8.0 INTRODUCTION

Children with hearing impairment are a disadvantaged group. This is so because, their disability is a hidden disability which does not get identified until the children start speaking or communicating. The hearing impairment affects all the aspects of the child’s life including education. Our education system is language based and hence children with hearing impairment face problem in the learning process. Kretchmer and Kretchmer (1978) and Quigley and Kretschmer (1982) reported that hearing impairment leads to developmental delays, deficit in language acquisition and affects the language dependent areas of academic. Cognitively, they are at par with their normal hearing peers, but due to language deficiency they perform much below their normal hearing peers.

The role of language cannot be avoided from mathematics. Its importance in developing mathematical skills is important. For developing basic number concept, language is very important. Bishop and Snowling (2004) have reported that language and number are developmentally inseparable. To help the children with hearing impairment succeed in mathematics learning, an appropriate teaching strategy is necessary which will help the children develop a likingness towards mathematics.

Children facing difficulty in mathematics and committing errors is very common. However, identifying those difficulties and rectifying the errors through a well defined remedial programme will benefit the children in the education process.
8.1 NEED FOR THE STUDY

Researchers have found that students with disabilities perform two grades below or more behind their peers without disabilities. Researchers have noted that math difficulties emerge in elementary school grades and continue as student’s progress through secondary school grades (Cawley, Parmer, Yan, & Miller, 1998). Ones children find difficulty in solving math problems; they tend to avoid it and hence leading to failure and ultimately dropout from school. Besides the total number special schools and the available special educator is disproportionate. Giving an individualized training to these children who have difficulty in mathematics is also not possible. Besides, teachers usually do not go into the depth of analyzing the problems, what the children are encountering in the mathematics. Even though they try to evaluate the difficulties faced by the children with hearing impairment in mathematics, they will not do an in-depth analysis of the difficulties and errors and remediate them. The investigator has undertaken the present study to identify the types of difficulties and analyze the errors made by the children with hearing impairment in mathematics, and develop an appropriate remedial instructional programme to help children with hearing impairment. The study will also provide guidelines to special educators as well general teachers to plan their teaching in such a way that it can address the learning needs of the children in any classroom keeping the Universal Design for learning model.

8.2 STATEMENT OF THE PROBLEM

In the study it was proposed to answer the following major questions

1. What percentage of students with hearing impairment studying in Grade-V of special schools who are free from additional disabilities and have mathematical difficulties?
2. What kinds of errors will be committed by children with hearing impairment studying in Grade-V of special schools while attempting the items relating to different Criterion measures in mathematics pertaining to Grades I to V?

3. Whether the remedial instruction programme planned in the study will be effective in improving the performance of children with hearing impairment?

**8.3 OBJECTIVES OF THE STUDY**

1. To find out the percentage of children with hearing impairment studying in Grade-V of special schools who are free from additional disabilities and have mathematical difficulties.

2. To construct a Mathematics Diagnostic Test for Grade-V children.

3. To ascertain the percentage of children with hearing impairment studying in Grade-V of special schools exhibiting difficulties in various criterion measures of arithmetic namely
   a. Number concept
   b. Addition of whole numbers
   c. Subtraction of whole numbers
   d. Multiplication of whole numbers
   e. Division of whole numbers
   f. Fractions pertaining to Grades I-IV

4. To ascertain the percentage of children with hearing impairment studying in Grade-V of special schools exhibiting difficulties in various criterion measures of Mathematics namely
   a. Number concept
   b. Addition of whole numbers, fractions and decimals
   c. Subtraction of whole numbers, fractions and decimals
   d. Multiplication of whole numbers and fractions
   e. Division of whole numbers and fractions
   f. Percentage
   g. Geometry pertaining to Grade-V
5. To analyse the types of errors in mathematics committed by children with hearing impairment studying in Grade-V of special schools while attempting items relating to different criterion measures of arithmetic namely
   a. Number concept
   b. Addition of whole numbers
   c. Subtraction of whole numbers
   d. Multiplication of whole numbers
   e. Division of whole numbers
   f. Fractions pertaining to Grades I-IV

6. To analyse the types of errors in mathematics committed by children with hearing impairment studying in Grade-V of special schools while attempting items relating to different criterion measures of Mathematics namely
   a. Number concept
   b. Addition of whole numbers, fractions and decimals
   c. Subtraction of whole numbers, fractions and decimals
   d. Multiplication of whole numbers and fractions
   e. Division of whole numbers and fractions
   f. Percentage
   g. Geometry pertaining to Grade V

7. To plan out a remedial instruction programme in improving the performance of children with hearing impairment studying in Grade-V of special schools in different criterion measures of Mathematics namely
   a. Number concept
   b. Addition of whole numbers, fractions and decimals
   c. Subtraction of whole numbers, fraction and decimals
   d. Multiplication of whole numbers and fractions
   e. Division of whole numbers and fractions
   f. Percentage
   g. Geometry pertaining to Grades I-V
8. To find out the effectiveness of the remedial instruction programme in improving the performance of children with hearing impairment studying in Grade-V of special schools in different criterion measures of Mathematics namely
   a. Number concept
   b. Addition of whole numbers, fractions and decimals
   c. Subtraction of whole numbers, fraction and decimals
   d. Multiplication of whole numbers and fractions
   e. Division of whole numbers and fractions
   f. Percentage
   g. Geometry pertaining to Grades I-V

**8.4 RESEARCH QUESTIONS**

An attempt was made in this study to answer the following research questions.

1. What percentage of students with hearing impairment studying in Grade-V of special schools who are free from additional disabilities and have mathematical difficulties?

2. What kinds of errors will be committed by children with hearing impairment studying in Grade-V of special schools while attempting the items relating to different criterion measures of Mathematics namely
   a. Number concept
   b. Addition of whole numbers, fractions and decimals
   c. Subtraction of whole numbers, fraction and decimals
   d. Multiplication of whole numbers and fractions
   e. Division of whole numbers and fractions
   f. Percentage
   g. Geometry pertaining to Grades I-V
3. Whether the remedial instruction programme planned in the study will be effective in improving the performance of children with hearing impairment in different criterion measures of Mathematics namely
   a. Number concept
   b. Addition of whole numbers, fractions and decimals
   c. Subtraction of whole numbers, fraction and decimals
   d. Multiplication of whole numbers and fractions
   e. Division of whole numbers and fractions
   f. Percentage
   g. Geometry pertaining to Grades I-V

8.5 HYPOTHESES OF THE STUDY

The present study verifies the following hypotheses:
1. The remedial instruction programme developed in the study will be effective in significantly improving the performance of the experimental group in the following areas of arithmetic (Grade I-IV)
   ▶ Number concept
   ▶ Addition
   ▶ Subtraction
   ▶ Multiplication
   ▶ Division

2. The remedial instruction programme developed in the study will be effective in significantly improving the performance of the experimental group in following areas of mathematic (Grade-V)
   ▶ Number concept
   ▶ Addition of whole numbers, fractions and decimals
   ▶ Subtraction of whole numbers, fractions and decimals
   ▶ Multiplication of whole numbers, fractions and decimals
   ▶ Division of whole numbers, fractions
   ▶ Percentage
   ▶ Geometry
3. The remedial instruction programme will be effective in enabling the participants of the study in attaining mastery in the criterion measures of mathematics pertaining to Grade I-V in the following areas.

- Number concept
- Addition of whole numbers, fractions and decimals
- Subtraction of whole numbers, fractions and decimals
- Multiplication of whole numbers, fractions and decimals
- Division of whole numbers, fractions
- Percentage
- Geometry

8.6 METHODOLOGY

The methodology adapted to achieve the objectives and test the hypotheses of the study are discussed below.

8.6.1 Sample

A total number of 25 children with hearing impairment studying in Grade-V from the school which gave permission, participated in the study. These 25 children included 12 boys and 13 girls. They were all late identified and late intervened children. At the time of data collection these children were in the age group of 11-13 years.

8.6.2 Finding out the Percentage of Children with Hearing Impairment Studying in Grade-V of Special Schools who are Free from Additional Disabilities and have Mathematical Difficulties

To achieve this objective, the 25 children with hearing impairment selected from the four special schools were subjected to a set of exclusionary and inclusionary criteria to eliminate children who are free from additional disability and have mathematical difficulties. The table below gives the set of criteria based on which
children with hearing impairment were selected. The various tools and techniques employed to measure each of those criteria are also given.

**Exclusion Criteria:** Those children who have no other additional disability like emotional or behaviour disorders, ADHD, physical handicap, autism or visual problems were not included in the study.

**Inclusion Criteria**

1. Moderate to profound hearing loss
2. Should be able to communicate orally or through sign language
3. Considerable difficulty in mathematics
4. Average intelligence and above average intelligence
5. Normal in reading and writing

**Table 8.1: Criteria for selecting the children**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Inclusion Criteria for Selecting the Children</th>
<th>Technique of selecting the children</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Moderate to profound hearing loss</td>
<td>Audiological evaluation report from authorized institutes maintained in the school record</td>
</tr>
<tr>
<td>2</td>
<td>Should be able to communicate orally or through sign language/gestures</td>
<td>Observation and informal conversation</td>
</tr>
<tr>
<td>3</td>
<td>Considerable difficulty in mathematics</td>
<td>Arithmetic Diagnostic test for Grade V and Grade IV</td>
</tr>
<tr>
<td>4</td>
<td>Average and above average intelligence</td>
<td>Standard Progressive Matrices (Raven, 1983)</td>
</tr>
<tr>
<td>5</td>
<td>Normal in reading and writing</td>
<td>Help of teacher’s opinion and informal reading test</td>
</tr>
</tbody>
</table>

The various steps followed to meet each criterion are discussed in detail in Section 4.1.1 of Chapter IV.
8.6.3 Ascertaining the Percentage of Children with Hearing Impairment Studying in Grade-V of Special Schools Exhibiting Difficulties in Various Criterion Measures of Mathematics Pertaining to Grades I-V

The second objective of the study was to find out the percentage of children with hearing impairment exhibiting difficulties in various criterion measures of mathematics pertaining to Grade I-V. To achieve this objective, the performance of the final seven participants selected after employing the various exclusionary and inclusion criteria were analysed on different criterion measures of the arithmetic diagnostic test for Grades I-V and mathematic diagnostic test for Grade V.

Details regarding the analysis of difficulties is discussed in Section 3.8.1 of Chapter III.

8.6.4 To analyze the Types of Errors in Mathematics Committed by Children with Hearing Impairment Studying in Grade-V of Special Schools while Attempting Items Relating to Different Criterion Measures in Mathematics Pertaining to Grades I to V

To achieve this objective, the arithmetic diagnostic test and mathematics diagnostic test administered on the participants were analyzed for errors. Each item of the criterion measures was analyzed. Errors means when a particular pattern of mistakes were observed repeatedly. The error analysis gave a detailed picture of the nature of errors committed by the participants. The errors were classified as conceptual error and procedural error. Conceptual errors were those wherein the concept was not present at all and hence the errors were committed. In procedural error, the concept was developed, however errors were committed while carrying out the procedure. Like adding instead of subtracting, forgetting to add the carried over number.

More details regarding the analysis of data at the error analysis phase is discussed in Section 3.8.2 of Chapter III.
8.6.5 Development of Remedial Instruction Programme for Children with Hearing Impairment

The main purpose of this study was to develop a remedial instruction programme for children with hearing impairment. This phase involved two stages:

1. Preparation of the remedial instruction programme
2. Evaluation of the remedial instruction programme

8.6.5.1 Preparation of the Remedial Instruction Programme

A remedial instruction programme was developed based on the difficulties exhibited and the errors committed by the participants in the criterion measures of the diagnostic tests. The programme was developed based on the principles of teaching mathematics to CWHI suggested and tested by various researchers and authors. The main principles, features and strategies used and the outline of the procedure of administration of the programme are given in Chapter VII.

8.6.5.2 Evaluation of the Remedial Instruction Programme

In order to meet the objective of finding out the effectiveness of the remedial instruction programme an experiment was conducted on the seven children with hearing impairment. These seven children were quite heterogeneous in nature, in terms of their degree of hearing loss, intellectual level and the grades at which they performed in the diagnostic test. They were the true representative of the CWHI.

Arithmetic Diagnostic Test (Ramaa, 1994, 2015) and Mathematic Diagnostic Test developed by the investigator which were used to identify difficulties in criterion measures and at the error analysis stage served as the pre-test.

To find out the effectiveness of the independent variable, that is the remedial instruction programme of arithmetic, the data was analyzed both qualitatively and quantitatively. For quantitative analysis, the mean performances of the participants
were compared in pre-test and post-test, followed by subjecting the data to Wilcoxin’s Signed Rank Test. Wilcoxin’s Signed Rank Test is a non-parametric equivalent of paired t-test.

The above test is applied when:

- The sample size is small
- Since the Standard Deviation was more in concepts like multiplication and division.

Qualitative analysis was also done with respect to pre-test-post-test performance. The total number of participants in terms of percentage who attained mastery, partial achievers and non-masters were calculated. Thus both qualitative and quantitative analysis was done. The results are discussed in Chapter VII.

8.7 MAJOR FINDINGS AND THEIR INTERPRETATION

The data was analysed at the difficulty level, error analysis stage and at the remedial stage. The detailed findings are discussed in Chapters V, VI and VII respectively. Here is a brief account of the findings and their interpretations are given:

1. Out of the 25 children with hearing impairment selected from the four schools in Mysore, seven children with hearing impairment got selected for the final study based on the criteria of average intelligence and above average intelligence and their performance in the ADT.

2. The selected seven children with hearing impairment had difficulty in number concept, addition, subtraction, multiplication, division, fractions, decimals, Geometry and Percentage.

3. In number concept, difficulty in reading/writing the numbers (upto 4 digits) and task related to reading and writing the fractions and mixed fractions were difficult as none of them had attained mastery in the above criterion measures for grade I.
to IV. It was also observed that the participants faced difficulty in tasks requiring them to comprehend difficult verbal instructions like pertaining diagnostic test to grade V.

4. The concept of lesser than the greater than was also found to be difficult for participants as only one participant (14.28%) attained mastery whereas the remaining six participants one i.e. 14.28% were partial achievers and the remaining five (71.4%) fell into the category of non-masters.

5. The above identified difficulties like reading/writing the numbers upto four digits and reading/writing of fractions required linguistic skill. Since these children have linguistic difficulty, they exhibited difficulties in language based tasks also.

6. In addition, the participants exhibited difficulty in criterion measures involving addition of fractions, task in there are two or more task like adding the numbers and arranging them in ascending order.

7. It was also clearly noticed that word problems involving spatial, verbal and numerical relations was not attempted by any of the participants. In Grade-V, the participants faced difficulty in addition of five digit numbers.

8. In subtraction, the numbers of criterion measures were also more as compared to addition. It included criterion measures pertaining to checking the equality and inequality, problem solving involving addition and subtraction. Most of the participants did not attain mastery in these two criterion measures.

9. Word problems involving visual, numerical relations and spatial, verbal numerical relations were not mastered by most of the participants except two (28%) participants who attained mastery in the visual-numerical relation problems. Similarly, problem solving involving numerical relations was mastered by only one (14.28%) participant. Four (57.12%) participants were partial achievers and
the remaining two were non-masters. For Grade-V, more difficulty was observed in four digit and especially in five digit subtraction problems involving transfers.

10. Multiplication and division was found to be the most difficult concept among all the other concepts discussed earlier. It is quite evident from the performance of the participants in all the criterion measures of multiplication and division that none of them attained mastery or were partial achievers in almost all the criterion measures of multiplication and division. The same trend was also observed for the criterion measures of multiplication and division of Grade V. The difficulties in multiplication and division were observed for 2 digit, 3 digit, 4 digit and 5 digit problems.

11. The participants exhibited difficulty in criterion measures involving computational skills as well as word problems in both multiplication and division.

12. However, it was observed by the investigator that the mathematic operations exclusively of Grade- V were not attempted by any of the participants. The probable reason for the non-mastery could be due to the fact that none of the above mentioned mathematic processes, might not have been taught them due to the difficulty level.

13. Following errors were noticed among children with hearing impairment in the area of number concept.
   a. Reading/Writing digit wise.
   b. Writing the number as it is said and omits a digit while reading/writing.
   c. Writing lesser than numbers in phase of greater than numbers.
   d. Few tasks like reading or changing the numbers to the nearer thousand place was not attempted by all by any of the participants.
The probable reasons for the errors noticed in the number concept could be due to:

a. Lack of concept of place value
b. Lack of concept of greater than number
c. Difficulty in following instructions.

14. The following errors were noticed among CWHI in the area of addition.

   a. In fractions, adding the numerator and denominator.
   b. Forgetting to add the carryover number.
   c. In statement problems, adding all the digits without reading the statement which required them to add few digits and then subtract.
   d. Does not perform for more than 5 digits.

15. The errors were due to lack of concept of fractions, language based word problems, wherein the participants did not read and comprehend as to what was expected out of them, they assumed that when numbers are given in a word problem, they have to add all the numbers, even though few word problems will require them to add and then subtract or multiply and then add.

   a. The important errors noticed while doing subtraction items are as follows:
   b. Not borrowing digit from hundreds place to tens place
   c. Subtracting lower bigger digit with upper smaller digit
   d. Conceptual error; Subtracting whole number but not fractions
   e. Adding all the digits in the statement problem instead of subtracting
   f. Forgetting to borrow.
16. Subtraction is an activity involving borrowing which requires the understanding of place value and a good processing memory. The errors identified in subtraction sums involving borrowing digits from the higher place. The errors could be due to poor working memory.

   a. The following errors were noticed among CWHI in the area of multiplication.

   b. No concept of multiplying a digit with ‘0’

   c. Carried out addition instead of multiplication

   d. In tasks involving, multiple operation, carried out only addition and no multiplication

17. The performance of the participants in multiplication related task was difficult as many children did not attempt them. However, among those children who attempted the task had also done it incompletely resulting in errors like carrying out addition in place of multiplication, wrong tables and omitting sums having more than three digits and tasks having multiple operation, only addition was carried out. It could also be observed that in verbal and numerical relation word problems, 71.4% did not attempt the task and the remaining 28.56% of the participants attempted but carried out addition in place of multiplication. This means that, for most errors, students had either not been able to understand the word problems or, if understanding had been present; they had not devised appropriate strategies for solving the given problems.

18. The following errors were noticed among CWHI in the area of division.

   a. Not attempting the tasks.

   b. The other error observed was that the participants stopped performing a task after a particular step when the numbers of steps were more.
19. For children to succeed in mathematics, a number of brain functions need to work together. Children must be able to use memory to recall rules and formulas and recognize patterns; use language to understand vocabulary, instructions, and explain their thinking; and use sequential ordering to solve multi-step problems and use procedures. Higher-order cognition helps children to review alternative strategies while solving problems, to monitor their thinking, to assess the reasonableness of their answers, and to transfer and apply learned skills to new problems.

20. Decimal (Addition and Subtraction): The errors committed for decimals were due to lack of knowledge of decimal as well as poor working memory. Word based problems were not attempted by the participants. Children with hearing impairment face problem in understanding rational number because of mismatch between the student’s ideas of particular words and the intended meanings of words have created confusion.

21. Criterion measures pertaining mathematical process like fractions (addition, subtraction, multiplication and division), geometry and percentage was not attempted by the participants and hence error analysis was not done.

22. All the children showed better performance after remediation in all the areas of mathematics processes like number concept, addition, subtraction, multiplication, division, fractions, decimals, percentage and geometry.

23. The participants attained mastery in all the criterion measures of the mathematics processes after the remedial instruction programme.

24. However, difficulties were still observed in few criterion measures pertaining to Reading the Fractions (limited to $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$) and mixed fractions involving these
fractions as 28.56% participants attained mastery and 57.12% were non-masters and 14.28% partial achievers.

25. In addition, criterion measure ‘addition of fractions’, difficulty still persisted, as only 28.56% participants attained mastery and the remaining 71.4% were partial achievers.

26. No mastery was seen in criterion measure pertaining to ‘Problem-solving involving spatial and verbal and numerical relations (S-V-N-R).

27. Similar trend was observed for subtraction also.

28. In multiplication and division also, language based criterion measures were still difficult even after the remedial programme.

29. The remedial instruction programme based on the suggested principles, strategies and approaches has significantly improved the performance in all areas of mathematics.

30. After the remedial instruction programme, the participants were brought upto Grade-V level.

31. The major finding which could be inferred from the individual performance of the participants were language is a major problem for children with hearing impairment, which was very well highlighted in the present study which showed that those criterion measures which were exclusively language based like word-based problems and fraction related tasks difficult even after the remedial instruction programme.

32. It cannot be concluded that a single participant had difficulty in mathematics, the performance was quite heterogeneous.

33. 100% mastery was observed for concepts and processes of Grade-V after the remedial instruction programme.
34. For Grade I-IV, 100% mastery was not observed for any of the concept or process, only 75% mastery was attained overall. However, if the performance is observed in individual criterion measures, the participants were masters for those criterion measures which were had very less language component in it. But as mentioned above language based criterion measures sill showed problem even after the remedial instructional material.

As the name of the tests suggest diagnostic test, these tests really helped in identifying the strengths and weaknesses of the participants. The results from the present study also showed that, in hearing impairment, language is a major problem. Those skills and task which were exclusively number based were mastered by children with hearing impairment (participants) after the remedial instruction programme, however, those tasks which had language base still remained a problem. This does not indicate that the remedial programme was not effective, it highlights the need for more attention from the part of the teacher and effort from the policy makers to modify the existing curriculum and making it more student friendly. This study clearly shows that if the evaluation system for mathematics is more number and computation based rather than including the language aspect, then all children with hearing impairment can perform well in mathematics. Other point which should be highlighted here is that, whenever a remedial programme is being planned, the learning needs of the children, their style of learning should be kept in mind thus meeting their individual needs, which was done in the present study.

Thus, we can conclude that if curricular materials are clearly designed and if effective instruction is provided, will help children to succeed in mathematics. Children with hearing impairment has difficulty in language, which is quite evident from their performance in criterion measure pertaining to numerical-verbal relations.
and fractions as most of the participants still were non-masters as well as their overall performance in all the mathematical processes. This difficulty in word problem could be due to lack of mathematics vocabulary and lack of input in their every day learning. As Witzel, Ferguson and Brown (2007) report that an understanding of word problems begins with building mathematics vocabulary. Mathematics vocabulary is often considered as a separate language and is treated much like any foreign language. However, this should not be case, it is discussed that mathematics terminology and language should be used in every day language from early childhood ages and not just while teaching mathematics.

8.8 EDUCATIONAL IMPLICATIONS

1. Children with hearing impairment drop out of school because of their inability to cope with the burden of language based curriculum, hence identifying the children’s problem at the root level and correcting it would be ideal.

2. The study clearly showed that the grade level discrepancy is more when not identified and. Hence, early identification and intervention should be provided.

3. The remedial arithmetic programme though developed for children with hearing impairment can be used for other children who have difficulties in arithmetic for various other reasons.

4. Since the effectiveness of the remedial instruction programme was observed, it is suggested that, the teachers and parents should make use of the remedial instruction programme developed in the study in remediating the specific difficulties faced by children.

5. Since arithmetic is not language bound, the same programme can be made use of anywhere for any language and culture with suitable modifications.
6. A model for qualitatively identifying the difficulties and errors committed by children was developed which will help the teachers to rectify the errors committed by the students in mathematics and plan their lessons/teaching to overcome the problem, instead of teaching the entire content.

7. Usually teachers fail to teach a concept to children with hearing impairment because of their lack of teaching learning material, or their inability to concretize abstract concept. The study provides ways of making and teaching concepts with the available materials and without the use of exclusive teaching learning material and simple techniques.

8. The strategies and the features of the remedial programme could be used for simplifying the teaching and adapting the content without omitting and deleting the content.

9. Teachers usually skip teaching a concept due to its level of difficulty. The present study has provided strategies for adapting the content, thus helping the teachers not delete the content, but simplify and modify the content.

8.9 SUGGESTIONS FOR FURTHER STUDY

1. Similar studies can be conducted/extended to beyond Grade-V.

2. The remedial arithmetic programme can be tried out on other children with below average intelligence and slow learners.

3. Those criterion measures which were not mastered by the participants like word based problems; fractions could be taken up as separate studies.

4. Follow-up studies should be carried out to test retention of concepts, procedures and skills learnt during the remedial classes.

5. Those mathematical processes not taught in the present study like average, simple interest, time, sets can be taken up as a separate study.