A REMEDIAL TEACHING PROGRAMME TO HELP CHILDREN WITH MATHEMATICAL DISABILITY

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ABSTRACT

Seventeen children with Mathematical Disability (MD), who were undergoing a remedial teaching programme in a special school were compared with an age-matched control group of seventeen children, also with MD, but studying in regular schools, on mathematical achievement over a period of one academic year. Both the groups were tested on mathematical skills once in the beginning and again at the end of one academic year. The ANCOVA results showed that the children who underwent remedial teaching showed significant improvement in pre-operational and operational domains of mathematical skills. This paper presents details of the remedial teaching method. (Samveda Remedial Teaching – Math; SRT-M) employed in the study.

INTRODUCTION

Specific Learning Disability (SLD) is defined as the difficulty in learning basic skills of reading, writing, and arithmetic despite adequate intelligence, exposure to adequate instruction, and absence of gross sensory, motor and neurological problems. Anywhere from 10-20% of the schoolchildren seem to suffer from SLD. Thus, in India with 180 million school children, a conservative estimate would mean that approximately 20 million children have SLD. But the classroom teachers, teacher educators, educational administrators, as well as parents are not well informed about this problem. Instead, these children are promoted from one grade to the next grade under a 'no detention' policy, a government policy to check the school dropout at primary school level, even though they do not master the grade appropriate skills or even the basic learning skills. Such children fail to proceed through the school system successfully and invariably become school dropouts at a later stage. But if they are provided with necessary remedial teaching and support, it is possible for them to successfully compete educational and employment requirements.

Though the definition of SLD includes mathematical disability (Federal Register, Department of Education part II 34 CFR-3007, USA, August 23, 1977), not many children are referred for evaluation specifically because of deficits in mathematics. Even when a child is classified a SLD, adequate assessment procedures and remediation of arithmetic deficits are rarely evident. As a result a potentially sizable number of students with arithmetic problems are excluded from the help they need (1). The situation in India is not different. Very few children are referred for evaluation specifically because of deficits in mathematics.

Most referral for special education services for potential SLD students are precipitated by delays in reading skill acquisition. A large percentage of these children, however, also have substantial problems in arithmetic skills (2, 3, 4). It is estimated that about 60% of dyslexics have some difficulty with school mathematics. Some researchers even suggest that math disabilities are as prevalent as difficulties in other academic areas (5, 6, 7, 8). But converging evidence (1, 9, 10, 11) reveals that about 6% to 7% of the school-age population suffers from mathematical disability (MD). The degree of severity may vary from simple aspects of numeracy to simple mathematical operations and higher mathematics. Despite its common prevalence, MD has not been the focus of research, as reading disability has become (12). This relative neglect is unfortunate considering that mathematics skill is important for one's success in employment, income, and work productivity even after intelligence and reading skills have been accounted for (13).

The purpose of the present study is to highlight the need for remedial teaching for children with MD and to illustrate the effectiveness of such a remedial teaching programme in helping such children. The study also presents a detailed account of the remedial teaching framework that was followed. The authors feel that there is a great need for such interventional studies in India. Majority of the Indian schools do not have a resource room facility or a special educator available. Under such conditions, children are just promoted from one grade to another grade without achieving grade level skills, which would ultimately lead to school dropouts.

METHOD

Participants

The study employed a pre- and post-test design with a quasi-experimental method. 17 children with MD, who were undergoing remedial teaching at Samveda Training and Research

Center®, a special school providing residential and full-time remediation to children with learning disability located in Davangere (Karnataka State, India), constituted the Experimental group (Group 1). The control group (Group 2) consisted of 17 age matched children with MD, studying at four regular schools (who do not provide any remedial teaching) in and around Davangere. Control group children were selected from a pool of 37 poor achievers studying in various regular schools after administering a screening test for SLD. All of them were studying in English medium schools, none of them had repeated any grade, but the local language was their mother tongue.

In the beginning of the academic year, Samveda preoperational and operational profile tests (pre test), designed to diagnose the Pre-Operational and Operational errors in arithmetic, were administered to both Group I and Group II. The Samveda pre-operational and operational profile tests were administered, in that order, in two sessions with a gap of 2 hours. For the whole academic year the Group- I children were taught using SRTM while Children of Group II were not taught according to any remedial programme and attended regular arithmetic classes in their respective schools. At the end of the academic year, the same tests were administered again to both the groups (post-test). A written consent by the teachers and parents was obtained for including those children in the study.

Testing tool

Two test batteries were used in testing and evaluation of participants to be included in the study.

1. **Samveda Screening Profile Test** used in Samveda Research Training Centre, where the study was taken up, was used in the screening and selection of participants. The test is designed to gather information about specific learning difficulties and plan appropriate instructional strategies. The test contained both screening and diagnostic components and covers three areas: Language (Kannada/ English), Mathematics and General concepts. Language section of the test contains the following parts: I a) Identification of letters, b) Letter reading, c) Dictation (letters); II a) Words and Paragraph reading, b) Dictation (words); III a) Phoneme oddity test, b) Phoneme reversal test, c) Phoneme stripping test; IV Reading comprehension (Gap test) and V Reading comprehension test (Questions). The mathematics section contains four parts: I a) Numeral identification, b) Numeral naming, c) Dictation

(Numeral), II Pre-Operational mathematical skills, III Operational mathematical skills and IV Verbal math questions. The General concepts part contained two parts to test basic science concepts and another to test basic social science concepts.

2. **Samveda Mathematics Basic Profile Test** was the second test used. It has two sections, Section A and Section B. This test is designed to assess specific strengths and weaknesses in basic mathematical operations.

Section A contained 12 types of questions, which measure pre-operational skills, and they are arranged in an increasing order of difficulty. The 12 items are as follows:

Type I: Mark the biggest number, 5 items.

Type II: Mark the smallest number, 4 items.

Type III: What comes after, 5 items.

Type IV: What comes before, 5 items.

Type V: Put the appropriate signs (<, >, =), 10 items.

Type VI: Write the missing number, 5 items (to check the sequence concept).

Type VII: Split and Write according to place value, 5 items (Ex: 181= 100+80+1).

Type VIII: Add, 5 items (Ex: 100+30+5=135).

Item IX: Write the place value of the marked digit, 5 items.

Type X: Write in ascending order, 5 items.

Type XI: Write in descending order, 5 items.

Type XII: Dictation, 10 numbers.

Section B contained the following 13 items that measure the basic operational skills.

Type I: Addition, 5 items.

Type II: Subtraction, 5 items.

Type III: Fill in the blanks, 5 items (to check the verification concept of the above two operations).

Type IV: Multiplication, 5 items.

Type V: Division, 5 items.

Type VI: Fill in the blanks, 5 items to check the verification concept in multiplication and division.

Type VII: Representing given figures in fractions, 2 items.

Type VIII: Representing given fractions in figures, 2 items.

Type IX: Separating fractions as Proper, Improper and Mixed fraction, 5 items.

Type X: Writing equivalent fraction, 2 items.

Type XI: Find the L.C.M, 2 items.

Type XII: Find the H.C.F, 2 items.

Type XIII: Simplify 10 items on simple fraction addition, subtraction, multiplication and division.

The above evaluation tools also help in sub-grouping children within a particular classroom or to form classroom groups for effective remedial planning.

PROCEDURE

An experienced special educator trained to administer these tests tested children for the present study. Children were tested in a group. During session one (Preoperational skills test) the researcher requested the children to sit on benches in the middle of the class room. Then they were asked to write their name and grade before starting the test. The researchers asked them to relax and cooperate by answering a few questions related to mathematics. There was no time limit. A two-hour rest was given after the completion of the first session, before moving on to the operational skill test. The procedure was similar to the first session. Children were given a test paper and were required to fill in the answers for which there was no time limit. Children were allowed to clarify their doubts, if any.

Remedial teaching:

Remedial teaching employed in the present study is the one that is practised at Samveda Research and Training Centre. This method is referred to as SRTM-Math (Samveda Remedial teaching Model-Math) in this paper. The SRTM-Math follows the following sequence: a) Error analysis, b) Developing Conceptual Base, c) Developing Language Component, d) Mastery learning and Instructional Techniques, e) Teaching Fundamental Math, f) Teaching Interface Math and g) Teaching Parallel Text.

The first four components are given priority before initiating specific remediation in Math. Fundamental math deals with Arithmetic, Algebra and Geometry. This paper deals with only the teaching of fundamental arithmetic. Algebra and geometry are outside the purview of the present study.

Each of the major steps in the remediation that was followed in this study is descried below.

a). Error Analysis: In this first phase, the task is to tabulate the errors committed by children in doing mathematics. By merely recording answers as right or wrong one misses an opportunity to analyse at exactly what point an error occurred. By further probing, the teacher can find the precise area where the student's level of competence in a specific skill breaks down. Besides, through error analysis, a teacher is encouraged to refrain from assigning drill activities such as worksheets, which only serve to reinforce incorrect strategies (14). The error analysis helps to establish the base for planning the Individual Education Plan (IEP). The error analysis phase involves observing the child's performance in a series of tests and class room performance. STRM-Math error analysis is based on the procedure suggested by Buswell and Leonore (15). In SRTM the errors are classified into two categories viz., **Dependent errors** (e.g., applying wrong operations because of confusing the mathematical signs) and **Independent errors** (e.g., confusion with zero).

b). Developing Conceptual Base: SRTM-Math gives prime importance to conceptual understanding, that helps children develop logical and sequential steps while doing operations. In the initial phase, at this level, children are taught with activities and concrete objects giving them oral instructions about the operation, but later on it changes to concrete objects with written signs and instructions. Initial activities includes informal activities such as preparing shopping lists, preparing small budgets, visiting markets, making purchases etc. In classroom teaching, concrete and usually colorful objects that can be easily manipulated by children will be used to teach math principles. Children with MD have problems in comprehending the abstract nature of mathematical operations. Hence, they need explicit examples to illustrate the principles implicit in such operations. For example, children are made to understand by way of numerous concrete examples that addition and multiplication concepts involve combination and the nature of the answer is to INCREASE whereas subtraction and division concepts involve partitioning and the nature of the answer is to DECREASE. It will help the student to comprehend the logic behind computational operations. Further, concepts are taught by a variety of illustrations, in order to avoid rigidity that one may develop in learning concepts.

c). Language Component in Remedial teaching of Math: This is a very important component of remedial teaching, as children in India are required to learn three languages in school, which is a very formidable challenge for children with SLD. Besides, many children study in schools where medium of instructions are in English, which is not their mother tongue. In addition, many of the children in Indian schools could be first generation learners. Under these circumstances it is necessary to consider linguistic factors while framing the remedial instructions for mathematics. In SRTM-Math, the age of the learner, number of years of general schooling before joining Samveda, level of proficiency in languages and social background all are taken into consideration while deciding about the language of remediation. General approach used is to use the mother tongue in explaining the concepts, but using the English terminology as well. If the child has severe problems in mother tongue as well as in English, a mixture of the mother tongue and English is followed in the instructions. In later stages, depending on language proficiency achieved, the instructional language will switch over completely to English or to the mother tongue. As a rule, verbal problems are introduced much later in the remediation as it is required for the child to concentrate more on the numbers, the signs and the space.

d). Mastery learning and Instructional Techniques

In Math, each new learning skill builds on the previous learning and these are intertwined in problem solving at a higher level. SRTM-Math gives importance to concept learning followed by simple activities that reinforce the concepts best. The learning material is in a simple to complex order and each previously learnt skill is intertwined with the next skills to be learnt, so that the reinforcement of previous skills will be automatic along with the new skills. It also employs extensive real-life situations to make it easy to learn complex skills.

Mastery learning is achieved in SRTM-Math by breaking down the complex tasks into simple sub-skills to master and later on, by presentation of the complex problems with combined sub-skills. Part learning is very important in the initial stages to master each sub-skill with the help of concrete examples and activities, while later, the stress is on whole learning which comprises combination of skills. Children are allowed to master these skills at their own pace, as it is not possible to teach a prescribed math syllabus in a prescribed time to children with MD. The progress is monitored individually and the teaching is adjusted to individual speed of learning. However, in order to keep up their motivation and competitive

spirit high, SRTM-Math also follows 'Continuous Reinforcement (CR)' through 'star system' of reinforcement schemes.

e). Teaching Fundamental Math

This includes teaching **Pre-operational Skills and Operational Skills.**

Teaching **Pre-operation skills** consists of two parts viz., Concrete math and Concrete-abstract math.

Concrete math includes teaching **Grouping, Categorisation, Comparison and Sequencing**. All these four concepts are taught by using concrete objects, so that mathematical concept formation will become easy. Children are provided with opportunities to manipulate various objects that differed in color, shape etc., while teaching the basic concepts of Grouping, Sorting, Distribution, Column arrangement, Row arrangement, Big–Small, Long–Short, Tall–Short, More–Less, Far–Near, Thick–Thin, After–Before, Left–Right-Center, Clockwise–Anti Clockwise, Reverse Order, Ascending–Descending Order, Counting (Oral with Concrete objects) and Basic Number concepts (10 Numerals with Pictorial representation). The problems are posed in the order of increasing difficulty. Each correct response is reinforced with a score generally. These skills are an important precursor to basic operational math skills.

Concrete – Abstract Math relates the earlier mentioned concepts to numerals (with the support of concrete examples). In addition, children are taught Counting (Oral with Pictorial representation), Number Reading, Number writing, Number showing, and Skip counting.

Each remedial lesson is followed by an exercise to check how much a child has grasped and to draw future lesson plans.

Teaching **Operational math** includes the following skills: Place Value and Face Value, Fundamental facts, Addition, Subtraction, Multiplication and Division.

The concepts of place value and face value are very important in order to understand the numeration system and the algorithms of the four basic operations. It is taught initially by grouping and regrouping concrete stimuli in the form of some games. The different places are matched with specific colors while teaching place value. The development of the number of the digit is achieved with the help of their fingers. E.g., if a teacher says One thousand

fifty six students are required to point their fingers immediately corresponding to each place and write each number on paper. Children with MD find it very difficult to write numbers with zeros (e.g. 10001 for 1001). In such cases the earlier mentioned immediate reference method will work very well. A place value box is also very useful to refer higher numbers.

Another method used is the "split and write" (Expanded Notation) method. This method is used after the first level of addition. In this method, the child has to split the number according to the place values (e.g. 180= 100 + 80 +0) and then match the split number to the number form (0 + 50 + 000 + 1000 = 1050, 1000 + 000 + 50 + 0 = 1050, 1 Thousand + Zero Hundred + 5 tens + zero ones/units = 1050 and in later stages 1000 + 50 = 1050 and 1 Thousand + 5 tens = 1050). In this method, money is used as a tool to teach place values. These are often taught in some game forms to make it interesting. Strategies to tackle the Place value included Number reading from right to left, Place Reading from left to right, using fingers as reference places, number of digits in each number (e.g. one thousand contains 4 digits), Split and Write to avoid confusion with zero etc.

Fundamental Facts: Here, the stress is to make children develop automaticity in processing basic fundamental skills discussed earlier. As children with SLD are prone to develop inflexible primitive strategy, divergent thinking, different methods of approaching the problem will be introduced. These can be inculcated in the form of activities and games involving reproductive (retrieving answer from memory) or reconstructive using fingers, marks etc to compute strategies. In later stages, reference counting is discouraged and mental counting is encouraged. The development of effective basic facts in the classroom is achieved through timed group competitions and activity oriented teaching which would force children to rely more on automatic mental operations. Another method employed by the authors is to give children a basic-math-fact card to master. While doing computations, if they face any difficulty, they are allowed to refer to the basic-math card and thus avoid reference counting. Introducing different computer games, group competition and group discussion in the classroom as well as during free time relieve the anxiety of math. As children practise more and more to master the basic facts in different strategies, they will memorise much better. SRTM-Math encourages children to use different strategies to master the skills. A more detailed account of four basic mathematical operations, addition, subtraction, multiplication and division, is given in the following.

Addition

In SRTM-Math, before introducing the two-digit addition, addition of tens and hundreds is taught. This is done to enhance mental computation and the holistic view about number. Otherwise, often such children concentrate more on the addition of basic facts in each column or row, which does not promote mental computation. For instance, when asked to add 210 + 100 children may continue to follow the procedure of adding 0+0, 1+0 and 2+1 column wise and then row wise. This decreases the holistic vision of knowing that the addition of zero ending numbers could be computed more easily. Children are also encouraged to make personal flash cards, which will help them to memorise basic facts in free time.

The initial addition of higher numbers without regrouping numbers, is taught by direct method as well as split-off method. Direct method involves the following steps:

a). Arrangement of addends on a place value box card (row and column wise).

b). Addition of each digit according to its place.

c). Writing down the carry over number on the respective column and place.

d). Arrive at the sum and read out the answer.

On the other hand, Split -off method is taught by two methods:

A. a). Split addends.

b). Arrange the split addends according to the split place values.

c). Add respective places by adding carry over number to next place.

d). Write the split number in combined form.

e). Loud reading of the sum.

B. a). Split addends.

b). Separate the places.

c). Add the respective places first.

d). Add the separated places.

If the students do not get the same answer by these two methods, or if they commit any mistakes, they were asked to check their calculations again. Addition by split-off method is generally found to be more effective in enhancing the understanding of the place value

addition, as well as speed. The addition of multiple addends of same and different numbers are also introduced as they help children to understand the concept of multiplication. Addition of facts which need regrouping will be taught by converting the addition fact to 10 first and then add the remainder to it. For e.g., 9 + 8 = (9 + 1)+7.

Subtraction

The concept of subtraction is achieved through a directive method of teaching in which children are required to manipulate colorful concrete objects and develop the notion of the relationship between addition and subtraction. Before introducing higher numeral subtraction, subtraction of tens, hundreds, and thousands is taught to enhance mental computation. Addition and subtraction of same numbers exercise are also introduced at the same time, to understand the relationship between addition and subtraction operations and to start the journey towards multiplication and division. Initially, subtraction without borrowing is taught. In borrowing problems, children use place value chart. Subtraction by direct method and split-off method are also taught. In order to verify the obtained answer, children will use addition for subtraction problems and subtraction for addition problems. Subtraction of zero from a numeral and zero from a number will be taught by direct method and some strategies are taught to tackle confusion while doing computation.

Multiplication

A directive method is used to teach concept and meaning of multiplication using a variety of manipulative objects, followed by pictorial representation. The mastery of multiplication of tens, hundreds and thousands is taught first. Children with MD find it difficult to remember the multiplication rules. This can be tackled by the rearrangement method. (e.g., 18 X 9 = 10 X 9 + 8 X 9).

After the multiplication of simple numbers, without borrowing, higher number (multi-digit) multiplication is introduced. Multiplication will be illustrated and taught by different methods such as addition, direct method, multiplication by addition-split method, and multiplication by subtraction split method. The general strategies taught include: Rapid addition of Similar numerals; Writing Multiplication Signs; Getting answer by rearrangement; Multiplication of zero Ending numbers; Multiplication with zero (Any number X Zero or Zero X Any number = Zero); Even X Even = Even; Even X Odd = Even; Odd X Even = Even; Odd X Odd = Odd; and One X any number = Number itself.

Division

Money and some pictorial representations are used to teach division. By using money one can teach division with and without remainder division problems concretely. The rules of division are taught explicitly and students are given a reference card to use in the initial stages. Verification is taught by combining multiplication and division computation principles. The general strategy followed include Rapid Distribution (Subtraction) of Similar numerals, Writing Division signs, Rules for Division, Getting answer by rearrangement, Rules for zero division, and Division of zero ending number.

Within the framework of SRTM-Math explained earlier, IEPs are made for each student, depending upon his or her special needs and other related factors such as speed of learning.

RESULTS AND DISCUSSION

In order to adjust the initial difference between the experimental and control groups on math achievement scores the authors employed Analysis of Covariance (ANCOVA) making the initial scores as covariate. Pre and Post tests scores on pre-operational and operational mathematical skills were used separately. The results of ANCOVA for pre-operational mathematical skills and operational mathematical skills followed by descriptive statistics for pre-and post-test measures are presented in Tables 1-4 respectively.

Table 1. Summary of ANCOVA (Dependent Variable: Pre-operational skills)

Source	Type III	df	Mean Square	F	Significance
	Sum of Squares				
Group	1454.474	1	1454.474	78.079	0.0001
Error	577.479	33	18.628		
Total	92369	34			

Table 2. Summary of ANCOVA (Dependent Variable: Operational skills)

Source	Type III	df	Mean Square	F	Significance
	Sum of Squares				
Group	1385.964	1	1385.964	65.901	0.0001
Error	630.931	33	21.031		
Total	27884	34			

Table 3. Descriptive Statistics: Pre-test measures

	N	Mean	S.D
Group I (Experimental): Preoperational test	17	49.41	13.41
Group I (Experimental): Operational test	17	15.65	10.12
Group II (Control): Preoperational test	17	34.24	9.16
Group II (Control): Operational test	17	9	5.89

Table 4. Descriptive Statistics: Post-test measures

	N	Mean	S.D
Group I (Experimental): Preoperational test	17	63	9.09
Group I (Experimental): Operational test	17	36.29	13.8
Group II (Control): Preoperational test	17	36	9.82
Group II (Control): Operational test	17	10.65	5.69

Results clearly reflect the effectiveness of SRTM-Math in bringing out significant improvements on both pre-operational and operational skills of mathematics (F is highly significant in both the cases) even after statistically controlling for the initial differences between the experimental group that was exposed to remedial teaching and the control group of children with MD, who did not get remedial teaching support. The purpose of the paper was to explain the remedial teaching method that was adopted as much as to show its effectiveness. The results also suggest the need for special remedial teaching support to

millions of children with SLD who attend regular schools. In the absence of any such support, children in such schools are moving from one grade to the next higher grade without mastering the necessary academic skills. It should be a serious concern of teachers, administrators and the government to realise the gravity of the problem and take appropriate measures.

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