a direct teaching approach in inclusion classrooms?	5 100%	0	0
8. Do you agree that there is a need for research concerning the teaching of basic addition skills to students with special needs who have intellectual disabilities and/or in a risk group?	5 100%	0	0
9. Do you agree that students having participated in this research will have more fruitful mathematics lessons in their classroom environments thanks to the basic additions skills they learnt through this research?	4 80%	0	1 20%
10. Do you agree that students having participated in this research will increase their grades in mathematics thanks to the basic addition skills they learnt through this research?	4 80%	0	1 20%

**Discussion**

Based on the findings of the research, the teaching provided in line with the Touch Math technique based on a direct teaching approach is found to be effective in teaching the basic addition skills to the



students with mild intellectual disabilities in general education classrooms. Findings on effectiveness reported in this research are in conformity with the findings of the previous four researches concerning teaching of basic addition skills with the Touch Math technique (Kokaska, 1975; Newman, 1994; Pupo, 1994; Simon and Hanrahan, 2004).

Under the scope of the research, the effectiveness of teaching provided in line with the Touch Math approach did not change either in the achievement or sustainment stage. The sustainability of teaching was proved by the fact that all the subjects could perform the taught skills, 10 and 20 days after the teaching sessions. This finding is also coherent with the findings of the research on the teaching of basic addition skills in line with the Touch Math technique, undertaken by Simon and Hanrahan (2004) and Scott (1993). Therefore, it may be claimed that the findings of this study have broadened the current literature concerning the assessment of sustainability effect of the Touch Math technique.

At the end of the pre-test and post-test sessions, all the subjects were observed to generalize the skills they had learnt to different number combinations and different environments. In the two previously published researches (Scott, 1993; Simon and Hanrahan, 2004), the subjects were tested whether they could generalize the basic addition skills taught in line with the Touch Math technique to addition problems that had not been used during teaching, and it was observed in both the researches that all the subjects could generalize the skills that they learnt to different addition problems. Only one research (Simon and Hanrahan, 2004) has presented a conclusion on whether the students could generalize the basic addition skills they were taught in line with the Touch Math technique in the source room to the classroom environment. Simon and Hanrahan (2004) held a separate test session so as to reach a conclusion concerning generalization. Based on the in-class observations of the subjects' primary school teacher, it was inferred that the subjects could generalize the skills that they had learnt to the classroom environment. Based on all the above-mentioned facts, the generalization findings of the research may be considered as having contributed to the literature concerning effective teaching and the use of a source room.

Research findings have shown that teaching sessions in line with the Touch Math technique based on a direct teaching approach is effective in teaching basic addition skills to the students with intellectual disabilities. These findings are coherent with the findings of other researches that adopted a direct teaching approach. Under the scope of this research, the single opportunity method was used in the probe sessions held to assess the subjects' performances. This situation may be assumed to have an effect on the error rates of the subject responses in the probe sessions.

In conclusion, the finding that teaching provided in line with the Touch Math technique based on a direct teaching approach is effective, sustainable, generalizable, and socially valid in teaching basic addition skills to students with mild intellectual disabilities in general education classrooms, conforms to other research conclusions in the literature.

Some limitations of this research that are thought to have an effect on the results of the research are as follows: a) the research is limited to three subjects attending second grade at Primary School located in Ankara. Therefore, this imposes a limitation on the generalization of the effectiveness, sustainability, and social validity findings of the research to environments of inclusion; b) the study is limited to five primary school teachers with a minimum experience of 5 years of primary school teaching in Turkey; c) teaching of addition is limited to single digit numbers added to single digit numbers, one over the other, with single digit or double digit totals; d) addition problems in this research are limited to numbers between 0 and 9, and additions consisting of different number combinations (e.g.,  $5+2$  or  $3+6$ ); e) is limited to teaching materials prepared in line with the Touch Math technique; f) the research is limited to addition problems used to teach and assess addition skills; g) limitations of the multiple probe design across subjects are imposed on this research; and h) limitations of the single opportunity method used in the probe sessions with an aim to assess subject performances are imposed on this research, and the data concerning erroneous responses could not be collected through error analysis method fearing that realistic error analysis pattern could not be achieved.

Furthermore, some suggestions for further researches in the light of the conclusions and limitations listed earlier are as follows: a) initially, similar researches should be repeated with different groups so as to increase the generalizability of effectiveness, generalizability, and sustainability findings of the research; b) the research should be applied to different disability groups at different ages, and thereby, the effectiveness should be assessed; c) the effectiveness and the productivity of the Touch Math

technique should be compared with those of other methods used to teach addition skills to students with intellectual disabilities.

### References

- Billingsley, F., White, O.R., & ve Munson, R. (1980). Procedural reliability: A rationale and an example. *Behavioral Assessment*, 2, 229–241.
- Bullock, J.K., Pierce, S., & McClelland, L. (1989). *Touch Math*. Colorado Springs, CO: Innovative Learning Concepts, Inc.
- Carpenter, T.R., & Moser, J.M. (1984). The acquisition of addition and subtraction concepts in grades one through three. *Journal of Research in Mathematics Education*, 15, 179–202.
- Christenson, S.L., Ysseldyke, J.E., & Thurlow, M.L. (1989). Critical instructional factors for students with mild handicaps: An integrative review. *Remedial and Special Education*, 10(5), 21–31.
- Groen, G.J., & Parkman, J.M. (1972). A chronometric analysis of simple addition. *Psychological Review*, 79(4), 329–343.
- Hanrahan, J.P., Rapagna, S., & Poth, K. (1993). How children with learning problems learn addition: A longitudinal study. *Canadian Journal of Special Education*, 9, 101–109.
- Hughes, M. (1986). *Children and number*. Oxford: Basil Blackwell.
- Kokaska, S. (1975). A notation system in arithmetic skills. *Education and Training of the Mentally Retarded*, 10, 96–101.
- Lock, R.H. (1996). Adapting mathematics instruction in the general education classroom for students with mathematics disabilities. *LD Forum*, 21(2), 19–23.
- Marsh, L.G., & Cooke, N.L. (1996). The effects of using manipulatives in teaching math problem-solving to students with learning disabilities. *Learning Disabilities Research and Practice*, 11, 58–65.
- Newman, T.M. (1994). *The effectiveness of a multisensory approach for teaching addition to children with Down syndrome*. Montreal: Unpublished master's thesis, McGill University.
- Porter, A.C., & Brophy, J. (1988). Synthesis of research on good teaching: Insights from the work of the Institute for Research on Teaching. *Educational Leadership*, 45(8), 74–85.
- Pupo, M. (1994). *Teaching intellectually disabled students addition through a multisensory approach*. Montreal: Unpublished Master's thesis, McGill University.
- Scott, K.S. (1993). Multisensory mathematics for children with mild disabilities. *Exceptionality*, 4(2), 97–111.
- Secada, W.G., Fuson, K.C., & Hall, J.W. (1983) The transition from counting-all to counting on in addition. *Journal for Research in Mathematics Education*, 14, 47–57.
- Simon, R., & Hanrahan, J. (2004). An evaluation of the Touch Math method for teaching addition to students with learning disabilities in mathematics. *European Journal of Special Needs Education*, 19(2), 191–209.
- Spencer, C.S. (1998). *Effective Mainstreaming* (3rd Ed.) Merrill Publishing: Ohio.
- Tawney, W.J., & Gast, L.D. (1984). *Single Subject Research in Special Education*. Columbus: Merrill Publishing Company.
- Tekin-İftar, E., & Kırcaali-İftar, G. (2004). *Özel Eğitimde Yanlızsız Öğretim Yöntemleri*. [Errorless teaching procedures in special education (2nd Ed.)]. Ankara, Turkey: Nobel Yayın Dagitım.
- Thornton, C., Jones, G., & Toohey, M. (1983). A multisensory approach to thinking strategies for remedial instruction in basic addition facts. *Journal for Research in Mathematics Education*, 14, 198–203.
- Wood, J.W. (1992). *Adapting Instruction for Mainstreamed and At-risk Students* (2nd Ed.). New York: Merrill.