
■ A Systematic Procedure for Identifying and Classifying Children with Dyscalculia among Primary School Children in India

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This paper describes the procedures adopted by two independent studies in India for identifying and classifying children with dyscalculia in primary schools. For determining the presence of dyscalculia both inclusionary and exclusionary criteria were used. When other possible causes of arithmetic failure had been excluded, figures for dyscalculia came out as 5.98% (15 cases out of 251) in one study and 5.54% (78 out of 1408) in the second. It was found in the latter study that 40 out of the 78 (51.27%) also had reading and writing problems. The findings are discussed in the light of previous studies. Copyright © 2002 John Wiley & Sons, Ltd.

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INTRODUCTION

Mathematics is a study of relationships between quantities. It is a universal language, as it crosses the barrier of all cultures and civilizations. As a symbolic language, it enables man to think and communicate ideas concerning elements and relationships of quantity. Mathematics requires application of number skills to solve problems, using a set of rules or algorithms. It is a part of mathematics that must be learnt before mathematical problems can be solved. Everyday problems require mathematical conceptualization, logic, reason and analysis. There is general agreement among educators about the importance of mathematics to success in life. McLeod and Armstrong (1982) reported that two-thirds of a school population had difficulty in arithmetic and were in need of remediation. However, studies of learning difficulties in mathematics have received little attention in the literature until

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recently (Ginsburg, 1997). According to Jordan and Hanich (2000), much of the current interest in young children with mathematics difficulties can be attributed to a growing number of studies on the normal development of mathematical cognition. Malmer (2000) listed certain primary and secondary factors responsible for difficulty in mathematics. The primary factors were deficient cognitive development, poor linguistic competence, neuropsychiatric problems—minimal brain damage (MBD), attention deficit hyperactivity disorder (ADHD), Asperger's and Tourette's syndromes and dyscalculia. She also mentioned dyslexic difficulties, other reading difficulties and inappropriate teaching methods as secondary factors. In a recent study in India, Ramaa and Gowramma (2001) attempted to identify the arithmetic difficulties among grade V students in government primary schools from low socio-economic status families. In this study, teachers were asked to give a list of children who were average in reading and writing. The percentage of such children was 43.53. For these children, when an arithmetic test meant for primary school students (grades I–IV) was given, it was observed that all of them had serious difficulty in arithmetic.

However, no attempt was made in the study to identify the factors responsible for these difficulties. There could have been some percentage of children showing the specific syndrome of dyscalculia among the subjects. As mentioned above, mathematical difficulties may be attributed to multiple factors. Each factor has its own implications for intervention. So it is necessary to find out the causes of the difficulties. It is a very complex process and requires thorough and systematic procedures. Especially, this is true in the case of ascertaining dyscalculia as a primary factor for difficulty in mathematics. The studies conducted by Ramaa (1990) Gowramma (2000) attempted to identify and classify children with dyscalculia in a systematic way.

THE CONCEPT AND NATURE OF DYSCALCULIA

Dyscalculia is a type of specific learning disability. The Learning Disabilities Association of Canada (1996) (cited in Ramaa, 2000b) defined learning disorders/disabilities in terms of the following important features:

- (a) Learning disabilities (disorders) is a generic term that refers to a heterogeneous group of disorders due to identifiable or inferred central nervous system dysfunction.
- (b) Such disorders may be manifested by delays in early development and/or difficulties in any of the following areas—attention, memory, reasoning, co-ordination, communication, reading, writing, spelling, calculation, social competence and emotional maturation.
- (c) Learning disabilities are intrinsic to the individual, and may affect learning and behaviour of any individual, including those with potentially average or above-average intelligence.
- (d) Learning disabilities are not primarily due to visual, auditory, or motor handicaps, to mental retardation or emotional disturbance or environmental disadvantage, although they may occur concurrently with any of these.

- (e) Learning disabilities may arise from genetic variations, biochemical factors, events in the pre- to perinatal period or any other subsequent events resulting in neurological impairment.

The above definition clearly indicates that difficulties in calculation can be considered as a learning disorder or disability.

The 10th revision of the World Health Organization's international classification of diseases and related health problems (ICD-10) and the American Psychiatric Association's Diagnostic Statistical Manuals DSM-III (1980), DSM-III R (1987) and DSM-IV (1994) (cited in Ramaa, 2000a) have included learning disabilities under developmental disorders. In DSM-IV (1994), mathematics disorder refers to difficulties in the following skills:

- (a) Linguistic skills—such as coding written problems into mathematical symbols.
- (b) Perceptual skills—recognizing numerical symbols.
- (c) Attention skills—remembering the rules.
- (d) Mathematical skills—different operations.

On the basis of this classification, mathematical disorder can be grouped along with reading disorder and spelling disorder, and often the three overlap. In many studies, the term dyscalculia can be considered synonymous with mathematics disorder (DSM-IV, 1994).

Kosc (1968) suggested that the term dyscalculia should cover much more than that is included in the above definition. He defined developmental dyscalculia as a 'structural disorder of mathematical disabilities which has its origin in those parts of the brain that are the direct anatomico-physiological substrate responsible for the maturation of mathematical abilities adequate to age without, however, having as a consequence a disorder of general mental functions. The origins may be either genetic or acquired in prenatal development'.

Factor analysis of mental abilities (Burt, 1949) suggests that ability at mathematics is only one factor in the general matrix of mental ability. Factor analysis of mathematical abilities (Barakat, 1951; Canisia, 1962; Kosc, 1967) and detailed psychological analysis of disorders of mathematical functions of the brain in adults (Cohn, 1961; Luria, 1966; Kosc, 1968) again showed clearly that even mathematical ability itself is not simple and compact. If any of its component abilities are unevenly developed and some areas are severely impaired, there will be a disorder in calculation ability—and that is dyscalculia.

The following are some of the important observations made by the earlier investigators as far as the factors associated with dyscalculia are concerned:

- (i) There may be deficiency in two areas of mathematical cognition, namely retrieval of number facts and the ability to solve story problems (Russell and Ginsburg, 1984).
- (ii) There may be use of preliminary calculation strategies such as counting with fingers; there may also be more counting errors, ones which may last for a longer period of time (Geary, 1990; Geary *et al.*, 1991).
- (iii) There may be persistence of fact-retrieval deficits throughout elementary school (I–VII grades) (Ostad, 1997, 1999).

- (iv) There may be fact-retrieval deficits in children attributed to general deficiencies in speed of processing (Ackerman and Dykman, 1995; Bull and Johnston, 1997).
- (v) The mathematically disabled children continued to have difficulty across different grades at the elementary school stage in story-problem-solving skills involving change, equalizing, combining and comparing (Parmer *et al.*, 1996; Ostad, 1998).
- (vi) Those who experience difficulty in mathematics may have problem in information-processing skills such as attention deficits, visual spatial deficits, auditory processing difficulties, memory problems and motor disabilities (Bos and Vaughn, 1994).
- (vii) There is a difficulty or delay in conservation, seriation and classification aspects of cognitive development among dyscalculics of elementary schools (Clarke and Chadwick, 1979; Kingma, 1984; Deborah *et al.*, 1986; Nishi, 1988; Ramaa, 1990).
- (viii) Mathematically disabled children experience extra stress, anxiety and depression (Magne, 1991; Maag and Behrens, 1989).
- (ix) Dyslexic children may also experience difficulty in mathematics (Lovitt, 1989; Sharma, 1990; Miles and Miles, 1992).
- (x) Not all reading disabled children will necessarily have serious arithmetic disability (Guttman, 1937; Goodstein and Kahn, 1974).
- (xi) Arithmetic disorders frequently co-occur with reading and spelling disorders (Fletcher and Loveland, 1986; Batchelor *et al.*, 1990; Miles and Miles, 1992).
- (xii) Subtle cognitive deficits in symbolic or representational thinking, temporal-sequential organization, verbal memory, and rate of verbal processing may underlie language deficits in children. Some of these verbal cognitive deficits also have been implicated as possible causes of certain arithmetic difficulties (Stark and Tallal, 1981; Stark and Montgomery, 1994).
- (xiii) The specific difficulties exhibited by children having arithmetic disability according to Wallace and Kauffmann (cited in Fass, 1976) are as follows:
 1. Mastering the skills pre-requisite for arithmetic achievement.
 2. Mastering the basic computational skills, time and money concepts.
 3. Acquiring problem-solving skills.

Although some of the aforementioned studies show that children with mathematical disabilities have fundamental and persistent weaknesses in the areas of number facts, story problems and application of calculation strategies, inadequate procedures for identification may limit the use which can be made of them. Those studies did not attempt to differentiate between children with mathematical disability alone and children with both mathematical and reading difficulties (Jordan and Hanich, 2000). Further neuropsychological and cognitive studies suggest that children with poor achievement in mathematics but not in reading show performance patterns in thinking skills that are different from patterns of children with poor achievement in both (Rourke and Finlayson, 1978; Rourke, 1993; Rourke and Conway, 1997).

Jordon and Montani (1997) investigated the calculation and problem-solving skills of two subgroups of grade III children with mathematics difficulty—those

with reading difficulty and those without. A matched group of normally achieving children was also included. The findings indicated that children with specific mathematics difficulty had weaknesses associated primarily with rapid fact retrieval and problem-solving efficiency, whereas children with both reading and mathematics difficulties had fundamental weaknesses associated with problem conceptualization and execution of calculation strategies. This observation is also supported by the findings of Geary *et al.* (1999) that children with mathematical difficulty who were good readers had a better understanding of counting principles than children with mathematics difficulty who were poor readers.

From the above review, it is evident that the procedure for identification of dyscalculics should be very systematic. It is also necessary to classify dyscalculics on the basis of presence of absence of additional difficulties in reading or writing—for the purpose of diagnosis of neuropsychological factors, specific arithmetic difficulties and remediation. Sometimes it is essential to restrict the subjects of study to those with dyscalculia alone, keeping in mind the feasibility factors for conducting the studies. However, while helping the children with dyscalculia in the classroom situation all the categories should be taken into consideration.

According to Baroody and Ginsburg (1991), dyscalculia is 'a specific disturbance in learning mathematical concepts and computation and is associated with an organic dysfunction. It is a term that applies to disturbance of quantitative thinking stemming from dysfunction of the central nervous system. The term precludes limited intellectual capacity, primary language disorder, anxiety or poor teaching as a cause of arithmetic failure'.

In the above definition, dyscalculia is identified in terms of a set of exclusionary and inclusionary criteria. According to this, children with dyscalculia are those who fulfil the following criteria:

- (i) problems in understanding basic arithmetic,
- (ii) no sensory or motor handicap,
- (iii) no mental retardation,
- (iv) no behavioural and emotional disturbance,
- (v) no environmental deprivation.

Usually, sets of both exclusionary and inclusionary criteria are being adopted in India for identifying any type of learning disabilities. Those criteria are listed in Ramaa (2000b). Similar procedures were also adopted by Ramaa (1990) and Gowramma (2000) in their studies for identification of children with dyscalculia. The details of the procedure are given in the following sections.

IDENTIFICATION OF DYSCALCULICS

Sample

In the study by Ramaa (1990), in order to identify children with dyscalculia (CWD), ten primary schools in Mysore city were selected where teaching was carried out through the medium of Kannada language. The selection of the schools depended upon the feasibility of administering various tests. As

dyscalculia is independent of regional differences as well as socio-economic status, there was no need to consider these variables while selecting the sample for the study. However, in order to control for the possible effects of certain pupil variables like interest and motivation to learn mathematics, school variables like methods of instruction, home-related variables like parental involvement in the education of the children, both private management and government schools, were included in the study. It is usually assumed that children attending private schools have more advantages than those who are studying in government schools with references to the above-mentioned variables which in turn can be attributed to many other factors. Thus, the intention in selecting both private management and government schools is to verify whether dyscalculia is independent of all these factors—in other words to find out whether it is an inherent problem and not merely due to environmental factors.

Since the objective was to identify not only children who have dyscalculia but also to identify those children with dyscalculia but without dyslexia (in the sense of literacy difficulties), a list of 308 children who were poor in arithmetic but normal in reading and writing was made on the basis of the teachers' opinion.

For the study by Gowramma (2000), 11 primary schools with 16 sections were selected in Mysore city, the selection depending upon the feasibility of administering various tests. Schools from both mediums of instruction—English and Kannada—were included. Out of the 11 primary schools selected, five were taught through the mediums of both English and Kannada. The total number of students was 1408 from grades III and IV (with ages ranging from 7 to 8 and 8 to 9 years, respectively). Out of these, 328 students were referred by the class teacher to the investigator as having below-average performance in arithmetic.

DESCRIPTION OF THE TOOLS EMPLOYED

The various tools employed in the study for the collection of data are explained below. This section gives a detailed description of each tool employed.

Tools Used at the Identification Phase

This section is devoted to describing the tools used at the identification stage of the study.

(a) *Kannada Word-Recognition Test (Ramaa, 1985)*. This test assesses the accuracy of Kannada word recognition and writing skills among students of grades III and IV. There were no norms for this test, which was usually intended for the identification and analysis of reading errors. There was, therefore, a need for establishing norms in reading and writing. For this purpose, the investigator administered the test to primary school children of grades III and IV ($N=200$ each) belonging to rural and urban schools.

The test includes 100 words consisting of almost all the letters of the Kannada alphabet and a sample of 'Kagunitha' (consonant+different sounds including vowels and diphthongs denoted by specific symbols). The words are arranged in an increasing order of number of letters.

Administration and scoring procedure. The reading test was administered individually. Normal readers require 5–8 min to read all the words, whereas a

child considered to be poor in reading may require 20–30 min to read all the words.

Each correctly read words was given a score. Depending upon the mean and standard deviation (S.D.), the following categories of performance in reading skills were formed:

Grade	III	IV
Mean	46.926	59.50
S.D.	26.20	30.40

Categories on the basis of mean and S.D. for the Kannada word-recognition test (reading) are as follows:

Category	II	III	IV
Very good	61+	74+	91+
Good	46–60	61–73	76–90
Average	31–45	35–60	45–75
Poor	15–30	21–34	30–44
Very poor	<15	<21	<30

The test meant for assessing reading skills was also used to assess word-writing skills. It was standardized on the same set of children on whom standardization was done for reading. The words were dictated aloud and repeated at least twice. Care was taken to see that every child had sufficient time to write the words. On average children took 45–60 min to write 100 words. Each correctly written word was given a score. Depending upon the mean and S.D., the following categories of performance in writing skills were formed:

Grade	III	IV
Mean	23.145	30.560
S.D.	20.018	20.236

Categories on the basis of mean and S.D. for Kannada word-writing test are as follows:

Category	II	III	IV
Very good	22+	44+	52+
Good	17–21	34–43	42–51
Average	7–16	14–33	21–41
Poor	2–6	3–13	10–20
Very poor	<2	<3	<10

(b) *Auditory Reception Test in Kannada (Ramaa, 1985)*. This test was designed to assess the auditory receptive ability of primary school children of age group 6–10 years of grades III and IV. The test consists of 24 items each containing a noun and a verb. The items contain both semantically correct and semantically incorrect forms which are presented orally by the examiner. The subjects are required to respond 'Yes' or 'No' to the items. One point is given to each correct response. Norms are provided for each age level and also grade level. The test is an adapted version of the auditory reception sub-test of the Illinois Test of Psycholinguistic Abilities (ITPA) (McCarthy and Kirk, 1961).

This test was used by the investigator as a measure of the child's auditory receptive ability.

The following are the norms for each group separately:

Grade	I	II	III	IV
Mean age	6.6	7.6	8.6	9.6
Mean score	15	16	19	21

(c) *Academic Achievement Motivation Inventory (Ramaa, 1985)*. The purpose of the test is to find out whether children of primary school studying in grades III and IV have adequate motivation towards academic achievement.

There are 12 statements written in the inventory to represent the construct for academic achievement motivation. These statements are descriptions of different situations or possible tasks. The subject has to tell how they would behave in each case.

Three alternative responses indicative of motivation—intrinsic, extrinsic and none are provided for each statement of which one was to be selected by the subject.

If the subject selects the choice of intrinsic motivation, a weight of 3 was assigned to it; for extrinsic motivation, a weighting of 2; and for no motivation, a weighting of 1. From this inventory, it is possible to make a rough classification of children according to whether they do or do not have adequate academic achievement motivation. For purposes of providing a norm, a cut-off score of 18 was used, which was the mid-point between the average and the lowest score.

By using this inventory, it is possible to estimate whether children have adequate academic achievement motivation.

(d) *The Raven Coloured Progressive Matrices (RCPM)*. This test was developed by Raven (1965). The coloured matrices are designed for young children and old people for anthropological studies and for clinical work. They can be used satisfactorily with people who for any reason cannot understand or speak the regional language, people suffering from physical disabilities, aphasias, cerebral palsy or deafness as well as with people who are intellectually subnormal. This test calls for recognition of abstract relationships, but the amount which the person has to hold in mind at once is strictly limited. He must recognize relationships as he scans the patterns horizontally and he must recognize relationships as he scans the patterns vertically, but he need not scan them both at once, and the number of defining properties of the correct design for completing the matrix is well within the limits of the load which he can carry.

The three sets A, AB, and B, each with 12 problems, are arranged to assess the chief cognitive processes of each child under 11 years of age.

The investigator administered the RCPM individually following the instructions given in the manual. The responses were recorded and scored as per these instructions.

The test gives the following classifications:

Intellectually superior: If the subject's score lies at or above the 95th percentile for his age group.

Above-average intellectual capacity: If the score lies at or above the 75th percentile.

Average intellectual capacity: If the score lies between the 25th and 75th percentiles.

Below-average intellectual capacity: If the score lies below the 25th percentile.

The above classification was followed for retaining those children whose score lay above the 25th percentile. However, a discrepancy score of +1 was used to include children who had scored 1 less than the required cut-off but in whose case this was thought to be due to cultural and social factors.

(e) *Grade Level Assessment Devise developed by Narayan (1994)*. This test was developed to assess children with learning problems in schools. It finds out the level of academic performance of children of grades I–IV. It is especially useful for children who are scholastically backward to know at which grade level they are performing. The test consists of two formats; format I and format II.

Format I includes items requiring verbal and written responses to questions. Instructions are given at the top of each worksheet. Format II is to be used by the teacher for recording observations made while the child is performing on Format I. Format II has three sections and a summary sheet.

Since the purpose of the investigator was to find out the grade level of the child, only format I was used along with its scoring sheets. The investigator made use of only mathematics-I of the device. For the study, only grade III and grade IV children were taken and since the test was given at the beginning of the academic year, grade III children were considered to be at grade II level and grade IV children were considered to be at grade III level in their arithmetic performance. The identification criterion-6 of the identification procedure says that 2 years retardation in arithmetic performance is an indication of dyscalculia. So the device was used to find out if the child is still below the grade I level. If the score of a child in grade III or IV fell below the grade I level, then that student was retained for the study.

(f) *Arithmetic Diagnostic Test (Ramaa, 1990, 1994)*. This test diagnoses the specific difficulties encountered by children of primary schools of grades I–IV, while solving arithmetic problems. The test covers three major areas of arithmetic, namely number concept, arithmetic processes (operations)—addition, subtraction, multiplication and division, and arithmetical reasoning.

Since it is a diagnostic test, it includes problems that represent each type and subtype of task that falling each of the major areas. Thus, the test is quite comprehensive in identifying the strengths and weaknesses of the individual child. Due weight is given to different types of task. Each subtype of the task is represented by two items in the case of arithmetic processes and reasoning. This helps in thorough diagnosis of the difficulties faced by the children in dealing with this particular subtype of arithmetical task. The subitems and the items are

arranged in the order of increasing level of difficulty within the different sections of item as well as between the sections.

PROCEDURE ADAPTED IN STUDY I

In order to cross-validate the opinion of the teachers that all these 308 children were normal in reading and writing, formal testing was carried out so as to assess their level of performance in these skills. The speed and accuracy of reading words were assessed through the Kannada oral reading test (Jaya Bai, 1958). It is an individually administered test, lasting 1 min. The number of correctly read words per minute gives the raw score. The raw scores expected for different grades of the primary school I–IV are 10, 22, 36 and 43, respectively. Since the testing was done at the beginning of the academic year, grade II children were considered to be equal to grade I, III to II and IV to III, respectively. Though the test was constructed in 1958, findings by various investigators confirm the suitability of the norms to date. So while considering the appropriateness of the level of speed and accuracy of children of different grades, the raw scores obtained by them were compared with the mean score for the previous grade. The children who were average or above average in speed and accuracy of reading words were retained for further screening and the others were eliminated from the analysis.

The same test was used to assess the accuracy of writing words. The number of words expected to be read for each grade was dictated to the subjects at a speed of one word per minute. Those who could not reach the norm were eliminated from the analysis. This test was administered to a group of 10–15 children at a time.

To those children who were retained in the previous step ($N=288$), a reading comprehension test in Kannada (Ramaa, 1985) was administered. It consists of eight passages, two for each of the four grades I–IV of the primary schools. The test was administered individually. The child was expected to read these passages and answer the questions pertaining to them. The questions assess three levels of comprehension, namely, literal, reorganization and inferential. The child was allowed to read as many passages as he could. The testing ceased when either of the two conditions specified by the author of test:

- (1) when the child committed 18 mistakes in any passage, or
- (2) when the child failed to answer at least one question of a particular passage although they had made fewer than 18 errors while reading it.

The grade-appropriate passages were dictated to the subjects of the study to test the skill of writing the passage accurately. Those who made more than 18 mistakes in the grade-appropriate passage were eliminated from the analysis. This test was administered to a group of 10–15 children at a time (Table 1).

An attempt was also made to find out whether those 251 children who were confirmed as being average/above average in reading and writing were deficient in arithmetic skills. For this purpose, the *Arithmetic Diagnostic Test for Primary School Children* (Ramaa, 1994) was administered to them individually. The test measures (i) number concept, (ii) fundamental operations and (iii) arithmetical reasoning. The children were continuously supervised; their doubts were

Table 1. Number of children eliminated from the analysis and retained during formal testing of reading and writing skills

Sl. no.	Criterion measures	Tools	Reason for rejection	No. of children Eliminated	Retained
1	Speed and accuracy of reading words	Kannada oral reading test (Jaya Bai, 1958)	Speed of reading was not appropriate to grade level expected	20	288
2	Reading comprehension	Reading comprehension test in Kannada, (Ramaa, 1985)	Inadequate level of reading comprehension	13	275
3	Writing the words dictated (read per minute)	Kannada oral reading test (Jaya Bai, 1958)	Failed to write the expected number of words dictated	13	262
4	Writing the passage dictated	Reading comprehension test in Kannada (Ramaa, 1985)	Failed to write the passage dictated	11	251

clarified; examples were given wherever necessary; they were encouraged to do the sums and to do the workings in the booklet itself. Strategies adopted by them were also carefully observed and noted. The answers in the booklets were evaluated and the responses were analysed qualitatively. Through such an analysis it was noticed that almost all the 251 children were below average in arithmetic skills, as judged by the grade norm given in the test but that they varied among themselves considerably with respect to consistency or inconsistency in response, perseverance and the difficulty exhibited in different levels of task. These differences were kept as the basis for the classification of dyscalculics. The observations are summarized in Table 2.

Table 2 clearly indicates that in only 15 out of 251 cases did the arithmetical difficulties exhibited by the children exemplify dyscalculia. Thus, the prevalence of dyscalculics who are free from dyslexia and dysgraphia is 5.98% in the population studied. This figure is exactly the same as that found by Kosci (1974).

PROCEDURE ADOPTED IN STUDY II

Identification of children with dyscalculia was based on exclusionary criteria. The criteria were as follows:

- (1) is normal in sensory functioning, visual tracking and eye-hand co-ordination,
- (2) shows no serious emotional and behavioural problems,
- (3) is aged at or above 8 years,
- (4) has not been absent from school frequently,
- (5) is normal in auditory reception,
- (6) has adequate academic achievement motivation,
- (7) has received extra help at home,

Table 2. General tendency to produce inappropriate/inadequate responses while doing arithmetic sums and the frequency of children who produced such responses

Sl. no.	Inappropriate/inadequate response	Possible reasons	Number of children who showed such responses
1	Difficulty in higher order tasks relating to each area of arithmetic tested	Unfamiliarity of the tasks	118
2	Inconsistent response to similar kinds of tasks	Lack of inadequate practice	45
3	Difficulty only in the recently introduced arithmetic operations	Lack of sufficient exposure	23
4	Failure to perform lower order tasks even though capable of handling higher order ones	Carelessness	25
5	Incomplete without obvious reason	Lack of perseverance	25
6	Consistent failure even in most basic skills	Inability to learn arithmetic	15

- (8) is normal in intellectual functioning, and
 (9) is at least 2 years retarded in arithmetic.

Criterion 1—is normal in sensory functioning, visual tracking and eye-hand co-ordination: This criterion was met by informal interaction with the child. The teacher's opinion was sought with regard to the child's ability to hear, see and respond to classroom questions. To check his eye-hand co-ordination, each subject was given a sentence to copy appropriate to his age and experience. Out of 328 students referred to the investigator, three were eliminated from the analysis on this criterion and 325 were retained for further screening.

Criterion 2—is without any serious emotional/behavioural problems: Information about family background was collected. The teacher's opinion regarding the behaviour of the child was also used. The child was observed interacting informally with others. Those who showed symptoms of emotional and behavioural problems such as maladjustment, withdrawal, over-anxiety, erratic behaviour and aggressiveness were eliminated from the analysis. This resulted in the elimination of six students, and the remaining 319 were retained for further study.

Criterion 3—is aged at or above 8 years: Since their difficulty in learning arithmetic could be attributed to their immaturity, children below 8 years of age were eliminated from the analysis. This was determined by checking school records. At this stage, 70 children were eliminated and 249 were retained for further tests.

Criterion 4—has not been absent from school frequently: Since arithmetic is a linear subject, absence in the previous class makes it very difficult for the child to get continuity in the new lesson. If he misses classes frequently that could be a possible reason for his poor performance. So such children were eliminated from

the analysis at this stage by referring to the daily attendance register and also after taking the opinion of the class teacher. Eleven children were eliminated from the analysis at this stage and 238 were screened further.

Criterion 5—is normal in auditory reception: To measure the auditory receptive ability of the child the auditory reception test developed by Ramaa (1985) was used. Those children who had average or above-average auditory receptive ability were retained for the study. At this stage, 13 students were eliminated from the analysis out of 238 and 225 children were kept for the study.

Criterion 6—has adequate academic achievement motivation: This criterion was met by administering the Academic Achievement Motivation Inventory (Ramaa, 1985). This was administered to each child and those who scored below the cut-off point were eliminated from the analysis. Only those students who had motivation were retained. At this stage, no children were eliminated from the analysis. All the 225 were retained for further screening procedure.

Criterion 7—has received extra help at home: This criterion was met by talking to the child informally. The intention was to find out if the child was receiving any help from tutor, parents or siblings at home. If the child did not receive extra help from any of these sources, he was eliminated from the analysis. Only one child was eliminated at this stage and the remaining 224 were retained.

Criterion 8—is normal in intellectual functioning: This criterion was met by administering the Coloured Progressive Matrices (Raven, 1965) individually to each child. Children whose score laid above 25th percentile were retained for the study as having the required level of intellectual functioning, i.e., average or above average. Children whose score laid at or below the 25th percentile were eliminated from the study as being below-average intellectual functioning, a possible factor for their poor performance in arithmetic. However, a discrepancy score of +1 was used to include children who had scored 1 less than the required cut-off score to rule out any possible error due to cultural/social factors. Out of the 224 children who were screened for this criterion, 58 were eliminated from the analysis as they exhibited below-average intellectual functioning. The remaining children who had above-average and average intellectual functioning were retained for further tests. Finally, 166 students were tested further.

Criterion 9—is at least 2 years retarded in arithmetic: To meet this criterion the Grade Level assessment Device (GLAD) (Narayan, 1994) was administered individually to each child. Children who performed below the grade I level, as scored by GLAD, were deemed at least 2 years below their grade level. Since the test was administered at the beginning of the academic year, grade III children were considered to be in grade II and grade IV children were considered to be in grade III for scoring purposes. Those children whose performance was below the level of grade I were retained for the study. At this stage, 88 students were eliminated from the analysis as their performance was at or above grade I level and 78 students were identified as having dyscalculia.

Thus, out of a total of 1408 children, of whom 328 were referred to the investigator, 78 were found to meet all the above criteria and they were identified as the children with dyscalculia.

Thus, it can be seen that the percentage of children who were considered to have arithmetic difficulty is 25% (328 out of 1408), among whom 24% were found to have dyscalculia (78 out of 328). In relation to the total population (1408) 5.54% of children exhibited dyscalculia.

Table 3. Number of children eliminated and retained at various steps in the process of identification of children with dyscalculia out of 1408 children

Steps	Reasons	No. eliminated	No. retained
1	Those who perform well in arithmetic	1080	328
2	Problem in sensory functioning and eye-hand co-ordination	3	325
3	Emotional/behavioural problems	6	319
4	Age below 8 years	70	249
5	Long absence	11	238
6	Poor auditory reception	13	225
7	No academic achievement motivation	0	225
8	No extra help	1	224
9	Below average intellectual functioning	58	166
10	Not below 2 years retardation in arithmetic achievement	88	78

Table 4. Distribution of children in the three different categories

Categories	No. of children in Grade III	No. of children in Grade IV	Total	Percentage
Dyscalculics without reading and writing problems	4	20	24	30.76
Dyscalculics with writing problems	7	7	14	17.97
Dyscalculics with both reading and writing problems	15	25	40	51.27

Tables 3 and 4 give the number of children eliminated from the analysis and retained at various steps against each criterion.

Classification of Children with Dyscalculia (CWD)

After identifying CWD, Gowramma (2000) was interested in classifying them on the basis of the presence or absence of reading and/or writing disabilities. The investigator attempted to subdivide categories among those 78 children as follows:

Group A—Children with dyscalculia without reading and writing problems.

Group B—Children with dyscalculia with writing problems.

Group C—Children with dyscalculia with both reading and writing problems.

To identify categories among children with dyscalculia, reading and writing tests were administered to all the 78 children identified in the identification phase of this study. For this purpose the Kannada word-recognition test (Ramaa, 1985), which was restandardized by the investigator, was used. Grade norms were set by standardizing the test on grades III and IV students.

Identification of Children with Reading Problems

For this purpose the Kannada word-recognition test (Ramaa, 1985) was administered individually to each child identified as dyscalculic. The children

were given the list of 100 words in the test and were asked to read them aloud. Each correctly read word was marked as such and the words which were read incorrectly or not read were marked as wrong. Each correctly read word was given a score and the total score on reading was calculated for individual cases. Grade III children who scored at the average level (scores between 35 and 59) or above-average level (score 60 and above) and grade IV children who scored at the average level (scores between 45 and 75) or above-average level (score above 75), were considered as having no problem in reading. Those who scored below 35 in grade III and below 45 in grade IV were considered as having difficulty in reading.

Identification of Children with Word-Writing Problems

For this purpose, the same test used for identifying reading difficulty, that is the Kannada word-recognition test (Ramaa, 1985), was administered to all those who were identified as dyscalculics. This test was administered in groups. The investigator read the words from the list loudly and clearly, repeating each word at least twice. Sufficient time was given for writing the dictated word. The word was repeated if any child so requested. They were asked to write the dictated words on a sheet of paper. The answer sheets were collected after dictating all the 100 words from the list. Each correct word was marked correct and the words not written correctly or not attempted were marked as wrong. Each correctly spelled word was given a score. The total score on word-writing was calculated. Grade III children who scored at the average level (scores between 14 and 32) and above average (score 33 and above) and grade IV children who scored at the average level (scores between 21 and 40) and above average (score 41 and above) in the writing test were considered as having no problem in writing. Those children in grade III who scored below 14 and those children in grade IV who scored below 21 were considered as having difficulty in writing.

Based on the above procedure, three categories were identified among the dyscalculics. Table 4 shows the distribution of children in the three different categories.

Procedure for Identification of Dyscalculia

Although both the investigators agreed upon the same set of exclusionary and inclusionary criteria, the purposes of their studies were slightly different. Ramaa (1990) (Study I) was interested in identifying children with dyscalculia among those who were free from reading and writing disabilities, whereas Gowramma (2000) (Study II) wanted to identify all the children with dyscalculia irrespective of the presence or absence of reading and writing disabilities. Hence, they adopted slightly different procedures for identification.

CONCLUSION

In the studies, the percentage of children who had dyscalculia was 5.98% (15 out of 251 referred cases) (Ramaa, 1990) and 5.54% (78 out of 1408 students)

(Gowramma, 2000), respectively. These figures are similar to those found by Baker and Cantwell (1985), Garnett and Fleischner (1987), Kosci (1974), Share *et al.* (1988). This indicates that both the procedures are valid in spite of slight variations between them. The findings also reveal the consistency in prevalence of children with dyscalculia alone and in combination with reading and writing difficulties is more or less same as observed in different studies. However, Lewis *et al.* (1994) found a lower percentage (3.6%) of children with specific arithmetic difficulties. In addition, they found that among the children of age group 9–10 years ($N = 1206$) those with specific arithmetic difficulties (SAD) constituted 1.3%, those with arithmetic and reading difficulties (ARD) 2.3%, and those with specific reading difficulties only (SRD) and constituted 3.9%. A similar result was obtained by Gowramma (2000). Out of the population of $N = 1408$, in the age group of 8–10 years, it was observed that 1.7% of the subjects had arithmetical disability only, 1% had arithmetic and writing disabilities and 2% had arithmetic, reading and writing disabilities. Thus, any one of the procedures can be adopted while identifying and classifying dyscalculic children in classroom, depending upon the purpose.

Share *et al.* (1988) reported a male-to-female ratio of 1.7:1 for children with specific arithmetic difficulties. The ratio observed in the present study was closer to 1:1.

In the study by Ramaa (1990) the ratio between boys and girls with dyscalculia alone was 1.3:1 (9 out of 15 and 6 out of 15, respectively). This shows the number of boys with dyscalculia as more compared with that of girls. But it was noticed that the number of girls (208 out of 359) who were referred by the teachers as poor in arithmetic outnumbered boys (151 out of 359), in the ratio of 1:1.3. It is, therefore, difficult to draw any firm conclusions from Ramaa's figures.

Although difficulty in arithmetic is experienced by a greater number of girls, their difficulties can be attributed to reasons other than dyscalculia. There is a need to explore the reasons.

The similar findings with reference to the prevalence of dyscalculics of different categories (with or without additional difficulties in reading/writing) and also male-to-female ratio supports the validity of the procedures adopted by the two different investigators in spite of slight variations between them.

Although studies relating to dyscalculia are limited in number, such evidence as there is supports the view that dyscalculia is a universal phenomenon. Irrespective of cultural and linguistic variations, and it seems that the number of individuals affected by this disorder is more or less the same in different parts of the world.

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