A Study of Preschoolers' Number Sense

Nu Nu Nyunt [1], Thin Thin Hlaing [2]

Abstract

The primary purpose of this study is to examine the preschoolers' number sense. Both quantitative and qualitative approaches were used in this study. A total of 412 preschoolers from 11 preschools participated in this study. Preschoolers' Number Sense Test (PNST) was used as the research instrument. It consists of 41 items and eight sub-scales. Alpha reliability for PNST revealed at 0.856.

In this study, ANOVA results by department/organization indicated that significant differences were found to be on five sub-scales of preschoolers' number sense test. Concerning preschool teachers' experience, the mean score of preschoolers whose teachers had less than 5 years teaching experience were found to be significantly lower than that of preschoolers whose teachers had 5 years and above teaching experience on the rote counting and counting backward sub-scales. However, there existed no gender related difference concerning all sub-scales of PNST. Moreover, it was found that older preschoolers outperformed younger preschoolers on the entire PNST.

Key words: Number Sense, preschooler.

Introduction

Children are naturally eager to learn. The early years of life are a time of huge growth of linguistic, conceptual, social, emotional, and motor competence. Right from birth a healthy child is an active participant in that growth, exploring the environment, learning to communicate, and, in relatively short order, beginning to construct ideas and theories about how things work in the surrounding world. The pace of learning, however, will depend on whether and to what extent the preschoolers' inclinations to learn encounter and engage supporting environments (Bowman, Donovan, & Burns, 2001). Today's preschoolers are not like the four-year-old of previous decades. Many have already attended on, two, or three years of child care or nursery school. Both collectively and individually, the experiential backgrounds of preschoolers are quite different from those of previous generations (Morrison, 1988).

There have been many research studies concerning the individual differences in the school age children's mathematical achievement. In general, it seems that preschooler's mathematical skills have not been

---

1. Dr., Assistant Lecturer, Dep artment of Educational Psychology, Yangon Institute of Education
2. Senior Teacher, No.5 State High School East Dagon, Yangon

widely studied. A lot of preliminary mathematical knowledge develops in early childhood, providing a basis for later formal mathematics learning and also difficulties in mathematical development emerge early years. Therefore, it is essential to acquire research knowledge on early number sense in order to understand the development and difficulties children encountered, as well as for planning the relevant educational support for these children (Aunio, 2006).

1.1 Significance of the Study

Myanmar parents send their children to preschools not only for their children's cognitive development but also for emotional development. Children can learn and develop numeracy skills, language skills, social skills and motor skills that are needed in their later learning for their survival during preschool years. According to Dehaene (1997), number sense that is relevant to learning mathematics takes root early in life before children enter school. Primary, or preverbal, number sense appears to develop without or with little verbal input or instruction, and it is present in infancy (as cited in Jordan, Glutting, & Ramineni, 2009). Therefore, educators need to investigate the fact that preschool children actually develop early number sense concept in the preschool years.

1.2 Purpose of the Study

The major purpose of this study is to assess preschoolers' number sense concept.

1.3 Research Questions

1. Is there any difference in number sense among preschoolers by department/organization?
2. Is there any difference in number sense among preschoolers by gender?
3. Is there any difference in number sense among preschoolers by age group?

1.4 Scope and Procedure

A study on the effect of preschoolers' number sense concept on the development of problem solving behaviors was conducted by survey method. Preschoolers' number sense was measured by modified version of Early Numeracy Test (Clarke B and Shinn M. R., 2002) and Sandwell Early Numeracy Test Revised (SENT-R) developed by C. Arnold, M. Talents and B. Walden (2008), and judgement task adapted from a task designed by Canobi et al. (2002). Participants of the study were preschool-age children selected from eleven preschools; 4 from Ministry of Education (MOE), 4

private schools, 1 from Myanmar Maternal and Child Welfare Association (MMCWA) and 2 from Department of Social Welfare (DSW).

1.5 Definition of the Key Terms

Number Sense

Number sense refers to a person's general understanding of number and operations along with the ability to use this understanding in flexible ways to make mathematical judgments and to develop useful strategies for solving complex problems (Reys, & Reys, McIntosh, Emanuelsson, Johansson, & Der, 1999).

Preschool

Preschool refers to a school for children who are not old enough to attend kindergarten (Morrison, 1988).

Preschoolers

Preschoolers refer to children between toddler age and age of entrance into kindergarten or first grade (Morrison, 1988).

Preschool Education

Preschool education refers to the early childhood education of children from one to six years old (Aunio, 2006).

Review of Related Literature

2.1 Number Sense of Preschoolers

Number sense refers to a person's general understanding of number and operations along with the ability and inclination to use this understanding in flexible ways to make mathematical judgments and to develop useful strategies for handling numbers and operations. It reflects an inclination and an ability to use numbers and quantitative methods as a means of communicating, processing and interpreting information. It results in an expectation that numbers are useful and that mathematics has certain regularity. Number sense is widely used in current mathematics education reform documents as it typifies the theme of learning mathematics as a sense-making activity. Like common sense, number sense is an elusive term which has stimulated discussion among mathematics educators, including classroom teachers, curriculum writers and researchers (McIntosh, Reys, & Reys, 1992).

The term number sense comes with many meanings and interpretations. These include basic number skills, preparatory arithmetic skills, concepts of numbers and counting, informal mathematical knowledge, number module, and number sense. Despite different theoretical emphases, all these terms refer to the skills that children acquire and display, before formal schooling

begins, and that are essential for learning mathematics at primary school (Aunio, Aubrey, Godfrey, Luejuan, & Liu, 2008).

Even though Case (1998) operationalized number sense that the characteristics of good number sense include: (a) fluency in estimating and judging magnitude, (b) ability to recognize unreasonable results, (c) flexibility when mentally computing, (d) ability to move among different representations and to use the most appropriate representation (as cited in Gersten, Jordan, & Flojo, 2005).

Previous Research on Number Sense

Previous research showed that girls and boys possess identical primary numerical abilities. Demie (2001), Gorard, Rees, and Salisbury (2001) analyzed the British National Curriculum Key Stage 1 measurements (children aged four to seven years) and reported that girls outperformed the boys in basic arithmetic. Carr and Jessup (1997) reported contradicting outcomes, as in their first school year, boys and girls may use different strategies for solving mathematical problems, but there is no difference in the level of performance (as cited in Aunio, 2006).

Methodology

This study sought to investigate preschoolers' number sense concept.

Sample of the Study

Simple random sampling technique was used in this study. First of all, the sample for 11 preschools such as 4 preschools from Ministry of Education (MOE), 4 from private schools, 1 from Myanmar Maternal and Child Welfare Association (MMCWA) and 2 from Department of Social Welfare (DSW) were selected. All are located in Yangon City Development Area (YCDA). Next, a total of 412 preschool children, at least 10 from each school were randomly selected. Out of 412 preschool children, 203 (49.7%) are girls and 209 (50.3%) are boys and their ages range from 3 to 5 years. The socioeconomic status of the sample ranged from lower, middle and upper class families. The headmistresses and administrators of eleven preschools from Yangon were contacted and invited to participate in the study.

Instrumentation of Preschoolers' Number Sense Test

The present study investigated preschoolers' number sense concept, their problem solving behaviors and the effect of number sense concept on the development of their problem solving behaviors. The instrument to measure preschoolers' number sense concept was developed by researcher. This process was undertaken by the guidance of existing standardized tests such as Test of Early Numeracy (TEN) by Clarke, B. and Shinn, M. R., (2002),

and Sandwell Early Numeracy Test Revised (SENT-R) developed by C. Arnold, M. Talents and B. Walden (2008). In this study, researcher adapted from the number sense components of SENT-R and TEN.

The instrument used in this study was adapted to Myanmar version to be suitable for Myanmar preschool children. Next, revisions in item length, and the wording of items were made during preliminary administrations of these two forms and pilot study was done with a sample of 15 preschool children from a private school to test whether the wording of items, statements and instructions had their clarity in Myanmar version. After preparing the measuring scale, expert review was conducted for face validity and content validity by 13 experts who have sound knowledge and closed relationship with this study area. The two instrument was reviewed by six experts from Educational Psychology Department, one expert from Educational Methodology Department and one expert from Educational Theory Department of Yangon Institute of Education, one expert from Educational Methodology Department of Sagaing Institute of Education, one retired expert from Educational Psychology Department of Sagaing Institute of Education, one expert from Yinthway Foundation, one expert from Sanpya Preschool and one expert from Myanmar Education Research Bureau. The initial item pool consists of 59 items: 6 items call for rote counting, 3 items for counting backwards, 6 items for number after, 6 items for number before, 6 items for number between, 6 items for number identification, 16 items for quantity discrimination, and 10 items for matching number/object. According to comments and suggestions of 13 experts, the wording of the items was revised. According to the piloting result, 18 items were left out.

Data Analysis and Results

After developing the required instrument, number sense of preschool children was investigated. Moreover, the other influencing factors on the children's number sense such as department/organization, preschool teachers' experience, age, gender, father's occupation and mother's occupation were also explored.

Number Sense of Preschoolers

The standard z-scores for Preschoolers' Number Sense Test are shown in Figure 1. Number sense test includes eight sub-scales such as Rote Counting (RC), Counting Backwards (CB), Number After (NA), Number Before (NB), Number Between (NBwn), Number Identification (NI), Quantity Discrimination (QD) and Matching number/objects (Mat). According to Figure 1, the standard score of rote counting of the

preschoolers was the highest in the eight sub-scales. The matching sub-scale was the second highest. Therefore, it can be said that preschool children can perform rote counting sub-scale better than other sub-scales of number sense. The standard score of quantity discrimination of the preschoolers was found to be the lowest on the entire number sense test.
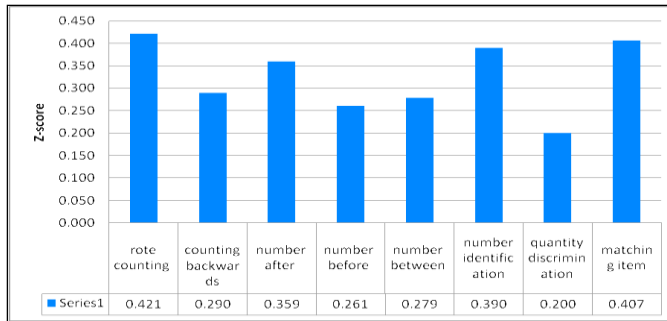

Figure 1 Sub-scales of Preschoolers' Number Sense by Standard Z-Score

Comparison of Preschoolers' Number Sense Sub-scales by Department/Organization

To explore whether or not there was significant difference among the number sense sub-scales by department/organization, further data analyses were conducted. Concerning school cluster, Table 1 shows the mean comparisons of eight sub-scales as well as total scale scores by department/organization. Based on the ANOVA results, significant differences were found among rote counting, counting backwards, number after, number identification and matching sub-scales of preschoolers' number sense test (See Table 1).

Concerning rote counting, there was significant difference between the mean score of preschoolers from preschools under MOE and that of preschoolers who attend preschools under MMCWA. Regarding number after sub-scale, there was also significant difference between the mean score of preschoolers who attend preschools under MOE and that of preschoolers who attend preschools under MMCWA.

In relation to rote counting, counting backwards, number after, number identification and matching sub-scales, the significant mean differences were found between the mean score of preschoolers who attend preschools under MOE and that of preschoolers who attend preschools under DSW. Concerning number identification, there was significant difference between the mean score of preschoolers who attend preschools under MOE and that of preschoolers who attend preschools from private school.

Table 1 Preschoolers' Number Sense Sub-scales by Department/ Organization

Sub-scales	MOE	Private	MMCWA	DSW	*F*	*p*
Rote Counting	2.367 (.7074)	2.317 (.7679)	1.837 (.8217)	1.750 (.8776)	16.297**	0.000
Counting Backwards	.47 (.501)	.37 (.483)	.28 (.454)	.12 (.327)	11.462**	0.000
Number After	4.391 (2.2329)	4.307 (2.2042)	3.488 (2.2821)	3.355 (2.5069)	5.391*	0.001
Number Before	1.427 (1.9885)	1.552 (2.2467)	1.407 (2.3761)	1.040 (1.9223)	1.208	0.306
Number Between	1.879 (2.3594)	1.541 (2.2396)	1.674 (2.4051)	1.375 (2.0990)	1.000	0.393
Number Identification	4.11 (1.745)	3.50 (2.089)	3.35 (2.148)	2.97 (2.148)	6.165**	0.000
Quantity Discrimination	5.790 (.7411)	5.779 (.7286)	5.616 (1.0956)	5.690 (.8220)	0.749	0.523
Matching	3.84 (1.884)	3.43 (2.104)	3.28 (2.240)	2.77 (2.296)	4.830*	0.003

MOE= Ministry of Education, MMCWA= Myanmar Maternal and Child Welfare Association,   DSW= Department of Social Welfare

Note. Numbers in parentheses are standard deviations.

*. The mean difference is significant at the 0.05 level.

**. The mean difference is significant at the 0.001 level.

To examine the highly significant differences across department/organization, Post-hoc Test was executed by Tukey HSD method and it became apparent that the mean score of preschoolers from preschools under MOE was significantly higher than that of preschoolers from preschools under MMCWA and DSW. To be specific, concerning rote counting, the mean score of preschoolers from preschools under MOE and that of preschoolers from preschools under MMCWA differed significantly at the 0.05 level. Concerning number after sub-scale, there was also significant difference between the mean score of preschoolers from preschools under MOE and that of preschoolers from preschools under MMCWA.

Concerning rote counting, counting backwards, number after, number identification, and matching sub-scales, there were significant differences between the mean score of preschoolers from preschools under MOE and that of preschoolers from preschools under DSW. Regarding number identification, there was significant difference between the mean score of preschoolers from preschools under MOE and that of preschoolers from Private School (See Table 2).

Table 2 Post-Hoc Analysis of Preschoolers' Number Sense Sub-scales across Department/Organization by Tukey HSD Method

Sub-scales	(I)Department/ Organization	(J)Department/ Organization	Mean Difference (I-J)	p
Rote Counting	MOE	MMCWA	0.622**	0.000
		DSW	0.747**	0.000
Counting Backwards	MOE	DSW	0.378**	0.000
Number After	MOE	MMCWA	1.182*	0.021
		DSW	1.241**	0.000
Number Identification	MOE	Private School	0.802*	0.008
		DSW	1.353**	0.000
Matching	MOE	DSW	1.314**	0.000

*. The mean difference is significant at the 0.05 level.
**. The mean difference is significant at the 0.001 level.

Comparison of Preschoolers' Number Sense Sub-scales by Preschool Teacher's Experience

The mean comparisons of preschoolers' number sense by preschool teachers' experience were shown in Table 3. The results of independent sample t-test revealed that there were significant differences between the mean score of preschoolers whose teachers had 5 years and above teaching experience and that of preschoolers whose teachers had less than 5 years teaching experience.

Table 3 Mean Comparison of Number Sense Sub-scales by Preschool Teachers' Experience

Sub-scales	Teachers' Experience	Mean	SD	t	p
Rote Counting	Under 5years	2.034	0.8976	-2.010*	0.045
	Above 5 years	2.205	0.7809		
Counting Backwards	Under 5 years	0.25	0.433	-2.613*	0.009
	Above 5 years	0.37	0.484		
Number After	Under 5 years	3.870	2.3119	-0.940	0.348
	Above 5 years	4.096	2.3467		
Number Before	Under 5 years	1.521	2.2953	1.037	0.300
	Above 5 years	1.295	2.0034		
Number Between	Under 5 years	1.616	2.3423	0.000	1.00
	Above 5 years	1.617	2.2199		
Number Identification	Under 5 years	3.71	1.802	1.96	0.060
	Above 5 years	3.59	2.117		
Quantity Discrimination	Under 5 years	5.740	0.8514	-0.079	0.937
	Above 5 years	5.746	0.7712		
Matching	Under 5 years	3.59	2.036	1.485	0.138
	Above 5 years	3.26	2.180		

*. The mean difference is significant at the 0.05 level.

Comparison of Preschoolers' Number Sense Sub-scales by Gender

Whether there was gender difference, or not, in the performance of preschoolers' number sense was worthwhile to explore. Therefore, to investigate whether number sense of preschoolers varies with regard to gender, analyses were conducted again. The results of t-test on the sub-scales of preschoolers' number sense by gender revealed that there was no gender difference for the whole number sense test (see Table 4). This finding is consistent with previous number sense research conducted by Howell and Kemp (2009). Howell and Kemp (2009) found that there was no difference between the boys and girls on most of the components of number sense.

Table 4 Results of Independent Sample t-test of Preschoolers' Number Sense Sub-scales by Gender

Sub-scales	Gender	Mean	SD	t	p
Rote Counting	Male	2.115	0.8873	-0.736	0.462
	Female	2.175	0.7612		
Counting Backwards	Male	0.32	0.466	-0.520	0.603
	Female	0.34	0.475		
Number After	Male	3.823	2.3328	-1.705	0.089
	Female	4.214	2.3245		
Number Before	Male	1.266	1.9716	-1.068	0.286
	Female	1.488	2.2457		
Number Between	Male	1.51	2.165	-0.974	0.331
	Female	1.727	2.3563		
Number Identification	Male	3.35	2.177	-1.886	0.060
	Female	3.73	1.898		
Quantity Discrimination	Male	5.675	0.9156	-1.790	0.074
	Female	5.815	0.6537		
Matching	Male	3.21	2.253	-1.673	0.095
	Female	3.56	1.993		

Comparison of Preschoolers' Number Sense Sub-scales by Age Group

In this study, preschoolers were categorized into two groups; younger preschoolers (under 4 years old) and older preschoolers (above 4 years old). And then, the mean comparisons of preschoolers' number sense sub-scales by age group were explored. The means and standard deviations for preschoolers in both age groups (younger and older) were shown in Table 5 and Figure 2.

Table 5 Preschoolers' Number Sense Eight Sub-scales by Age Group

Number Sense	Age	Mean	SD	t	p
Rote Counting	younger	1.438	0.6951	-15.21**	0.000
	older	2.493	0.6452		
Counting Backwards	younger	0.05	0.222	-9.18**	0.000
	older	0.46	0.500		

Number After	younger	2.316	2.2226	-12.06**	0.000
	Older	4.853	1.8933		
Number Before	younger	0.257	0.9108	-8.11**	0.000
	Older	1.926	2.3094		
Number Between	younger	.338	1.0644	-8.77**	0.000
	Older	2.246	2.4247		
Number Identification	younger	1.92	2.171	-13.54**	0.000
	Older	4.34	1.424		
Quantity Discrimination	younger	5.419	1.1389	-6.033**	0.000
	Older	5.904	.4907		
Matching	younger	1.62	2.133	-14.42**	0.000
	Older	4.25	1.510		

**. The mean difference is significant at the 0.001 level.

To investigate the mean differences of number sense of preschoolers by age group, independent sample t-test was conducted and it became apparent that there were significant mean differences on eight sub-scales as well as overall number sense test. The results of t-test confirmed that older preschoolers outperformed younger preschoolers in the entire number sense test. This finding is consistent with previous research conducted by Jordan, Kaplan, Olah, and Locuniak (2006). Jordan, Kaplan, Olah, and Locuniak (2006) found that children who are older when they enter kindergarten demonstrate significantly better exit number sense scores than their younger counterparts.

The Relationship between Preschoolers' Number Sense Sub-scales and Age Group

The results revealed that the eight sub-scales of preschoolers' number sense test were positively correlated with their age group (See Table 6). This finding is consistent with previous research conducted by Jordan, Kaplan, Olah, and Locuniak, (2006).
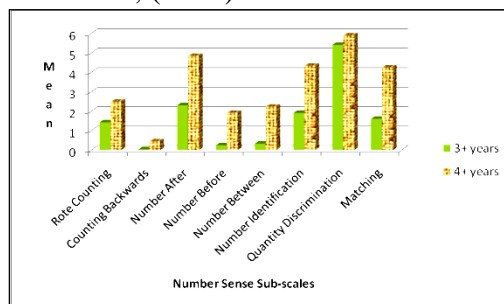

Figure 2 Mean Comparisons of Preschoolers' Number Sense Sub-scales by Age Group

Jordan, Kaplan, Olah, and Locuniak, (2006) found that there was a positive and statistically significant association between the age of entry into kindergarten and exit number sense score across the three classes of total number sense, meaning that children who are older when they enter kindergarten demonstrate significantly better exit number sense scores than their younger counterparts.

Table 6 The Relationship between Preschoolers' Number Sense Sub-scales and Age Group

	2	3	4	5	6	7	8	9	10
1.Rote counting	0.523**	0.669**	0.472**	0.466**	0.621**	0.426**	0.640**	0.756**	0.601**
2.Counting backwards	1	0.456**	0.586**	0.542**	0.409**	0.166**	0.441**	0.630**	0.413**
3.Number after		1	0.475**	0.483**	0.711**	0.392**	0.704**	0.833**	0.512**
4.Number before			1	0.686**	0.436**	0.155**	0.463**	0.737**	0.372**
5.Number between				1	0.424**	0.185**	0.460**	0.737**	0.397**
6.Number identification					1	0.355**	0.921**	0.842**	0.556**
7.Quantity discrimination						1	0.375**	0.438**	0.286**
8.Matching							1	0.861**	0.580**
9.Number sense total								1	0.614**
10.Age group									1

**. Correlation is significant at the 0.01 level (2-tailed).

5.1 Conclusion

The primary purpose of this study is to investigate to what extent preschoolers possess number sense concept. A total of 412 preschoolers (209 boys and 203 girls) from 11 preschools participated. Sub-scales of preschoolers' number sense test were categorized into rote counting, counting backwards, number after, number before, number between, number identification, quantity discrimination and matching number/object. Concerning preschoolers' number sense test, ANOVA results by type of school indicated that significant differences were found to be on rote counting, counting backwards, number after, number identification and matching sub-scales of preschoolers' number sense test. Concerning rote counting, and number after sub-scales, there were also significant differences between the mean score of preschoolers from preschools under Ministry of Education (MOE) and that of preschoolers from preschools under Myanmar Maternal and Child Welfare Association (MMCWA). Regarding rote counting, counting backwards, number after, number identification, and matching sub-scales, there were significant differences

between the mean score of preschoolers from preschools under MOE and that of preschoolers from preschools under Department of Social Welfare (DSW). Concerning number identification, significant difference was found between the mean score of preschoolers from preschools under MOE and that of preschoolers from Private School.

Regarding the preschool teachers' experience, the mean score of preschoolers whose teachers had less than 5 years teaching experience were found to be significantly lower than that of preschoolers whose teachers had 5 years and above teaching experience on the rote counting and counting backward sub-scales. However, there existed no gender difference concerning all sub-scales of preschoolers' number sense test. Moreover, it was found that older preschoolers outperformed younger preschoolers in the entire number sense test.

5.2 Discussion and Recommendation

The majority of Myanmar parents have expressed concern that their children may not able to learn cognitive skills such as mathematical skill, social skill and language skill. Nevertheless, teaching mathematics to young children, prior to formal school entry, is not a new practice. In fact, early childhood mathematics education (ECME) has been around in various forms for hundreds of years. Educators, administrators, policy makers, and families must work cooperatively to enhance awareness of the importance of mathematics in early education. Staff-development programs and up-graded training courses should be frequently conducted to inform preschool teachers and caregivers with developmentally appropriate teaching methods and simultaneously provide them with essential resources of high-quality, equitable mathematical teaching practices.

Again, Mathematics educators should be aware that children need to be immersed throughout the day in a variety of numeracy activities that enable them to be as fluent with numbers as they are with letters, sounds and words, and eventually can solve mathematical problems using their number sense.

Therefore, Myanmar parents and teachers should notice the importance of number sense concept of their children during preschool years. Parents and teachers should perceive that the fact that early learning of number sense concept and problem solving behaviors during preschool years can achieve higher educational outcomes for their children. This research was designed as an initial attempt to assess preschoolers' number sense concept, problem solving behaviors, and the effect of number sense concept on the development of problem solving in preschoolers. Nowadays, the increase in

the number of preschoolers attending preschools or daycare centers has provided an opportunity for early detection of their number sense and problem solving.

Findings from this study significantly extend the knowledge of preschoolers' number sense. The results reported above were largely descriptive and provided the first evidence that the majority of preschoolers showed good performance in number sense.

Another important component is that of the teachable moment: recognizing and capitalizing on children's spontaneous math-related discoveries by asking questions that require children to reflect and respond, by providing vocabulary and representational support, and by demonstrating extension activities that elaborate on and further support mathematical ideas. Actually, play is the most popular component for early childhood education. It is also needed to use effective strategies and materials in different learning environments for the development of preschoolers' number sense and problem solving behaviors. Therefore, teachers need to apply suitable teaching strategies so that individual preschoolers may be familiar with number sense.

5.3 Limitation

There are some limitations in this study. In the case of the study of number sense, longitudinal design is more desirable. Due to scarcity of time and resources, such design is impossible for this study, and the research area is restricted to Yangon city development area. This study would have benefited from greater teacher and parental participation. But, in a few of the samples, teachers had little interest in research work and they did not much appreciate the value of it. To be specific, some demographic factors such as parents' support and interest in their children's number sense, parental involvement in school activities, their cooperation with teachers, educational status of preschoolers' parents, teachers' concept attainment of number sense and preschoolers' duration at their respective preschools have not been considered in this study because of available time.

5.4 Suggestion for Future Research

A study of longitudinal design is necessary to clarify the age appropriate differences in preschoolers' number sense and problem solving behaviors. The limited study area pointed out the necessity to conduct a nationwide study to find out the differences between rural and urban areas. Fathers' and mothers' educational status and teachers' concept attainment of number sense should be taken into account since many studies pointed out their critically important roles.

Parents should consider the fact that their children's number sense concept and problem behaviors should be supported by day by day experiences at home. Parents should spend more time with their children on number sense related activities.

Preschool teachers should arouse children's interest in number sense concept. Most important of all, for preschool teachers and all the personnel in the field of early education, more attention should be given to implement teaching learning activities that are carefully planned to achieve learning objectives of developing children's number sense.

References

Aunio, P. (2006). Number sense in young children- (Inter) national group differences and an intervention programme for children with low and average performance. Retrieved from Helsinki University, Faculty of Behavioural Science Website: http://ethesis.helsinki.fi/julkaisut/kay/sovel/vk/aunio/numberse.pdf

Aunio, P., Aubrey, C., Godfrey, R., Luejuan, P., & Liu, R. (2008). Children's early numeracy in England, Finland and People's Republic of China. Retrieved October 2, 2012 from http://go.warwick.ac.uk/wrap

Bowman, B. T., Donovan, M. S., & Burns, M. S. (Eds.). (2001). *Eager to learn: Educating our preschoolers.* Washington, DC: National Academy of Sciences.

Carboni, L. W. (2010). Number sense every day. United State of America: University of North Carolina. Retrieved November 11, 2012 from http://www.learnnc.org/number sense

Clarke, B., & Shinn, M. R. (2004). A preliminary investigation into the identification and development of early mathematics curriculum-based measurement. Retrieved October 12, 2012 from http://www.expanding-educationalhorizons.com/Articles%_20on%20 Curriculum%_20Based%20Measurement/early%20math%20cbm.pdf

Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and interventions for students with mathematics difficulties. *Journal of Learning Disabilities, 38,* 293-304.

Jordan, N. C., & Levine, S. C. (2009). Socioeconomic variation, number competence, and mathematics learning difficulties in young children. *Developmental Disabilities Research Reviews* 15, 60-68.

McIntosh, A., Reys, B. J., & Reys, R. E. (1992). A Proposed framework for examining basic number sense. *For the Learning of Mathematics,* 12(3), 2-8.

McIntosh, A., Reys, B. J., Reys, R. E., Bana, J. & Farrell, B. (1997). *Number sense in school mathematics: Student performance in four countries,* Perth, Australia: Edith Cowan University.

Morrison, G. (1988). *Early Childhood Education Today.* (4th Ed.). Ohio; Merrill Publishing Company.

Reys, R., Reys, B., McIntosh, A., Emanuelsson, G., Johansson, B., & Yang, D. C. (1999). Assessing number sense of students in Australia, Sweden, Taiwan, and the United States. *School Science & Mathematics, 99*(2), 61-70.

Appendix

Sample Items of Preschoolers' Number Sense Test (PNST)

၁။ ကိန်းများကို အစဉ်လိုက်ရေတွက်စေခြင်း

(Rote Counting)

   (၆) ၁ မှ ၃၀ အထိ အသံထွက်၍ ရေတွက်ပါ။

၂။ ကိန်းများကို ကြီးစဉ်ငယ်လိုက် ရေတွက်စေခြင်း

(Counting Backwards)

   (၁) ၅ မှ ၁ အထိ ကြီးစဉ်ငယ်လိုက် ရေတွက်ပါ။

၃။ ကိန်းတစ်ခုကိုပြပြီး ထိုကိန်းပြီးရင် မည်သည့်ကိန်းလာသနည်းဟုမေးခြင်း

 (**Number After**)

   (၁) ၂ ပြီးရင် မည်သည့်ကိန်းလာသနည်း။

   (၆) ၁၅ ပြီးရင် မည်သည့်ကိန်းလာသနည်း။

၄။ ကိန်းတစ်ခုကိုပြပြီး ထိုကိန်းမရောက်ခင်မည်သည့်ကိန်းရှိသနည်းဟုမေးခြင်း

(Number Before)

   (၁) ၃ မရောက်ခင် မည်သည့်ကိန်းရှိသနည်းဟုမေးခြင်း။

   (၅) ၁၃ မရောက်ခင် မည်သည့်ကိန်းရှိသနည်းဟုမေးခြင်း။

၅။ ကိန်းနှစ်ခုကိုပြပြီးထိုကိန်းနှစ်ခုကြားရှိကိန်းကို မေးခြင်း
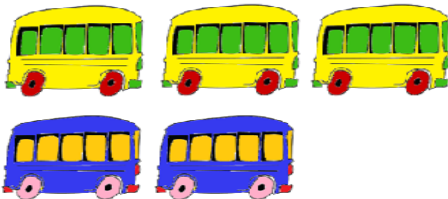
(**Number Between**)

   (၁) ၂ နှင့် ၄ ကြားရှိကိန်းကိုမေးခြင်း။

၆။ ကဒ်ပြားပေါ်ရှိ ကိန်းကို ထောက်ပြ၍ မေးခြင်း (**Number Identification**)

   (၁) ၂ ကိုထောက်ပြကာ မည်သည့်ကိန်းဖြစ်သနည်းဟုမေးခြင်း။

၇။ ပစ္စည်းအရေအတွက်အနည်းအများခွဲခြားဆန်းစစ်ခြင်း (**Quantity Discriminition**)

   (၁) ကားအပြာရောင် နှင့် အဝါရောင်မည်သည့်အရောင်က အရေအတွက် များသလဲ။

၈။ ကိန်းဂဏန်းသိမသိ ဆန်းစစ်ခြင်း (**Number Identification**)

   (၁)ကလေးငယ်အားကတ်ပြားပေါ်ရှိ ၂ ကိုထောက်ပြကာမည်သည့်ကိန်း ဖြစ်သနည်း ဟုမေးမည်။

   မှတ်ချက်။ ။မေးမြန်းနေစဉ်မေးမြန်းသူသည်မေးမြန်းလိုသောကိန်းရေးထားသော ကတ်ပြား အားထောက်ပြရမည်။

၉။ အောက်တွင်ဖော်ပြထားသောရုပ်ပုံများကို ကြည့်၍ သက်ဆိုင်ရာရုပ်ပုံအရေအတွက်နှင့် ကိုက်ညီသော ကိန်းကဒ်ပြားကို ရွေးချယ်ယှဉ်တွဲဖြေဆိုပါ။ **(Number/Object Matching)**