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Number concept acquisition during pre-school age

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Abstract
Number concept is defined as a person's general understanding to perform operation on numbers. National Council of Teachers of Mathematics (NCTM, 2002), USA (it is world's largest mathematics organisation), states that "the foundation for children's mathematical development is established in the earliest years". Therefore, pre-school age is crucial period of life and considerable amount of attention should be paid to this phase. It is the time when skills are attained which acts as a foundation for all the subsequent years in the life-span. Studies show that to lead a positive life in future it is necessary to expose children to number concepts in early years of life. Thus, the study aimed at assessing attainment of number concepts in pre-school children. The number concepts were assessed in the categories of Number sense, Number representation and Number relation, which are based on the five principles of counting proposed by Gelman and Galistell. The study was carried out on twenty four numbers of pre-school children belonging to the age of 3- 4 years, selected through purposive sampling method. The investigator developed activities to assess the number concepts formed by preschool children. It was found that the concept of Number sense i.e. naming and matching numbers were better formed in children than Number representation and Number relation. The concept of number relation was not clear in preschool children. Among the three areas of Number relation *viz*., Sequencing, Cardinality and Magnitude, it was found that children performed well in the activities of sequencing numbers and poor in cardinality of numbers. It is very important for young children to master with the early number concepts for later achievement in mathematics.

Keywords: Number concept, pre-school children, assessment, number sense, number representation, number relation

1. Introduction

Concepts are regarded as the fabric of life; they serve to carve up the person's world into functional units. Individuals differ in their level of concept formation on the basis of their age, intelligence and experience.

Jordan *et al*., (2012) [1] states that insufficiency in number sense is a core marker for severe and persistent learning disabilities in mathematics. Innate basic abilities and acquired general skills both contribute to mathematics development (Siemann and Petermann, 2018) [2].

Askew *et al*., (2014) [3] highlighted the role of embodied cognition in learning early counting. Their focus on forward and backward counting implicitly emphasized ordinality of numbers and connected it to the embodied metaphors in teachers' gestures that support learning opportunities.

In this study, the formation of number concepts are covered which includes the skills of counting and comparing. Both these basic concepts of mathematics should be attained by all children so that they can advance for more complex learning in mathematics

Mathematics is an important part of learning for children in the early years because it provides vital life skills to children. It also helps to measure and develop the children's spatial awareness. Social cognitive theory (Bandura; 2005, 2012) [4] states spatial skills could impact an individual's motivation for mathematics when he believes that spatial skills are relevant in mathematics performance. Atit *et al*., (2020) [5] in their study revealed that both spatial skills and motivation to learn mathematics contribute to students' middle school mathematics outcomes, integrating both of these components into the everyday K-12 mathematics curriculum could result in long-term benefits to all students' mathematical achievement.

1.1 Present study

Pre-school age is one of the most crucial period of life. This phase should be handled with considerable amount of attention because the child undergoes greatest development during this period. During this time new skills are attained which acts as a foundation for all the subsequent years in the life-span. According to Piaget's framework, children between the age group of two to seven, gradually overcome various mental barriers to systematic and logical thinking. Therefore, children must be provided with stimulating and enriching learning environment to facilitate the learning process. This affirmation raises concern on teaching and learning materials employed in pre-school education, whether they are capable of helping the child to develop his abilities and interests or not.

There have been innumerable researches going in the field of development of number concepts among children, so that it becomes easy for child psychologist to understand the child's thought processes and as well as to discover best ways to help the child gain facility in working with number and numerical concepts.

Children become aware of words relating to number soon after they begin to speak and use these words in their own speech, but this is merely "parrot speech", and what these words mean to the child is difficult to determine (Hurlock, 1972) [6].

Wohlwill (1960) [7] indicates that the process of the development of number concepts is most adequately described in terms of three discrete phases: the initial phase is one in which the child responds to numbers wholly on a perceptual basis, without using symbolic representation. The intermediary phase is the one in which the mediating structures representing individual stimuli are developed, so that dependence on perceptual support is reduced. The final phase is that phase in which numbers are dealt with in an abstract way, and the structures representing the number concepts are elaborated, thereby leading to an understanding of such functional principles as the conservation of number and the coordination between ordinal and cardinal numbers.

According to Potter *et al*. (1968) [8], in order to count a set of things, the child must pair a numeral with an object in proper sequence. Three skills underlie this ability: the first skill is that of knowing the numeral names in the correct order; children aged two or younger often grasp this ability. The second skill underlying counting is the understanding of one-to-one correspondence. This is the ability to take (or point to, or look at) each item in an array, one at a time, until all have been taken exactly once. The third skill is the ability to coordinate the first two skills, to bring the numerals in a one-to-one relation with the items in an array (Potter *et al*., 1968; D'Mello *et al*., 1969; Ogletree *et al*., 1970) [9, 10].

Hargis (1971) [11] listed the four component steps of learning to count: (1) One-to-one correspondence; (2) Rote counting; (3) Assigning by one-to-one correspondence the number names learned in sequence to a set of objects; and (4) Rational counting, or enumeration, learning that each assigned number name tells "how many" have occurred or are contained through that point.

Gelman and Galistell (1978) [12] stated five conceptual principles that govern counting are stable order principle, one-one-correspondence principle, cardinality principle, abstraction and order-irrelevance principle. The first three principles are viewed as the essential principles because they represent the basis for children's knowledge of counting (Gelman and Meck, 1983; Geary, 2004) [13, 14].

According to Butterworth (2004) [15], children do not master all essential principles at the same time. The stable order principle is mastered first while the cardinality principle is mastered last. In the study conducted by Le Fevre *et al*. (2006) [16] found that children's knowledge of the stable order principle was very good in kindergarten, Birars and Siegler (1984) [17] found that children had good understanding of the one-one-correspondence principle at the age of five and that this understanding improved with age.

On the other hand, the mastery of the cardinality principle is much debated skill. A few researches concluded that this principle is excelled at the age of three (Gelman and Meck, 1983). Some others argued that the understanding of the principle begins at the age of three and a half (Wynn, 1992) [18]. Yet, some other researchers found that children could not determine quantities before the age of four and a half and that principled understanding of cardinality does not appear before the age of five (Freeman *et al*., 2000) [19].

Baroody and Coslick (1998) [20] classified counting skills into two main categories, oral counting and object counting. Oral counting involves citing the number words. Usually children learn first the forward counting sequence (one, two, three, …) and later it provides assistance for representing the number after and number before. Subsequently forward counting helps them with counting backward also. Then children are able to use skip counting by twos, fives, and tens.

Baroody and Coslick (1998) has given two views regarding the development of number concept:

1. The logical-prerequisites view and
2. The counting view

The prerequisites view was adopted by Piaget. He believed that number concept depends on logical thinking and that children should rely on matching, not counting, to establish equivalence and in-equivalence. According to the second view, however, counting is the key to understand number concepts and arithmetic.

Many researchers agree that children construct basic number and arithmetic concepts gradually from experiences that largely involve numbers (Gelman and Gallistel, 1978; Baroody, 1987[22]; Fuson[21], 1988; Baroody and Coslick, 1998). Mathematics educators agree that children's success in mathematics in early grades depend largely on their counting skills.

Stock *et al.* (2009) [23] found that mastery of counting principles in kindergarten predicted arithmetic abilities one year later in the first grade. In opinion of Boruah and Borah (2021) [24], it was revealed that the attainment of the concept of number varies from individual to individual. In their study it was found out that children performed better in naming numbers among all the related activities of number concepts in pre-assessment and after giving musical intervention children showed improvement in categories such as number sense, number representation and number relation.

Bakar *et al*., (2021) [25] regards mathematics as a challenging subject by the young ones as well as the adult students. Researchers have identified numerous drawbacks of using traditional mathematics curriculum and instructional methods to teach students. Traditional methods of instruction may be ineffective, because they are unable to reach all students and meet their needs (An and Tilliman, 2015) [26]. Therefore, researches employed a variety of techniques and approaches such as signing dancing, playing music etc. in early education to create interest in learning of mathematics and to reduce the fear of it (Manocha and Narang, 2008) [27]. Teaching mathematics using effective didactic strategies and instructional approaches provides opportunities for students to understand and apply mathematical knowledge in meaningful ways. It also provides an enjoyable environment which can

facilitate students' learning of mathematics in effective ways (An & Capraro, 2011) [28].
With this background the present study entitled, "Number concept acquisition during pre-school age" was undertaken assess the number concepts attained by preschool children.

2. Materials and Methods

2.1 Target population and sample-

The target population of the present study was children belonging to the age of 3-4 years who are studying in preschool of Jorhat town of Assam, India.
Since it was not feasible to study the whole population, hence a sample of population was selected by adopting appropriate sampling techniques. The study comprised of 24 numbers of samples who were given musical intervention.

2.2 Sample design and sampling procedure-

The sampling design that was used in this study was Non probability sampling methods. Convenience and purposive sampling methods were adopted.
An English medium preschool located in urban area of Jorhat town was selected through convenience sampling. It was selected conveniently for the easy of communication and cognizance of researcher.
The preschool was selected with the following criteria:

- Firstly, the researcher's communication services were looked for the purpose of easy progress.
- Secondly, the researcher should obtain consent from the selected schools and obtain permission from the parents/guardian of the samples to participate in the study.
- Thirdly, the pre-school should not have more than 30 children in a class.

2.3 Tools & Techniques used-

The tool was self constructed for the assessment of number concepts of children. It was divided in the categories of - Number sense, Number representation and Number relation. The categories were based on the conceptual principles of number, given by Gelman and Galistell (1978).

Table 1: Principles of gelman and galistell

Principles of gelman and galistell	Definition	Category used in the research
The stable order principle	Number words must be used in a fixed order in counting	Sequencing
The one-one-correspondence principle	Every number word is assigned to one object in the counted set	Number representation
The cardinality principle	The value of the last number word in the counting sequence represents the quantity of the counted objects	Cardinality
Magnitude principle	Higher number of objects is greater	Magnitude
The Relation principle	The relation between the numbers	Number sense

Table 2: Techniques used for assessment of number concept

Number concepts	Criteria	Technique
Naming numbers	Speaking numbers verbally. 	The children were asked to name numbers from 1 to 10. The baseline for each child was assessed depending upon their continuity and fluency in number naming. The point where they have difficulty (or confusion) in naming was considered as baseline of intervention for that particular child
Recognising numbers	Matching number with number cards. 	The children need to pick up and name the particular number assigned by the researcher.
Number representation Understanding that each number relates to the things/objects being counted	The ball number game	Children were asked to pick up a number card and as per the number in the card they had to count and group the balls.

		
Sequencing The ability to use number in fixed order.	Jumble number game 	The numbers were jumbled and the children were asked to keep in correct sequence(1,2,3.10)
Cardinality Knowing that the last number counted is the number of objects.	Objects in basket game 	Objects were placed in baskets and according to the assigned numbers the children need to pick up the number of objects from the basket.
Magnitude Recognising that higher numbers reflect larger quantities.	Flower game 	Children were given different flower cards which had different number of flowers pasted on it. Children need to identify the card which had more number of flowers among the two

2.4 Statistical procedure
After collection of data, raw data were categorized, coded, scored and tabulated for statistical computation.

2.5 Coding: To facilitate the coding procedure, each response in the schedule was coded. The data collected were recorded and coded using Microsoft Office Excel.

2.6 Tabulation: After coding, the collected data were tabulated to give a clear picture of the findings of the study. For the tabulation process the data obtained from the respondents were divided into different ranges on the basis of their capacity to know the number concepts. It was divided into 4 ranges, they are:

a. 4 - children who were able to know numbers concepts from 7 to 10 or above
b. 3 - children who were able to know numbers concepts from 5 to 7 or above
c. 2 - children who were able to know numbers concepts from 7 to 10 or above
d. 1 - children who were able to know numbers concepts upto 2

3. Results and Discussion
The results were represented using appropriate graphs and bar diagrams.

3.1 Distribution of responses of children according to their concepts of Number sense

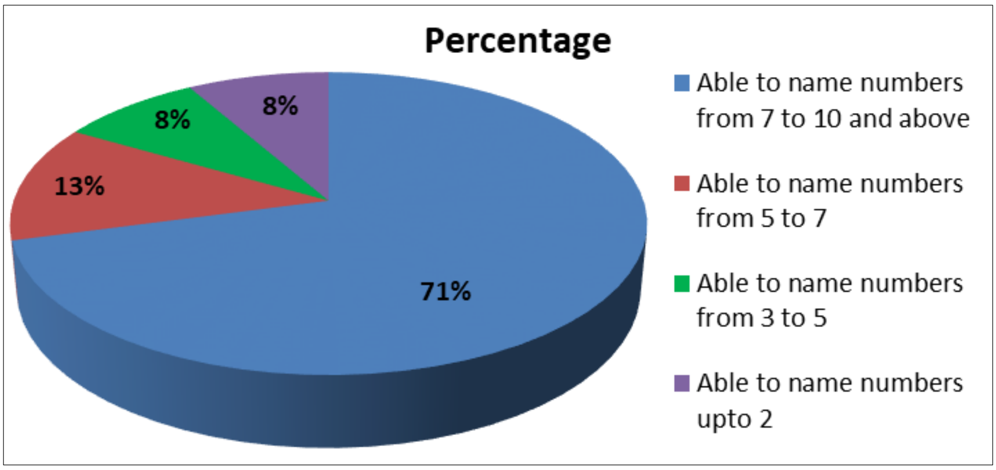

Fig 1: Responses of children in the category of naming number

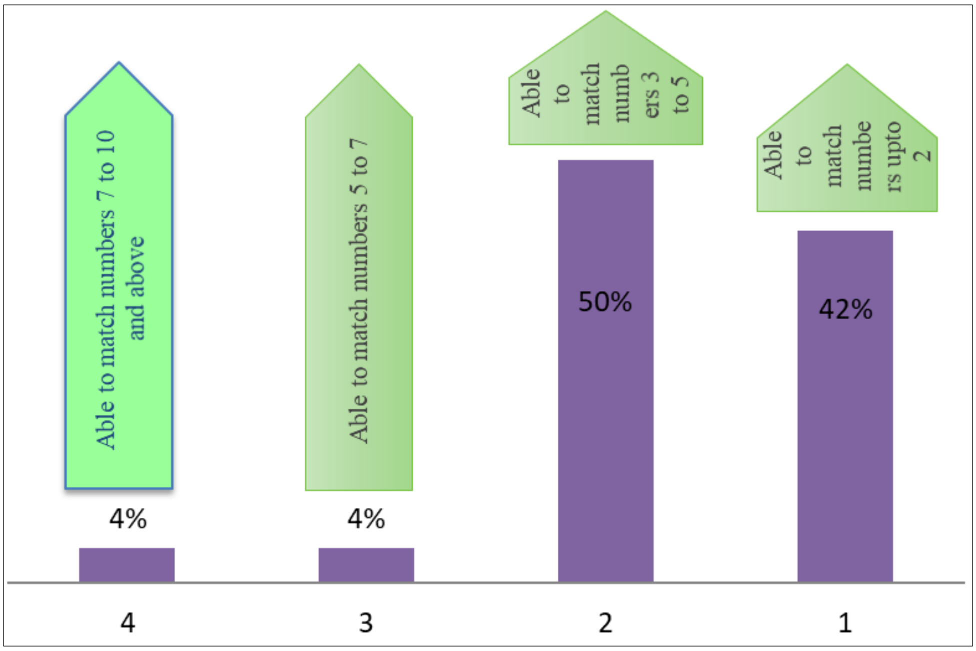

Fig 2: Responses of children in the category of matching numbers with number cards

Fig 1 shows that, majority (71%) of the children were able to count numbers in the range of 7 to 10 or above, followed by thirteen percent children who were able to count in the range of 5 to 7.

In the activity of matching number with number cards (Fig 2), it was found that fifty per cent children were able to recognise the numbers visually in the range of 3 to 5 which was followed by forty-two percent who could recognise upto 2.

Among the two activities of number sense, seventy–one percent children were able to name number in the range of 7 to 10 or above, whereas only four percent were able to match numbers with number cards in the range of 7 to 10 or above (Fig 1). Thus, the probable reason for such a difference in the results may be as young children have an innate capability to hear sounds and music (Zentner and Eerola, 2010) [29]; therefore, they are initially exposed to oral knowledge. This knowledge is regarded as informal knowledge. It is gleaned from everyday activities such as home, playground, grocery store, shopping mall, family car, or park (Ginsburg *et al.*, 2006) [30]. The parents might count in the motion as one two three four... or they would recite rhymes of number count. Potter *et al.* (1968) mentioned three skills of counting of numbers. First skill attained by the children is learning to name the numbers, without breaking the fluency of numbers. This skill is attained by age two or younger. Thus, in the study it was observed that majority of the students were able to name numbers. As children move through the preschool years, formal mathematical knowledge begins, largely represented in written form, and frequently the result of deliberate efforts by teachers and students. They gradually learn how to recognize, describe numbers. Later on they learn spelling of numbers. The early mathematical skills such as counting numbers and recognising numbers helps children to be better in mathematics at school. Therefore, it is very important for young children to begin with the skills of number sense.

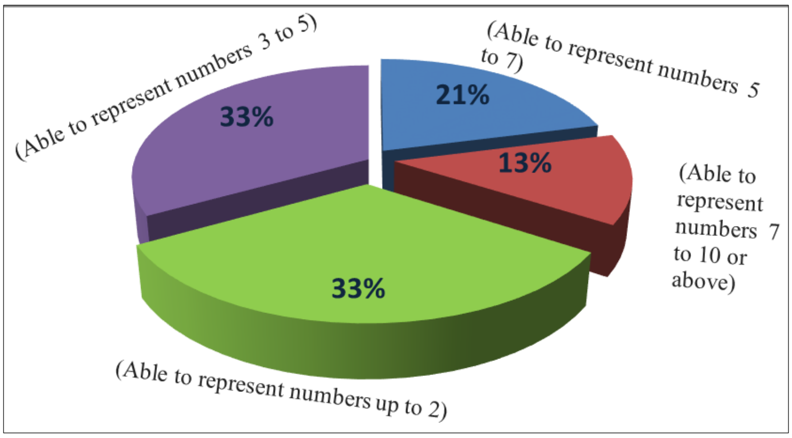

Fig 3: Responses of children in the category of number representation

From the Fig 3, it is evident that the frequency of children who were able to represent numbers up to 2 and those who could represent numbers from 3 to 5 were equal (33%). It may be because, when children start going to school, teachers use different teaching methods to make the children understand the concept of numbers. Therefore, after the children attain the ability to name numbers through verbalisation, they slowly began to represent the numbers. This can be supported by the study of Birars and Siegler (1984), who found that children attain good understanding of the one-one-correspondence principle (number representation) at the age of five and that this understanding improved with age. The study was conducted among the children of age 3- 4; therefore, very few could represent numbers upto seven (i.e. 21%).

3.2 Distribution of responses of children according to their concepts of Number relation

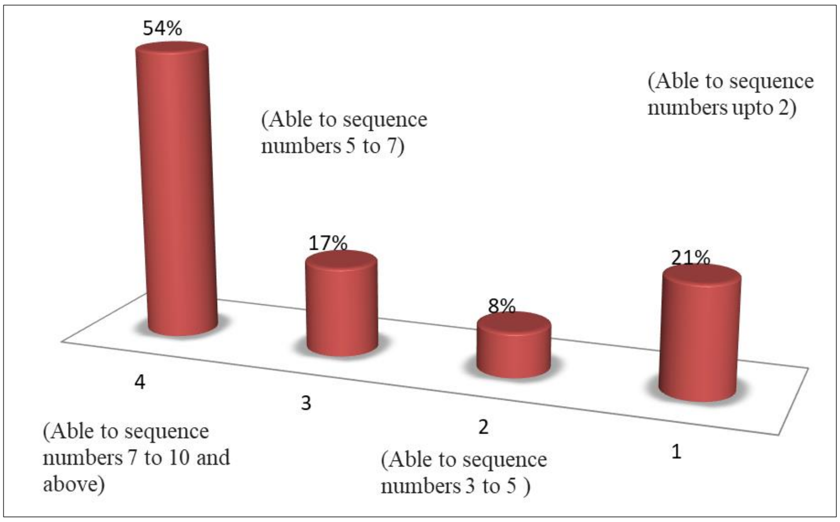

Fig 4: Responses of children in the category of sequencing of numbers

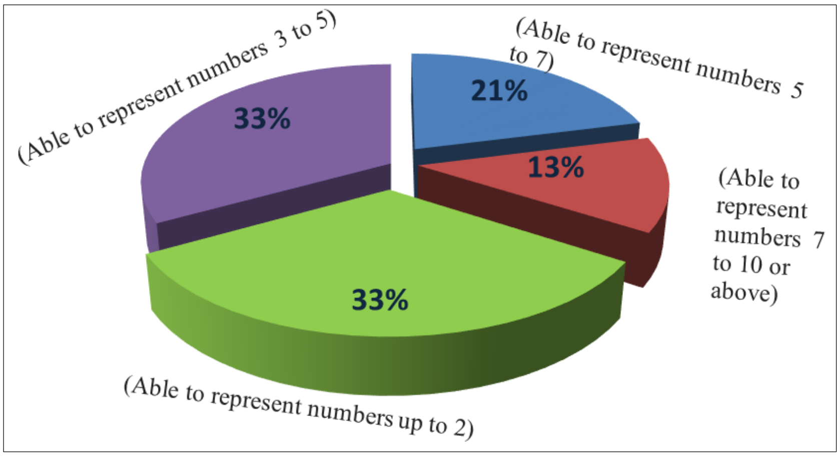

Fig 5: Responses of children in the category of cardinality of numbers

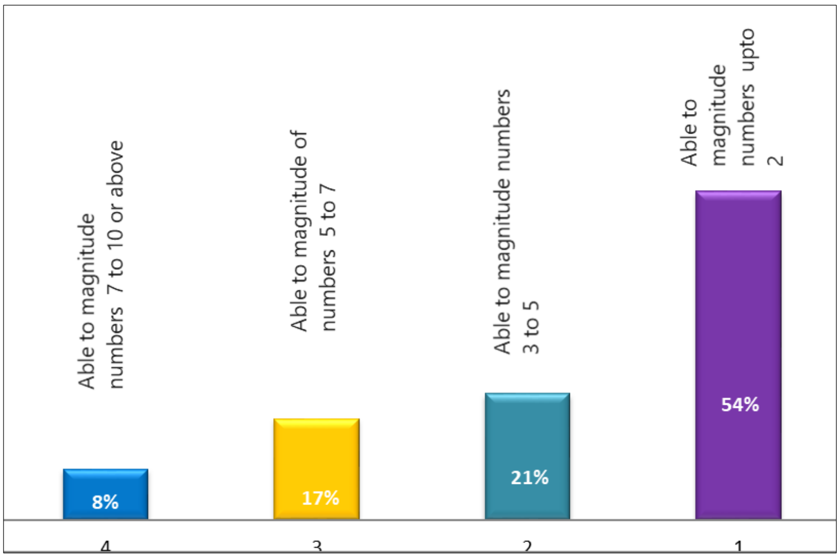

Fig 6: Responses of children in the category of magnitude of numbers

Among the 3 subdivisions of number relation *viz.*, Sequencing, Cardinality and Magnitude, it was observed that children performed well in the activities of sequencing numbers (Fig 4). Majority (54%) of the children were able to sequence numbers from 7 to 10 or above, which was followed by twenty-one percent who could sequence numbers up-to seven.

In case of magnitude of numbers, fifty-four percent of respondent children were able to distinguish magnitude of numbers up to 2; followed by thirty eight percent of children who were able to distinguish magnitude of numbers in between 3
to 5 (Fig 5).

The performance of children in activities related to cardinality of numbers was poor as compared to sequencing and magnitude of numbers. From the Fig 6, it is evident that, majority (54%) of the children could do number cardinality activity up-to the number 2 only. Thirty-eight percent could cardinalize numbers in the range of 3 to 5. None of the children could cardinalize numbers from 7 to 10 or above.

The results of the Table 2, depicted that the stable order principle is mastered first while the cardinality principle is mastered last as the performance of children in activities related to sequencing of numbers was better as compared to the other activities of number relation *viz.,* sequencing, magnitude and cardinality. It was evident that majority (54%) children could sequence the number upto 10 or above, followed by the range of numbers from 5 to 7. This might be because children attain the concept of naming number earlier through verbally or visually. Therefore, it became for the children to perform the task with ease.

The mastery of the cardinality principle of preschool children is much debated. Some psychologist concluded that the understanding of the principle starts at the age of three and a half (Wynn, 1992). Yet, some other researchers argued that children could not determine quantities before the age of four and a half. Further, it stated that understanding of the principle of cardinality appears after the age of five (Freeman *et al.*, 2000).

Results of the present study (Table 2), also concluded that the principle of cardinality is attained at last. In the table, majority (54%) of the children could perform number cardinality activity up-to 2 only. Thus, the results are consistent with the finding. Further, the results of this study support the finding that the understanding of the cardinality principle is the most difficult among the number concepts. According Freeman *et al.*, (2000), the principled understanding of cardinality does not appear before the age of five.

In the activity of cardinality of numbers (basket activity), the child needs to pick a card and according to the picked number card the child needed to take out objects from the basket. If the child fails to do the task, it could be concluded that the child does not have the concept. Other factors, such as lack of procedural knowledge might also influence the child's lack of demonstration of the concepts.

The researcher observed that while performing number cardinality task, often children were not able to stop at the assigned numbers. They either go on placing the objects from the basket or forget the sequence. It might be difficult for them to count as well as represent number cardinality at the same time. Thus none of the children could complete till 10.

The development of early mathematical skills in pre-schoolers can help children to be better in mathematics at school. It is very important for young children to begin with the skills of number concepts. Mastery of mathematics at the early stage of schooling is the indicator of achievement and mastery of advanced mathematics (Sarama *et al.*, 2012) [31]. Mastery of number concepts at the preschool stage plays an important role in the development of mathematics achievement during age 1-8 years and at the secondary level (Locuniak and Jordan, 2008; Jordan *et al.*, 2009) [32].

4. Conclusion

The assessment of the number concepts formed by pre-school children revealed that all children possess number concepts in varying levels. But all the number concepts are not mastered at same time. Butterworth (2004) stated that naming of numbers is mastered at the beginning and cardinality principle is mastered last. In assessment of number concepts, it was found that children performed better in the activities related to naming of numbers and performed poor in activities related to cardinality of numbers.

Studies show that learning of number concepts at preschool school level is of crucial importance in developing the beliefs and values that they associate with mathematics. Children who are exposed to early number concepts are likely to lead positive attitudes, values and beliefs about number concepts (Van de Walle, 2004) [33]. In addition, children who learn mathematics with understanding tend to be more confident, autonomous and flexible in their learning and use of mathematics, and more likely to persevere in the face of difficulties (National Council of Teachers of Mathematics, USA, 2000) [34].

5. Limitation

The study was undertaken only in one pre-school and was confined to only a small sample size, therefore, the current findings and conclusions were limited to the groups examined at the time of this research.

6. Further Research

Future research can be made by increasing the sample size, adding more number of preschools and follow them for an adequate period of time.

Experimental study can be carried out to investigate the results of controlled group. Further studies could focus on other aspects of humans such as home environment, temperament.

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