CHAPTER – I

INTRODUCTION

1.0 NEED FOR LEARNING MATHEMATICS

According to the Right to Education Act (2009) and Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act 1995 ‘Every child has a right to free and compulsory education in an appropriate environment till completion of elementary education’. These acts have given opportunities for children with special needs an access to education. As per the law they are also to be treated alike like any other normal child studying in the school and are also expected to study the same curriculum like the normal child. Hence, it becomes mandatory for the children with special needs to learn mathematics also. Even though children with special needs have language exemption, they do not receive exemption from learning mathematics till Grade X, and hence it is mandatory for them to learn, understand and like mathematics. According to National Curriculum Framework (2005), Mathematics curriculum has an important role to play in school owing to ‘Universalization of Schooling’, which states that every child should have access to quality mathematics education as mathematics being a compulsory subject of study in school. The framework further emphasises on mathematics education being affordable and enjoyable to every child. The two principles underlying excellent mathematical education is that mathematics could be learnt by all students and that there is a need for all students to learn mathematics. Hence, every child receives mathematics education of highest quality.
1.1 IMPORTANCE OF MATHEMATICS

Maths is a numerical and symbolic language that helps to study the relations between quantities. The fundamental reason of learning mathematics is to understand and become part of the technologically oriented world. Knowledge of mathematics, is essential in every aspect of our life. We need mathematics, to calculate our daily living expenses and the time spent on a particular activity. A man without a sound knowledge of numbers, money and time will face difficulty in many aspects of his life. The subject has found its application in the field of science, technology, economics and other array of life. But for a common man, knowledge of mathematics helps him understand the functioning of the world around him.

The knowledge of mathematics helps in the following i.e. fulfilling personal goals, being an active and contributing member of the society and employability in modern society. This competence in mathematics has to be developed from a very young age like reading which has to begin early in life. Similarly an early learning and understanding of mathematics can help children develop likingness for the subject later in life. Having a strong mathematical foundation can help in developing logical thinking and thus helping in solving real-life problems. Learning Mathematics will help children to reason, to connect ideas logically. It utilizes a universal language that is understood and shared all over the world.

According to Harniss, Carnine, Silbert and Dixon (2002) the goals of instruction in mathematics as stated by National Council of Teachers of Mathematics which states that students should learn to value mathematics, become confident in their ability to do mathematics, become mathematical problem solvers, learn to communicate mathematically and learn to reason mathematically. After learning
mathematics, students should be able to value it, solve it confidently and reason out mathematically.

Thus learning mathematics, equips a child to get higher level careers as well as they learn to solve real life problems too. To achieve the goals of higher level careers as well as solving real life problems, a high quality school mathematics program is essential.

According to Principles and Standards for School Mathematics by NCTM (2000) “A high quality school mathematics programme should encompass common foundation of mathematics to be learned by all students”.

NCTM further emphasised the need for teachers who are well prepared, who has the support of good administrators, thus the teachers and administrators in turn should acknowledge the importance of carefully organized system for assessing the student’s learning and effectiveness of the programme. The principle and standards also lay importance on building a high quality programme for students.

The principles on which the school mathematics should be based are as follows.

1.1.1 Equity

Here equity does not mean every student is receiving identical instruction. In this context, equity means regardless of the personal characteristics, backgrounds or physical challenges, all students can learn mathematics when they have access to high quality mathematics instruction. It further recommends that the content should be challenging and promote access and attainment for all students.

1.1.2 Curriculum

The Mathematics curriculum should be coherent, i.e. it should not be just collection of activities but the mathematical ideas should be linked and build on one
another. This linkage is important as it will deepen the student’s understanding and knowledge as well as their ability to apply mathematics expands. An effective mathematics curriculum should focus on preparing students for continued study and for solving problems in a variety of school, home and work settings.

1.1.3 Teaching

Mathematics learning will become more interesting if the teacher has taught in an interesting manner. The teaching-learning becomes more effective when the teacher understands the needs of the learner. A good teacher will shape the students’ mathematical understanding and motivates them to do maths. An in-depth knowledge and good content understanding is a must for good teachers. This will bring about flexibility in their teaching. Ample opportunities and resources to enhance their knowledge should be given.

1.1.4 Learning

Conceptual understanding is an important aspect in learning mathematics. Students should be actively involved in learning mathematics by understanding each aspect of it. Learning of new concept should occur from experience and previous knowledge. A student can become an effective learner by aligning factual knowledge with conceptual knowledge and procedural proficiency. Reflective thinking and learning from mistakes should be encouraged among students. A challenging task will develop competence and confidence in the children, thus enabling them to tackle difficult problems and challenges.

1.1.5 Assessment

Mathematics instruction is incomplete without assessment which is an integral part of students learning process. It plays the role of informing and guiding teachers in their instructional decisions. The type of assessment task selected by the teachers
conveys the students the kind of knowledge and performance that is valued’. Feedback from assessment tasks helps students in setting goals, assuming responsibility for their own learning and becoming more independent learners. A good assessment task includes feedback which helps in setting goals for further learning, taking the responsibility of self-learning thus becoming independent learners.

Sood and Mackey (2014) confirms having a strong number sense and the quantity it represents, it important as it makes an integral part of all areas of life thus affecting successful functioning on the job, in school, at home and in the community.

Thus it could be concluded that mathematics teaching and learning should be given equal importance early in life, so as to bring about success later in life. Mathematics teaching is based on theories of learning mathematics, which is discussed in the section below.

1.2 THEORIES OF LEARNING MATHEMATICS

The learning process is not easy to understand, it is amusing, fascinating and a mystery. Researchers/Psychologists have been investigating for centuries to understand how learning takes place in human being. Numerous theories have been emerged which describes the process of learning in children. The theories about learning have been classified in various ways (Pa, 1986).

These theories have not only focused on how learning takes place, but have a significant bearing on how mathematics is learnt. One of the theories in the late 19th century named the mental discipline described the mind as a kind of muscle that required a reasonable amount of exercise to keep it properly tuned. The complexity of the computation problems in mathematics served as a major form of exercise.
However, further more theories on the learning of mathematics emerged, these theories fell into two general categories namely the behaviourist theory and the cognitive or constructivist approaches.

Both the theories are discussed in detail below.

1.2.1 The Behaviourist Approach

The mental discipline theory which came up in late 19th century did not put much light into the learning of mathematics. Another theory emerged at the beginning of the 20th century which emphasized on curriculum and instruction. The curriculum and instruction procedure in schools largely followed the new theory which was highly influenced by the behavioural psychology. This theory was given by E.L. Thorndike (1922) which is based on the theory of Stimulus-Response. The theory of mental discipline was gradually replaced by Stimulus-Response Theory. According to the S.R. Theory which stated that learning occurred when a ‘bond’ was established between some stimulus and the person’s response to it. This theory emphasized more on the drill component. In the instructional process, when a correct response is given to a particular stimulus, the bond becomes more established. Programmed Instruction is the outcome of this theory.

The behaviourist theory was followed by Gagne’s theory on intelligence and conditions of learning. In the 1960s, Robert Gagne’ a neo-behaviourist worked on intelligence and conditions of learning. He stated that learning takes place, based on the principles of pre-requisite learning. The simplest of these situations is stimulus response. The learning situation follows an order like the verbal sequence, multiple discriminations, concept learning, principle learning and at the highest level is problem solving (Gagne, 1985).
His contribution towards curriculum development cannot be ignored, as his one of the contributions in curriculum development lays on analyzing the structure of a task or concept to be learned.

Thus, the behaviourist’s theory based on the stimulus response principle by B.F. Skinner and the Gagne’s theory on pre-requisites largely paid attention to the concept of learning takes place under a stimulus – response condition and however, there were another school of thought which gave more insight into the learning of mathematics.

1.2.2 The Cognitive/Constructivist Approach

According the constructivist approach, individuals actively construct their own knowledge and do not depend on outside source to passively receive it, and that they organize their own world and the discovery of some independent, pre-existing world outside the mind of the individual does not lead to learning.

Based on the above two hypotheses, mathematics teaching and learning has been influenced. The behaviourist and constructivist views of learning are different with respect to the source of knowledge and acquisition of knowledge. The behaviourist theory believed that the child is a passive recipient and the teacher who is also the curriculum designer is the source of knowledge and their main task is to transmit knowledge to the child. On the other hand, the constructivist believes the child constructs his/her own knowledge, i.e. mathematical knowledge emerges. The two significant implications based on the constructivist theory for teaching mathematics according to (Kamii, 1990) should be focussed on writing correct answers, and the other point is encouraging children to discuss; disagree among themselves rather than concentrating on getting the right answers and correcting wrong ones. The teacher’s role is that of a facilitator, structuring appropriate
experiences thus actively engaging the children in meaningful learning. Furthermore, the constructivist theory emphasized more on the role of the teacher, wherein the environment for learning is set by the teacher, and thereby sparking children’s interest and opening areas of study. However, the responsibility of learning is that of the child. Thus constructivist approach provides the child with utmost autonomy in the class.

1.3 EDUCATIONAL IMPLICATION OF JEAN PIaget’S THEORY

According to Piaget, in the concrete operation stage is when most children enter the elementary grades. Thus at the stage of elementary school learning takes place by manipulating materials and observing the surrounding. The teacher’s role is that of providing concrete and appropriate experience that facilitates learning. At the middle school stage, the children require concrete representations and not ready for formal learning. He further suggested that children should be given opportunities for exploring ideas. In mathematics learning, this is most effectively done with the aid of concrete manipulative materials. Furthermore, according to Piaget, the process of adaptation should be viewed as a part of intellectual growth.

Thus the concept of including manipulative materials while teaching mathematics was taken from Piaget’s theory of concrete operational stage.

1.4 STAGES OF DEVELOPMENT

According to Piaget (1958), when a child develops or constructs a mental model of the world, it is a part of his cognitive development. According to him, the stages of development are universal i.e. the same sequence of development occurs in children all over the world.
Stages of Development

a. Sensorimotor (0-2 Years)

b. Preoperational (2-7 Years)

c. Concrete Operation (7-11 Years)

d. Formal Operational (11 Years+)

These stages of development have an impact on the educational development of the children. The educational implications of the Piaget’s theory are discussed below.

1.5 EDUCATIONAL IMPLICATIONS

Many of our educational policy and teaching is highly influenced by Piaget’s Theory. Piaget’s theory laid emphasis on readiness i.e. biological maturation and notion of readiness. Readiness means when a child is ready to accept information or concepts taught to him. Piaget’s theory emphasised that cognitive development is essential to learn certain concepts. According to him, learners should play an active role in the learning process. Children should discover the problem solving skills rather than teaching it.

Thus the theories of learning focused on how learning takes place but also laid emphasis on how mathematics is learnt. Mathematics teaching and learning follows a particular principle which is discussed as follows.

1.6 BASIC PRINCIPLES OF LEARNING MATHEMATICS

The principles of learning mathematics were derived from Piaget’s work. The following six guidelines can be considered while teaching – learning mathematics.
1.6.1 Begin with Concrete Representation

Mathematical concepts are learnt better with concrete representation. The best possible way to provide concrete representation is through multiple embodiments. Using manipulative materials in all mathematics classrooms is a way of providing multiple embodiments. Manipulative helps in abstracting the essence of the concept as well as to lend variety to the mathematics program. However, manipulative should be such that it supports the lessons’ objectives, children should get an orientation to the use of manipulative, children should actively participate in the lessons and lessons taught should provide for an opportunity for developing reasoning skills. Clements and McMillen (1996), states that mathematics teaching could be taught not only through the use of concrete manipulative, but also through the use of mental images and computer images.

1.6.2 Develop Understanding

Mathematics is a subject which becomes interesting to learn. The essence of teaching mathematics lies in those activities and experiences which are well planned and structured that will enable the student’s to build understanding of the subject. Understanding of mathematical concept is not restricted to straight recall or recognition. But if a concept is understood properly, the children can exhibit understanding through atleast four higher level cognitive processes. These processes are application, noting relationships, transformation and transfer. The explanation for each is given below.

Application involves using concepts wherein the children can identify and state relationships among concepts, they are likely to have a meaningful understanding of those concepts. For example, being able to relate multiplication to addition is one example of this level of understanding.
Transformation involves taking a problem or idea in one form and representing it in another form. Restating ideas in other words, constructing a graph, and drawing a diagram to illustrate a concept are examples of transformation. Transfer involves using an idea or concept in a context different from that in which it was learned.

All these cognitive processes help in learning mathematics. Even though cognitive processes are important, the understanding of mathematics develops by carefully selecting modes of representation (Behr, Lesh, Post, & Silver, 1983). The five modes of representation are real–world situations, manipulative models, pictures, oral language and written symbols. A child learns mathematics in the following ways: building relationship by representing it through spoken language, representing and manipulating it with blocks (concrete objects) and then writes a response on paper (written symbol). Hiebert (1990) states that in mathematics meaning or understanding comes from building or recognizing relationships either between representation or within representations.

Van de Walle (1994), points out that a child develops understanding when connections are formed between procedural knowledge and conceptual knowledge. Procedural knowledge is a symbolic knowledge used to represent mathematical task. Conceptual knowledge connects a number of mathematical ideas or concepts. Thus performing mathematical activities require understanding of prerequisite concepts. Understanding of a new concept requires certain pre-requisites. When children possess this pre-requisite concept mathematics learning becomes easy rather than superficially understanding or learning concepts by rote.

Another principle which is considered important is the communication.
1.6.3 Encourage Communication

Communication which involves the reception and expression of information not only plays an important role in our daily living, but in our mathematics learning also. A more refined understanding of a concept is possible through a good communication in mathematical terms; communication involves interactive conversations as they work through mathematical processes. A mathematical communication in a classroom takes place in the form of oral or written, it could be a port, a story or a word problem for other children to solve. Communication should be an integral part of mathematics classrooms as it provides the teachers with an insight into the children’s understanding thus helping the teacher for further instructions.

1.6.4 Make Connections

A meaningful learning is always useful as it helps to build connections between mathematical ideas and other topics. A thematic approach is one which addresses not only basic skills but also more open ended and higher level objectives. Experiences provided while learning will encourage children to look for other connections in the world around them.

1.6.5 Take time to motivate children

According to Holmes (1990), Motivation plays an important role in learning. A motivated child will attend to instruction, understand the meaning, stayed persevered when difficulties arise. This holds true for mathematics learning also. Even though teachers might be competent, instructional models might be effective and the activities thought provoking, but above all, the motivation for learning mathematics is important. Motivation plays an important role in the process of learning. A motivated child will give his attention, time, energy and perseverance to
learning. Motivation is an internal component which differs from child to child. But it could be developed externally with the help of the teacher. When the concepts that are learnt by the children are meaningful, they experience satisfaction, success and recognition in their learning process. Communication and meaningful opportunities for students to engage in mathematics is also important. Conversations about real world problem can be motivating in addition to enhancing children’s understanding of mathematic concept. Variety in activities while learning mathematics keeps the children motivated. Thus the factors contributing to develop mathematical understanding are internal interest and motivation.

1.6.6 Provide Opportunities for Practice

Practice helps in making a routine procedure regular, even though children understand mathematics in a meaningful situation, once understood, they construct their own mathematical knowledge, but the need for practice cannot be ruled out. For overcoming the problem of dullness and boredom during practice sessions, games, puzzles, riddles, little surprises, novel algorithms, novel formulas, calculators and computers are all useful ways of providing practice. Along with the above, flash cards and other traditional means could be used. The purpose of providing practice is to promote thinking versus rote memorization. Thus, teaching and learning mathematics can become more interesting and challenging if the principles of mathematics are applied in the daily mathematical class.

1.7 DEVELOPING MATH CONCEPTS IN PRE–KINDERGARTEN CHILDREN

Mathematics learning is an active endeavour. Children learn mathematics better when they investigate, compare, wonder and check to see what happens. Mathematics is not about rote–learning, it is about experiencing and children should
be given the opportunity to think about what they are experiencing while learning. Usually, children learn mathematical ideas when they make connections or see relationships. They should learn to think, listen and pay attention to what other people have to say. Number concept is not learnt on its own; the children need to observe, make recordings of their experiences. Play is an important aspect in learning new things and new ideas. Same holds true for mathematics also; wherein new mathematical ideas will arise out of children’s play. Haynes (1999) states concept learning should be learnt and taught in such a way that children should develop the ability to think mathematically and the new experiences which they have learnt should allow them to refine their existing knowledge and ideas in constructing new knowledge.

Children get their first mathematical experiences through their play and interest. The experiences gained by the children during their play become the base for learning mathematics. A preschooler does not learn mathematics when confined to the four walls of the pre-school; rather learns it through his own self-directed intrinsically motivated activity through the use of natural language.

National Council of Teachers for Mathematics (NCTM) (2000), outlines that as children progress through school, they should have the ability to identify both content and process standards.

There are five areas in the content standards as given by NCTM. They are namely number and operations, algebra, geometry, measurement and data analysis and probability. Similarly for process standards the areas are problem solving, reasoning and proof communication, connections and representations. The NCTM standards show that children can appreciate the world around them and enrich their experience through mathematics.
The following paragraph highlights the components of mathematics; what the children are expected to know and how they learn mathematics that is important to them.

1.8 LEARNING OF NUMBER CONCEPTS

According to NCTM, in Pre-kindergarten through grade 2, students learn counting by standing and recognizing ‘how many’ in sets of objects. They should be able to connect words and symbols to the quantities they represent.

The understanding of number concept is beyond rote counting and numeral recognition. A sense of quantity is the most important number concept that has to be developed in pre-kindergarten. A child when uses counting to find out how many, then only we can say learning has occurred. The number concept should be developed in such away that children should believe that numbers make sense and to be confident about their own abilities to deal with them.

The child should be able to develop true understanding of number out of his own experience and reflections of those experience. Opportunities should be provided to children to look and to think, they must be encouraged to figure things out for themselves. The following are the basic concepts that children are expected to meet so as to make sense of the numbers.

1.8.1 Quantification

Quantification is a concept wherein the children need to understand that the number word they say includes all the objects previously counted.

1.8.2 One-to-One Correspondence

One-to-one correspondence is a concept wherein the children should understand that when they count any object (Physically or mentally) once and only once.
1.8.3 Conservation of Numbers

The ability to conserve number quantities under varies configuration marks a certain maturity. According to Piaget, the age of 6-7 years is the time, when a child is successful at number conservation tasks, but not all children attain the capability at that age. A teacher should become knowledgeable of children’s conservative abilities so that children are not expected to complete number exercises beyond their cognitive level. (Maschand, Bye, Harrison & Schroeder, 1985)

1.8.4 Relationship between Numbers

It is a pre-requisite in learning number concept. The relationship between numbers is a concept where in children should know that what happens when one is added to a set of objects. They should have an idea that even if numbers are reorganized in different ways, the quantity stays the same. Ex. 4 and 2 is equivalent to 1 and 5 or even 2 and 4.

1.8.5 Symbolization

Children should learn to associate symbols with the quantities they represent. Children should know the importance of symbolization as useful tools for writing down information. E.g. for children the number ‘3’ is a symbol on paper. They should understand that it represents something else. It is important to help them associate symbols with the quantities they represent. The most important thing about symbolization is children should see numerals as an informative tool.

Thus the above mentioned concepts are essential to make sense of numbers. However, all these require a good language base for understanding and learning mathematics. A hearing child will pick up much information from incidental learning and from his/her surrounding environment, but a hearing impaired child will miss out on all these information. As Flexer (1999) notes since children with hearing
impairment have problem with their listening skills, they have a limited range or
distance of hearing and due to this, they may not learn many concepts and skills
incidentally like normal children, they need to be taught directly. Since language
becomes a base for all the learning which takes place, children with hearing
impairment faces many problems which is discussed in the following sections.

1.9 MODELS FOR TEACHING MATHEMATICS

A teacher using a constructivist theory of learning is likely to use a
developmental model of teaching wherein the children will actively engage in inquiry
and investigations.

Riedesel (1990) identifies four aspects in which the “developmental” approach
is different from the “telling” approach. The features of developmental approach are
as follows:
1. The developmental approach emphasizes on active learning wherein the learners
   are actively participating as opposed to waiting for the teacher to explain and take
   the forefront.
2. In developmental approach experience plays an important role. Therefore it is
   socially relevant. It is independent of teacher or a textbook as new knowledge is
   built on it.
3. In developmental approach the classroom is child-centred as the stress is on
   children’s thinking.
4. The developmental approach emphasizes a “search for relationships and patterns
   and leads to an understanding of a mathematical structure”.

In diagnostic model, the children’s current level of mathematical
understanding is assessed. This knowledge is then used as a base for further learning
and activities that will help the child build on to existing mathematical knowledge.
A diagnostic model developed by Ashblock, Johnson, Wilson and Jones (1983) suggested a sequence of five types of lessons arising from a diagnostic core.

1. Initiating – Experience about the concept to be learnt is provided
2. Abstracting – focuses on the attributes of the new concept
3. Schematizing – The interrelationships between the new concept and previously learned concepts is focussed upon
4. Consolidating – provides practice to sharpen and clarify the new concept.
5. Transferring – problem-solving activities that show application of the new concept to new settings.

In the investigative model, the emphasize is on experimentation and inquiry. Mathematical knowledge is built upon by children when they explore and experiment ideas with processes or data.

These models of teaching mathematics are not exclusive. A good teacher adapts a model based on his or her physical setting, the nature of the children and their individual differences, the mathematical topic and his or her philosophy of teaching.

**1.10 EDUCATIONAL ACHIEVEMENT OF CHILDREN WITH HEARING IMPAIRMENT**

Since speech and language is affected in children with hearing impairment, it has an impact on the education of these children also. There is a significant delay in the educational achievement of children with hearing impairment as compared to their hearing peers. Our education system is exclusively language based which is primarily dependent on spoken word and written language which is difficult for children with hearing impairment (Paul & Quigley, 1990) reports that low achievement is a characteristic of deaf students. On an average they are three to four years below their
actual grade. Children with mild to moderate hearing loss achieve below expectations based on their performance on test of cognitive ability (Greenber & Kushe, 1989; as cited in Gargiulo, R., 2003).

Traxler (2000) reports that when an average student who is hearing impaired leaves high school in the USA; the reading age of the child at the time of leaving the school is at Grade level four.

Overall individuals who are hearing impaired read at a third to fourth grade level (Holt, 1993). Not only reading is affected in children with hearing impairment, mathematics is also affected as, mathematics is not only number based, but for understanding of mathematics a sound language base is equally essential. The problems face by children with hearing impairment in mathematics is discussed in the following section.

1.11 PROBLEMS OF CHILDREN WITH HEARING IMPAIRMENT IN MATHEMATICS

A good communication skill is essential to develop mathematical processes like problem-solving, developing logical reasoning and communicating the mathematical ideas. Hearing children pick up much of the information incidentally and from their surroundings. To develop proficiency in mathematics, language is important; children should have adequate language that allows them to participate not only during mathematics instruction but also engage themselves in the outside world quantitatively. As it is rightly put that, “learning and doing mathematics are steeped in oral and written language much like reading” (Adams, 2003; Adams & Lowery, 2007; Schleppegrell, 2007).

Comprehending verbal and written mathematical problems; is the most difficult task for children with hearing impairment. Pau (1995), states that for solving written problems correctly, deaf/hearing-impaired children should correctly interpret
the words given in the problem’s text. In terms of verbal problems; deaf/hearing-impaired children simplify it by converting it into understandable linguistic forms. Furthermore researchers like Jordan and Levine (2009), Jordan, Mulhern and Wylie (2009), Locuniak and Jordan (2008), have observed that children encounter more difficulty with language based mathematical tasks (e.g. number facts, word problems) than with those tasks with fewer language demands (e.g. nonverbal calculation, number sense). Thus these findings suggest that there is an inextricable link between linguistic skills and mathematical performance.

The challenges encountered by deaf/hearing impaired children when learning mathematics are many and severe. There are many barriers for these children to learn mathematics. They encountered difficulty in problem-solving due to weak language base. A strong base is necessary for putting observations into words. Deaf/hearing impaired children are isolated in the learning environment thus leading to their inability to participate fully in mathematical activities and discussions. Review of literature between 1980 and 2000 indicates that children with hearing impairment (CWHI) lag behind their hearing peers in mathematics achievement tests (Swanwick, Oddy & Roper, 2005). Children usually find it difficult to comprehend concepts as the level of difficulty increases, among the operations division is the most difficult of the four fundamental operations (Gowramma, 2005).

Furthermore, these problems will lead to errors in mathematics and how to analyse the errors which is discussed in the section given below.

1.12 ERRORS MADE BY CHILDREN WITH HEARING IMPAIRMENT IN MATHEMATICS

Children tend to make mistakes while learning which should be considered as a process of learning. However, if the same mistake is repeated and a particular
pattern is observed in the mistake, then the teacher need to pay attention to the type of mistake made by the child. Mathematical errors may arise due to variety of reasons. These reasons could be the pace of work, slipping of a pen from the student’s hand, lapse of attention, lack of knowledge or a misunderstanding. Student errors and incorrect responses are the result of students “partial understanding” (Saxe et al., 2010) or correct answers to slightly different questions (Wells & Coffey, 2005). Some of these errors could be predicted prior to a lesson and tackled at the planning stage to diffuse or un-pick possible misconception. Sax et al. (2010) continues that instead of considering incorrect responses as errors or mistakes to be avoided, take the position that they are often a normal part of the development of student’s understanding of a topic. Teacher’s role in identifying the errors is important. For a teacher to identify errors in mathematics, the teacher should have the knowledge of what the misconception might be, what could be the underlying cause for the errors and how to help the child to overcome the errors, so that they can continue learning. Teachers can overlook the errors made by children terming it as a regular and random error, addressing these errors and categorizing them into a productive mistake is even more challenging. The solution to the problem lies in error analysis, which will help teachers not to ignore mistakes but to categorize into a more productive mistake.

Error analysis is a traditional technique in Mathematical Assessment. It involves the analysis of error patterns which identifies the difficulties that students face with respect to facts, concepts, strategies and procedures. A learner need could be addressed more efficiently if the teacher knows how to identify errors. Cox (1975), has thrown light between systematic computation errors and errors that are random or careless mistakes. In systematic errors a pattern of errors are observed wherein the students are consistent in their use of an incorrect number, operation or algorithm. An
analysis of errors helps the teacher in identifying the patterns of errors or mistakes that students make in their work, it also provides an understanding as to why students make the errors and provide targeted instruction to correct the errors. Error analysis helps the teacher to check the students’ errors and categorize them. The errors are classified in mathematical areas like addition and subtraction, multiplication and division. Ashlock, (1986), Tindal and Marston (1990) classified students errors into (a) lack of understanding of regrouping, (b) confusion of 1s and 10s in carrying and writing, (c) forgetting to regroup when subtracting 10s and 100s, (d) regrouping when it is not required, (e) incorrect operation, (f) lack of knowledge of basic number facts. Further they have classified errors occurring in multiplication and division into (a) forgetting to carry in multiplication, (b) carrying before multiplying, (c) Ignoring place value in division, (d) recording the answer from left to right in multiplication, (e) Lack of knowledge of basic number facts. The knowledge of the type of errors made by children will give an insight into the reasons for the errors and measures to overcome the errors.

The solution to overcome the difficulties and reduce the errors lies in selecting and implementing an appropriate remedial instruction for the children.

Remedial instruction is a multifaceted approach, wherein the remedial intervention plans are tailor made to a child’s specific needs. Remedial instruction helps in gaping the bridge between achievement and performance. A child might be capable of better achievement but due to difficulties in understanding, poor teaching and inappropriate materials, the child’s performance might be much below his actual ability.

A remedial instruction focuses on skills rather than content, it is not subject specific, but widely used to correct problems in reading and mathematics.
The unsatisfactory performance of the pupils in the area of mathematics, the increasing demand in our technological society and for those students who do not perform adequately, remedial instruction is beneficial. According to Burns (2007), students with a weak foundation of mathematical understanding often demand more time and attention, and require supplemental instruction to ensure students’ academic success. Therefore, appropriate remedial instruction is necessary for those students who lend to have learning difficulties.

1.13 NEED FOR REMEDIAL INSTRUCTION

The fall in standards of learning is contributed to the introduction of compulsory education. The introduction of compulsory education/subjects like mathematics wherein the children do not have the option of not learning it, makes the teaching learning process difficult. A large number of pupils who fail to make normal progress in rural schools are merely backward or slow learners. The intellectual capacity of children with hearing impairment is not low; however there are few factors equal which put them into the category of backward performers. The factors could be very poor home conditions which result in an impoverished cultural atmosphere and a limitation of extra experience, irregular attendance and failure are other causes.

But the pupil’s scholastic disabilities are of a remedial kind. The problem faced by the child could be solved comparatively easily and systematically. Research studies by Eniolorunda (1998), Heward (1996) and Keller (2005) reported that the learning process of persons with hearing impairment is inferior to that of hearing children, however if these children with hearing impairment are taught through direct instruction and other multimedia modes like captioned video instruction, they found it beneficial and a useful strategy for learning among children with hearing impairment.
The remedial teaching should be such that it provides progress for all pupils in the fundamental subjects. The scholastic backwardness observed among the children could be removed using appropriate remedial measures. If remedial teaching is given, dropout, failure and wastage can be avoided. The benefits of remedial teaching was also reported by Karibasappa, Nishanimut, Padakannaya (2008), which states that children with mathematical difficulty when given remedial teaching to improve mathematical skills, resulted in an over-all improvement in pre-operational and operational domains pertaining to mathematical skills.

Remedial teaching is an integral part of all good teaching. It takes into consideration, pupils own level of performance; and by internal factors like motivation leads the students to increased standards of competence. Careful diagnosis of defects and the needs and interests of the pupils are important factors kept in mind while planning for remedial teaching. A good diagnostic test will help in developing appropriate remedial material. Blair (1962) emphasized importance of diagnostic test. He mentions that through informal methods, it is possible to locate those pupils who are deficient in the fundamentals of mathematics. A standardized mathematics test as a rule will show the grade level at which pupils perform the various mathematics processes and are very useful in screening out individuals needing careful diagnostic and remedial attention. A good remedial instruction should help the child to overcome wrong learning. Remediation keeps the child away from practicing wrong learning by constantly and effectively monitoring. An unmonitored practice will invariably result in the strengthening of any wrong concept which exists. Remedial instruction highlights the needs of small group work and encourages whole – class discussion. It helps the child to learn systematically, thus encouraging questioning and debate. Remedial instruction is different from traditional text book approach which
emphasizes drilling in prescribed procedures and deemphasizing explanation of students’ solutions to problem (Bottage et al., 2007; Yang, 2006; Yang & Wu, 2010). However, remedial teaching could be done through few approaches, which are as follows.

1.14 APPROACHES TO REMEDIAL TEACHING

A child could be provided with an effective remedial programme using different approaches one at a time. The ultimate goal of any remedial teaching is to help the child overcome his learning problem and develop his potential to the maximum. Below given are few approaches to help the child overcome his problems.

1.14.1 Individualized Educational Programme (IEP)

IEP as it is popularly known aims at overcoming the learning difficulties of the learner by reinforcing the foundation of learning. It helps to identify the strength and weaknesses of the pupils and develop their potentials. It is a systematic approach with components like short-term and long term objectives, easy learning steps and tailor-made activities and continuous assessment that ensures the programme is implemented effectively.

Teaching involving IEP could be done in small group or individuals can avail the IEP service. IEP is not the effort of a single person rather it is a team approach. The IEP team includes the remedial teachers, other teachers, student guidance officer/teacher, parents and pupils alike are to participate in designing the programme. The teacher in-charge of the remedial teaching holds meetings regularly to evaluate the effectiveness and the progress of work and gather opinions for further improvement.

1.14.2 Peer Support Programme

A good peer can help a struggling peer to overcome the learning problems. Remedial teachers can take the service of “little teachers” i.e. those pupils who
perform better in certain subject to help those pupils who are struggling to learn. These little teachers are responsible for helping their struggling classmates with learning disabilities in group teaching and self-study sessions as well as outside class.

A good peer support programme is beneficial in many ways as it helps pupils reinforce their knowledge and develop their communication and co-operation skills as well as good interpersonal relationship. Peer teaching will be successful only when remedial teachers support peers by providing training to the pupils concerned beforehand and reviewing regularly to check its effectiveness. Ideally, peer teaching programme is more suitable for those pupils studying in higher grades.

1.14.3 Reward Scheme

Motivation is an important factor for learning. It enhances the pupils’ performance positively. A positive reward motivates the child to cultivate interest in learning, thereby increasing a sense of satisfaction and achievement during the learning process. When the rewards that are to be offered are designed, remedial teachers should take note of the following.

- Specific and clear targets should be set
- Objectives should be achievable
- Rewards could be diverse in nature
- Immediate feedback, instant rewards
- Include and encourage parent participation

1.14.4 Masterly Level Learning

Mastery learning is an optimistic theory about teaching and learning that asserts that any teacher can help virtually all students to learn excellently, swiftly and self-confidently (Bloom as cited in Block (1984). Bloom, Hastings and Medaus
(1971) believe that both exceptional and non-exceptional learners can benefit from instruction if it is systematic, if the task is broken down into small steps, if goals are clearly stated, students are given sufficient time to achieve mastery and there is some criterion of what constitutes mastery.

It could be concluded from the above discussion that even though there are different approaches for remedial teaching, selecting an appropriate approach for teaching is important, a combination of approach could also be adopted for teaching learning process.

1.14.5 A Diagnostic – Remedial Approach

The diagnostic–remedial approach is based on the principle of diagnosing learning needs by identifying errors and categorizing them.

This approach is based on the few principle adopted by Carolyn Oliver, Oliver and Bowler (1996). The principles are as follows.

1. Don’t make any assumption
2. Start at ‘zero point’
3. Student accountability is important
4. Use multi-sensory approach
5. Explain structure, patterns and rules.
6. Mistakes could be treated as a step for learning
7. Instruction could be paced
8. Micro – Unit
9. Use student’s interests
10. Teach to automatization

A diagnostic remedial approach will determine the problem areas of the child, thus paving way for making use of other approaches for overcoming the problems faced by children.
1.15 CONTEXT, NEED AND IMPORTANCE

Mathematics is a study of numbers and relationship in quantity. It is used throughout our lives. The multiple decision skills of our lives are a result of our ability to compute, solve problems and apply concepts and skills in mathematics. The National Research Council (1989) said that mathematics is the “invisible culture of our age” and emphasized that mathematics is a part and parcel of our lives in many ways. This is evident in our technology-rich society, wherein the importance of mathematics cannot be neglected.

However, mastering mathematics is often challenging for students with and without disabilities. The students’ results on performance in mathematics as given in recent commissions and reports (NCES, 2004; USDOF, 2000) state students in the United States are weak in mathematics as compared to students in many other developed countries. According to the National Assessment of Educational Progress (NAEP, 2003) report, 23% of Grade 4 students and 32% of Grade 8 students scored below the “basic” level.

Wagner (1998) reported that students with disabilities typically perform two grades levels or more behind their peers without disabilities.

These students face difficulty in conceptual understanding of the core concepts, that are a part of operations and algorithms which is used to solve problems which involves whole and rational numbers (Fuchs & Fuchs, 2001). For example, difficulty in multiplication operational facility results from not only poor recall of the multiplication facts but also poor conceptualization of the meaning of multiplication.

Usually remediation is given superficially wherein a standardized diagnostic test is administered on the children and the difficulties faced by them is remediated, thus not solving or identifying the underlying problems in mathematics. For a
remediation programme to be effective, an effort to identify the difficulties and analysis of errors is required, so that remediation can help overcome the difficulties and reduce the errors. However, there is still scope for development of diagnostic test for better remediation.

The following issues need more light to be thrown on, related to children with hearing impairment (CWHI) and mathematics.

1. Diagnostic tests for identifying the students’ strengths and weakness in mathematics to which the parents and teachers could be alerted.
2. There is a need to find specific difficulties faced by these children in natural setting pertaining to management of money, time and problem-solving in daily life situations.
3. Assessment tools in different languages and for different grade levels as mathematical difficulties could be observed in higher grades also.
4. Educators should be made aware of the prevalence and difficulties of the children.
5. A detailed study of the errors committed by CWHI in various concepts and operations involved in mathematics should be done.
6. There is a need to develop a comprehensive remedial programme which develops different concepts and skills of mathematics among CWHI.
7. The remedial programmes developed have to be empirically validated.
8. There is a need for longitudinal studies on CWHI to establish that the improvement observed after remediation persists.

There has been very little effort to identify specific difficulties and errors in mathematics among CWHI in India. Even though, remediation is carried out to solve the mathematical difficulties in CWHI, it is not being done taking into consideration different criterion measure in each concept. With current emphasis on
Universalization of elementary education and inclusive education, it is expected that CWHI perform at par with their normal hearing peers.

Even though it is achievable keeping in mind the cognitive ability is par with normal peers. However, the teachers are unable to identify their underlying mathematics problem because of the learning deficiency in CWHI and inadequate training.

Teachers are not in a position to remediate the difficulties of these children as the preservice and inservice programmes for teachers do not focus their attention on these areas.

There is no component of identification of difficulties and analysis of errors in their curriculum. It seems, the teacher educators are also ignorant about the existence of these children in regular set up as well special educators are also not aware of identification of different errors and development of appropriate remedial teaching programme accordingly.

Hence there is a need for educating the teacher educators as well as the teachers about CWHI and their mathematical abilities and disabilities.

In a country like India, large percentage of school population are from low socio-economic environment. Besides, the learning based curriculum of our education system fails to accommodate the needs of CWHI, thus leading to failure and dropout. The textbooks of the schools in India are not developed separately according to needs of diverse and special need learners. There are insufficient and inappropriate materials, which do not serve the purpose of teaching CWHI.

Similarly, the teachers in special schools have an additional burden of adapting to some extent to meet the learning needs of the children which is also not fulfilled or met appropriately due to paucity of time and the linguistic problems of
these children. Hence, the problems, difficulties are not solved and the child carries these problems and difficulties in higher grades.

Universal Design for Learning and ‘Education for All’ being the UN declaration, identifying the difficulties and errors and giving an appropriate remediation should become a priority in elementary education. Universal design for learning as the name suggest, makes curriculum flexible in terms of the materials and activities used for teaching; it provides an alternatives for students with differing abilities in the classroom. These alternatives are built into the instructional design which the teacher incorporates while teaching the children.

To reduce the gap between ability and achievement in mathematics, early identification and intervention is necessary. Thus study is undertaken with this aim. To bring these CWHI at par with their normal hearing peers for successfully integrating them.

An attempt is made by initiating research in diagnosis and remediation, and not only remediation. There is a need to develop and experimentally validate the remedial programme for CWHI. The investigator has undertaken this work with a hope that the remedial mathematic programme developed in the study will serve as a guideline to special educators as well as regular school teachers to help CWHI in mathematics.

1.16 STATEMENT OF THE PROBLEM

In view of the present need arising from the status of research, the present problem is stated in terms of nature and scope of the study and objectives, followed by a brief definition of key terms included in the study.
1.17 NATURE AND SCOPE OF THE STUDY

The present study is a qualitative study involving methods like diagnostic and clinical method. It was a diagnostic study because it diagnosed the difficulties and errors made by the children in mathematics Grades I-V, with single case pre-test post-test design i.e. without a comparable control group. This study also employed clinical method as the remedial instruction was planned based on Individualized Educational Plan (IEP) at experimental treatment stage. While planning the remedial instruction programme, the principles of IEP was kept in mind, wherein the long term and short term goals were planned, difficulties and errors committed by the participants in the Arithmetic Diagnostic Test (Grade I-IV) and Mathematics Diagnostic Test (Grade-V) were analysed individually followed by individual remedial treatment. Remedial Instruction Materials were prepared for individual participants. Analysis was done in terms of pre-test and post-test for individual participants to check the effectiveness of the remedial instruction programme. A systematic procedure for identifying and assessing the difficulties and errors committed by children with hearing impairment would be an invaluable tool to the teachers teaching in both special schools for children with hearing impairment and inclusive set-up.

Usually difficulties are identified in term of the content of the diagnostic test or for mathematical process in general, this study will provide an insight into different criterion measures for each mathematical processes which is independent of each other, thus analyzing the children’s performance not in terms of marks, but in terms of mastery or non-mastery.

The group of children identified for the study represents the actual population of children with hearing impairment and also the difficulties and the errors committed
could be generalized for normal hearing children also. Thus the remedial instruction programme developed could be used for children with hearing impairment as well as normal hearing children.

Usually teachers teaching mathematics do not put an attempt to rectify the errors committed by the children due to lack of teaching learning material or appropriate strategies. However, the strategies used for the present study was simple and easily adaptable and available. Thus incorporating the principle of Universal design for learning wherein flexibility is seen in terms of curriculum, materials and activities. According to Mace (1997) UDL is “the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design”. Thus, the study was taken up with the following objectives.

1.18 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

1.19 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

1.20 LIMITATIONS AND DELIMITATION OF THE STUDY

1. The study was restricted to only special schools in Mysore and only Kannada medium children. It would have been desirable to include special schools outside Mysore and also English medium schools.

2. Only seven children were finally selected to try out the remedial instruction programme and test its effectiveness. However, the selected children became the representative sample of children with hearing impairment in terms of their specific mathematical difficulties and errors.
3. Word based problems involving spatial, verbal, numerical relations and reading and writing names in fractions were not mastered even after the remedial instruction programme. However, it was ensured that the concept of fractions, addition and subtraction of fractions with common denominators were taught.

4. Mathematical processes like multiplication and division of decimal numbers, simple interest, average were included in the for identifying the difficulties, however, error analysis was not done and remedial instruction was not provided for the above processes because of
   a. Lack of time
   b. They omitted all of the above in the pre-test
   c. The increase in the abstractness of these mathematical processes
   d. These processes requires more time to learn and understand
   e. Stretched beyond the time limit of the investigator

5. The experiment was conducted with a single group pre-test-post-test design. Getting a control group with the same level of difficulty in mathematics was very difficult.

1.21 DEFINITIONS OF THE KEY TERMS

This section gives the definitions of the key terms used in different stages of the study. The study uses different terms like hearing impairment, children with hearing impairment, children with no additional disabilities, remedial instruction programme, mathematics, difficulties in mathematics, errors, criterion measures, special schools, and diagnostic test. The key terms are defined in detail below:

**Hearing Impairment:** According to World Health Organization, a person who is not able to hear as well as someone with normal hearing – hearing thresholds of 25 dB or better in both ears – is said to have hearing loss. Hearing loss may be mild, moderate, severe or profound. It can affect one ear or both ears, and leads to difficulty in hearing conversational speech or loud sounds.
**Children with Hearing Impairment:** Children with hearing impairment will include children in the category of minimal (16-25 dB HL), mild (26-40 dB HL), moderate (41-55 dB HL), moderate to severe (56-70 dB HL), severe (71-90 dB HL) and profound (91 dB HL or more). However, for the present study, children studying in special schools with moderately-severe, severe and profound hearing loss as per the audiological records from authorized institutes was selected. The children selected for the study is a heterogeneous group which required special aural/oral program with emphasis on all language skills and academic areas. For the present study, students without any additional disabilities will be included.

**Special Schools:** Special school refers to those schools which meets the needs of children with special needs studying in those schools. They are special in terms of their infrastructure facilities, method of teaching, method of communication and have trained teachers. For the present study, special school refers to those exclusively for children with hearing impairment in Mysore having residential facility where the children stay in the school even after school hours.

**Total Communication:** The theory or practice of incorporating all means of communication, including speech, speech reading, auditory training, sign language and writing, in the education of deaf or hearing-impaired children.

In the present study, children with hearing impairment who participated in the study used total communication like gestures, speech reading, reading and writing to communicate their needs as well as for educational purpose also.

**Children with no additional disability:** Disability is the consequence of an impairment that may be physical, cognitive, mental, sensory, emotional, developmental, or some combination of these. A disability may be present from birth, or occur during a person's lifetime. In the study, no additional disability means, the
child is suffering from only one type of disability i.e. hearing impairment. Any other
disability like emotional or behaviour disorders, attention deficit hyperactive disorder,
physical handicap, autism or visual problems is not present.

**Average and above average intelligence:** Average and above average intelligence
was measured by using Raven’s progressive matrices. Based on the performance of
the children with hearing impairment on the Raven’s progressive matrices, the level
of intelligence was determined. In the present study, those children who had average
and above average intelligence were retained for the study. (The details regarding
classification of intelligence based on the performance is given in section 3.2.1 of
Chapter III.)

**Criterion Measures:** Criterion measures are a specific set of concepts/skills related
to different tasks. It is based on task analysis and it is designed to measure changes in
successive performance. In the present study, Criterion measures refers to the various
concepts/skills pertaining to different concepts and processes in Arithmetic and
Mathematics, which the participants were expected to master before moving on to the
next skill. Criterion measures pertaining to Grades I-IV are listed out in table 3.2 of
Chapter III and Criterion measures pertaining to Grade V is listed out in table 3.6 of
Chapter III.

**Diagnostic Test:** Diagnostic test is a test which identifies the strengths and
weaknesses of children in a particular subject. The diagnostic tests used in the study
were Arithmetic Diagnostic Test for Primary school children (Grades I-IV) (Ramaa,
1994, 2015) and Mathematics Diagnostic Test (Grade V) developed by the
investigator. These diagnostic tests helped in identifying the strengths and weaknesses
of the children with hearing impairment. In the present study the diagnostic tests were
used for diagnosing the difficulties and errors in arithmetic and mathematics.
• **Arithmetic Diagnostic test:** In the present study, Arithmetic Diagnostic Test for Grade I-IV covers three major areas namely number concept, arithmetic processes like addition of whole numbers, subtraction of whole numbers, multiplication of whole numbers and division of whole numbers and arithmetic reasoning. Arithmetic will not have the component of Geometry in it. The test had criterion measures for number concept, addition, subtraction, multiplication and division. The details regarding the different criterion measure is given in table 3.2 of Chapter III. (Refer to section 3.2.2 of Chapter III for more details on the Arithmetic Diagnostic Test.)

• **Mathematics Diagnostic test:** In the present study, Mathematics Diagnostic Test for Grade-V covers numbers concepts, addition of whole numbers, fractions and decimals, subtraction of whole numbers, fractions and decimals, multiplication of whole numbers and fractions and division of whole numbers and fractions, average, simple interest and percentage and geometry. The test had different criterion measures for number concept, addition of whole numbers, fraction and decimals, subtraction of whole numbers, fraction and decimals, multiplication of whole numbers and fractions, division of whole numbers and fractions, average, simple interest and percentage and geometry. The details regarding the different criterion measures pertaining to Grade-V is given in table 3.6 of Chapter III. (Refer to section 3.2.2.1 of Chapter III for more details on Mathematics Diagnostic Test.)

**Difficulties in Arithmetic:** In the present study, difficulties in arithmetic are considered when the child is not able to do a sum or perform in the given test. The test used for identifying the difficulties in the present study was Arithmetic Diagnostic Test Grade I-IV (ADT-Grade I-IV), (Ramaa, 1994, 2015). The difficulty was
measured based on the scores in each criterion measures for the arithmetic concepts and processes of ADT –Grade I-IV. The scores obtained in each of the criterion measures were converted into percentage. The cut off score was 75% of the expected score in each criterion measures. The performance of the children was classified as Masters, Partial Achievers and Non-masters. Those children who performed above 75% of the expected score for each criterion measures were termed as masters, partial achievers were those who performed below 75% of the expected score for each criterion measures and non-masters are those who have not performed in any of the criterion measures of the diagnostic test. For more details on difficulties in mathematics refer Chapter V.

**Difficulties in Mathematics:** In the present study, difficulties in mathematics are considered when the child is not able to do a sum or perform in the given test. The test used for identifying the difficulties in mathematics was Mathematics Diagnostic Test Grade-V, (Developed by the investigator). The difficulty was measured based on the scores in each criterion measures for the mathematics concepts and processes of Mathematics Diagnostic Test. The scores obtained in each of the criterion measures were converted into percentage. The cut off score was 75% of the expected score in each criterion measures. The performance of the children was classified as Masters, Partial Achievers and Non-masters. Those children who performed above 75% of the expected score for each criterion measures were termed as masters, partial achievers were those who performed below 75% of the expected score for each criterion measures and non-masters are those who have not performed in any of the criterion measures of the diagnostic test. For more details on difficulties in mathematics refer Chapter V.
Errors in Arithmetic: Errors means those mistakes which are committed by the children with hearing impairment which follows a particular pattern and is repetitive. The errors could be classified as conceptual errors where the child does not have any concept of the given task or procedural errors, wherein the mistake occurs while carrying out the process. In the present study, errors in arithmetic means when the children were committing repeated errors in the task given in the diagnostic test. The diagnostic test used for identifying the errors committed by the children was Arithmetic Diagnostic Test (Grades I-IV). The errors committed were classified as conceptual errors and procedural errors. For more details on errors, refer Chapter –VI.

Errors in Mathematics: In the present study, errors in mathematics means when the children were committing repeated errors in the task given in the diagnostic test. The diagnostic test used for identifying the errors committed by the children was Mathematics Diagnostic Test (Grades-V). The errors committed were classified as conceptual errors and procedural errors. For more details on errors, refer Chapter VI.

Remedial Instruction programme: According to McCulloch (2012), remedial means ‘to rectify, improve or remedy something’. The remedial teaching could be math, reading or spelling. Assessment is the first step in remedial instructions which identifies specific areas of concern. This assessment is followed by intervention programme to overcome the concern.

Remedial Instruction Programme in Mathematics: In the present study, intervention programme was provided to children with hearing impairment who have been identified as having difficulties in mathematics which was assessed by using Arithmetic Diagnostic Test (Grades I-IV) and Mathematics Diagnostic Test (Grade-V). This remedial programme was planned based on the principles and strategies of remedial instruction. The remedial instruction programme was aimed at
overcoming the difficulties and reducing errors which was identified in different criterion measures in mathematics pertaining to Grades I to V. The criterion measures were assessed by using the Arithmetic Diagnostic test and Mathematics Diagnostic Test. (Details of remedial instruction programme is given in section 7.2 of Chapter VII.)

**Mastery Level Learning:** Mastery level learning in the present study is calculated at three levels. For criterion measures; 75% mastery level is expected i.e. the participants should perform atleast 75% of the expected score. For overall performance, the mastery level is calculated at 80% and 100% of the expected score.