

# The Effect of Early Numeracy Program on the Development of Number Concept in Children at 48-60 Months of Age<sup>i</sup>

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**Abstract** This study investigates the effect of Early Numeracy Program on the development of number concept in children at 48-60 months of age. The study was carried out in the central district of a province (Mugla/ Mentese) in the Aegean region of Turkey. The study group of the research included 78 children (40 in experiment group, 38 in control groups) attending two different kindergartens in the central district of the aforementioned province. In this study in which quasi-experimental design with pre-test-post-test control group was used the data were collected with Early Numeracy Assessment and Number Development Assessment Tool. SPSS was used for data analysis and whether there was a significant difference between the mean scores of the experimental and control groups in terms of pretest, post-test, and follow-up test was checked using Independent Samples t-Test and Dependent Samples t-Test. Early Numeracy Program supported with educational material was applied to children for 2 days a week over a period of 12 weeks. In the statistical analysis, it was found that the mean post-test scores of the children in the experiment group were significantly higher than the mean scores of the children in the control group. As a result, it was determined that the applied Early Numeracy Program significantly increases the level of development of number concept for children at 48-60 months of age.

**Keywords** Preschool Education, Number Concept, Number Development, Educational Materials

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## 1. Introduction

Mathematics, a crucial component of preschool education programs, is a powerful tool for children to understand and explore the world and an important academic skill to be acquired by children [1-2]. Research

on preschool period demonstrates that mathematical skills should be given to children from an early age. It is because preschool years are critical in acquiring academic skills in future years, in gaining advanced mathematical skills and in developing attitudes towards mathematics [3-4-5-6-7-8-9-10]. The National Council of Teachers of Mathematics (NCTM) has set out various principles and standards for the programs to be prepared in the field of mathematics and explained the mathematical skills that should be acquired in the preschool period [11]. According to this, preschool period mathematical concepts and skills include the elements such as recognition, naming, comparison, matching, classification, sorting, numbers, addition and subtraction, part-whole relation, pattern, geometry and spatial perception, measurement, graph-making. Of all these, the concept of number is considered by NCTM (2000) as one of the most important elements of educational programs from preschool to the end of secondary school [11].

The numbers, which form the cornerstone of mathematics programs are the most important determinants of advanced mathematics ability and a prerequisite for teaching advanced mathematics skills [13-14-15]. The knowledge on number in preschool period is found analogous with the phonological sensitivity in reading process. As the lack of phonological sensitivity in preschool period leads to some problems in reading in the future, the lack of knowledge on the concept of number in early period may similarly lead to difficulties in mathematics in the following years [16]. In the majority of studies on the concept of number, it is put forth that mathematics-related learning problems originate from the lack of knowledge on number concept in the preschool period [17-18-19-20].

Children need time and more experience to better understand the concept of number [21]. For number development, therefore, the experiences provided to

children in preschool education institutions should be enriched with a systematic education program [22]. Within the framework of this understanding, there are mathematics programs for preschool period with enriched content for number concept skills such as Building Blocks, Pre-K Mathematics, Big Math for Little Kids, Number World and A Good Start To Numeracy developed in accordance with the NCTM standards in the US and Europe. [23-24-25-26-27-28]. One of the common features of these programs is that they include various educational materials that children may have a first-hand experience [29-30]. Educational materials, an indispensable part of learning environments, play a crucial role in the acquisition of mathematical concepts [31]. Holmes (2013) also states in his meta-analysis that the educational materials are highly effective in mathematics achievement of children from pre-school to 12th grade [32].

When the subject is examined throughout the literature; it can be seen that in recent years, there has been a large increase in the number of studies related to number development in the preschool period in the international literature. In these studies, in addition to applied programs and to the endeavor to develop assessment/ evaluation tools to determine the level of competence levels of preschool children in terms of number concept and skills and accordingly identifying the children at risk, it has been reported that studies are being carried out to prepare education programs or educational materials enriched in terms of number concept and skills.

When we examine the literature on the subject parallel to the international domain, it has been established that in Turkey, the number of studies on the concept of number development of children in preschool period has increased in recent years. When these studies are examined, it is seen that adaptation efforts are made for the programs developed abroad (Big Math for Little Kids) that include assessment/evaluations tools developed or adapted for the assessment and evaluation of number development and programs based on supporting the concept of number and number skills through different methods and techniques are being developed. Additionally, a great majority of education programs on number development are directed towards children at 61-72 months of age [27-37-38-39-40-41-42-43].

Considering that the concept of number is an important element of advanced mathematics, it is believed that it is important to develop education programs in order to support number skills from early ages in preschool period and to enhance the number skills of children by means of these programs. Moreover, it is thought that educational programs enriched with educational materials related to number skills will be useful in providing a different perspective to the teachers working in preschool education institutions and will contribute to the studies on this subject. From this point of view, the main purpose of the study is to investigate the effect of Early Numeracy Program on the development of concept of number in 48-60-month-old

children.

## 2. Materials and Methods

### 2.1. Research Design

In this study, quasi-experimental design with pre-test-post-test control group was used to examine the effect of the Early Numeracy Program on the development of number concept for children at 48-60 months of age. Quasi-experimental designs are a high-validity model in studies in the field of education where it is not possible to control all variables [44]. In accordance with the quasi-experimental design with pre-test and post-test control group, the decision to determine which group would be experiment and which would be control was made with random assignment and Early Numeracy Assessment and Number Development Assessment Tool were applied to each group simultaneously. In the design, the dependent variable is 'The Development of Number Concept', and the independent variable of which the effect on the development of number concept in children at 48-60 months of age is investigated is 'Early Numeracy Program'.

### 2.2. Study Group

The universe of the study consisted of children with normal development at 48-60 months of age attending public kindergartens under the Ministry of National Education in a central district (Mugla/ Mentese) of a province in the Aegean region of Turkey

In order to create a working group, a list of public kindergartens was obtained from the Provincial Directorate of National Education. Then, the preschools were visited and the principals were informed about the purpose and content of the study and the number of school divisions in which 48-60-month old children are educated schools was determined. Among the four divisions selected, experiment and control groups were formed with random assignment. In this respect, 40 children (22 girls and 18 boys) from two divisions of the school A were included in the experiment group and 38 children (18 girls and 20 boys) from two other divisions of the school B were included in the control group.

In order to test the effectiveness of the method / program applied in experimental studies, it should be determined whether there is a significant difference between the groups in terms of the effect of the variable examined before the application [45]. To this end, independent samples t-Test analysis was conducted to find out whether there was a significant difference among the mean scores of children in the experiment and control groups obtained from the subs-scales of Early Numeracy Evaluation Scale and Number Development Assessment Tool before the application and results are given in Table 1.

**Table 1.** Independent Samples t-Test results for the pre-test scores of children in the experiment and control groups.

Early Numeracy Assessment	Group	n	$\bar{X}$	sd	t	p
Count Objects-Circle Number	Experiment	40	9.73	76	0.48	0.63
	Control	38	10.36			
Count Objects-Write Number	Experiment	40	6.32	76	0.17	0.86
	Control	38	6.13			
Identify Number-Draw Circles	Experiment	40	2.80	76	0.53	0.59
	Control	38	3.10			
Total of Early Numeracy Assessment	Experiment	40	18.85	76	0.28	0.77
	Control	38	19.60			
Number Development Assessment Tool	Experiment	40	5.37	76	0.45	0.64
	Control	38	3.10			

Table 1 show that there is no significant difference between the pre-test scores of the children in the experiment and control groups in terms of the sub-scales of the Early Numeracy Assessment Scale, the sum of the scale and of the Number Development Assessment Tool. According to this result, it can be said that the children in the experimental and control groups had similar characteristics in terms of their number development skills on the onset of their education.

### 2.3. Data Collection Tools

*Early Numeracy Assessment:* Early Numeracy Assessment Scale is one of the sub-scales of the Kindergarten Early Numeracy and Literacy Assessment-KENELA developed by Van Der Heyden, Witt, Naquin and Noell in 2001 [43]. The scale was developed based on six principles set forth by the NCTM [46]. Early Numeracy Assessment Scale given the final form by Van Der Heyden in 2008 consists of three sub-scales as follows: Count Objects-Circle Number to 10, Count Objects-Number Number 10 and Identify Number-Draw Circles. [43]. Early Numeracy Assessment has a total of 61 questions and the application period of the scale is approximately 20-25 minutes. The application of the scale starts from the first sub-scale. The items included in the sub-scales are evaluated as true, false and no response; one point for correct answers, zero score for no response and false answers. The correct score for each sub-scale is collected and the total score of the scale is calculated by summing sub-scale scores [43].

The validity and reliability study of the Early Numeracy Assessment Scale was carried out by Yilmaz and Inal Kiziltepe (2017) on 300 children at 48-60 months of age, continuing their independent kindergartens in the central district of a province in the Aegean region [43]. Expert opinion consulted for the validity of the test was evaluated using the Lawshe Technique. Since the Content Validity Index (CVI) values for the sub-scales and the total of the scale were obtained as 1.00, it was assumed that the scale

had a content validity. For the reliability of the scores in the scale's reliability study, Kuder Richardson (KR-20) values were found to be .963, .976, and .971, respectively for Count Objects-Circle Number, Count Objects-Write Number, Identify Number-Draw Circles. For the sum of Early Numeracy Assessment Scale, the KR-20 value was found to be .985. In order to support the KR-20 reliability coefficients of the scale, the relationship between sub-scales within themselves was examined. As a result of the Spearman Brown Sequence correlation analysis, it was found that the relationship between all sub-scales was positive and statistically significant at the level of ( $p < .05$ ). These results indicate that the Early Numeracy Assessment Scale is valid and reliable for children at 48-60 months of age [43].

*Number Development Assessment Tool:* Counting Development Assessment Tool was developed by Olkun, Fidan and Babacan Ozer (2013). The assessment tool was developed for the purpose of examining the development of counting principles in children and their level of knowledge on counting and their ability to use counting in different problem solving contexts. Assessment tool was prepared similar to the questions used in a study conducted by Sophian (1987). The main aim of the assessment tool is to examine the development of counting principles that include stable-order, one-to-one and cardinal value in more detail. There are 14 questions in the Number Development Assessment Tool and an application conducted individually with each child lasts 15-20 minutes. In the assessment tool, the questions are evaluated as either true or false, a score of 1 is given for the correct answers and zero for the wrong answers. For the first question in which children are asked whether they know how to count, they should manage to count at least to 8 so that the answer is accepted as correct [47].

In the validity and reliability study of the assessment tool, carried out on 74 children in five different regions of a large province in Central Anatolia region of Turkey, KR-20 reliability coefficient was calculated as .64 [47].

*Early Numeracy Program:* In order to create the Early

Numeracy Program, firstly, literature review on mathematics, mathematics standards and its content, mathematical concepts and skills, number concept, counting, number development, number preservation, counting principles and stages in number counting was made. Then, the contents of the mathematics programs enriched in terms of number concept skills and developed within the framework of NCTM standards such as Building Blocks, Pre-K Mathematics, Big Math for Little Kids, Number World and A Good Start To Numeracy were examined. In this respect, the content of education program was developed in such a way to include skills to support the development of number concept such as pairing, classification, comparison, sorting, rote counting, logical counting, cardinal, ordinal and nominal numbers, number recognition, number writing. In the preparation of the content of the program, the acquisitions and indicators in the Ministry of National Education (MONE) Preschool Education Program (2013) were taken as basis along with the literature analyses [48]. In line with the identified acquisitions and indicators, the program was prepared by taking into consideration the individual differences of children, their developmental characteristics, from their immediate surroundings to remote surroundings, from simple to complex, from concrete to abstract, principles and the active participation of children in the process.

In the Early Numeracy Program, activity plans are composed of the integrated activities of Mathematics, Games, Reading-Writing Preparation, Drama, Literature and Art activities, which include individual, small and large group activities. The program entails 24 activity plans prepared twice a week within a 12-week period. Furthermore, for each activity in the program, educational materials under the name of ‘material of the day’ have been developed to support children’s number development in accordance with acquisitions and indicators discussed on a given day.

The material of the day (at least eight of each material) was placed in the mathematics center in the classroom prior to the activity to be carried out that day. In this way, it was ensured that children came into an interaction with the materials. In this framework, 24 materials were developed in parallel with the activity plans. The reason why ‘material of the day’ application is added into Early Numeracy Program is that educational materials are frequently used in the programs created for number development in the international sphere and also because learning centers and children’s interaction with the materials in these center gained significance in accordance with the implementation of Ministry of Education’s preschool education program for 36-72 month-old children in 2013 [48]. It was also aimed to provide pre-school education teachers with the guidance to be able to prepare materials to support number development and to use these materials effectively by children through learning centers.

The Early Numeracy Program prepared was presented to

the opinion of five preschool education experts working in different universities. Experts were asked to evaluate the education program prepared taking into account the criteria such as acquisitions and indicators, concepts, learning process and suitability of the program in line with the material of the day, adequacy of learning processes, suitability and adequacy of materials used, appropriateness of distribution of acquisitions and indicators and clarity of the instructions given. After the necessary corrections have been made in line with the criticism and suggestions of the field experts, Early Numeracy Program was finalized. Early Numeracy Program was implemented after obtaining the necessary permits from the parents of the children and from the Provincial Directorate of National Education.

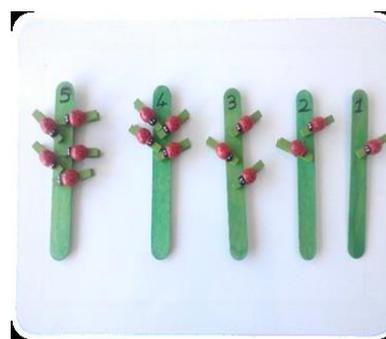


Figure 1. Sample for ‘the material of the day’



Figure 2. Sample for ‘the material of the day’

## 2.4. Data Collection

After the pre-test, Early Numeracy Program was applied to the children in the experiment group in a period of 12 weeks, two days a week (Tuesday-Thursday), 90-120 minutes per day. When the Early Numeracy Program was not implemented, classroom teachers continued to apply the Ministry of National Education’s Preschool Education Program for 36-72 month-old children. The children in the experiment group were able to interact with the materials placed in the learning center within the scope of the application of the material on the days when the Early Numeracy Program was not applied. For the control group, however, the Ministry of National Education 36-72 Month Preschool Education Program was implemented by the classroom teachers. After the experimental application, Early Numeracy Assessment Scale and Number

Development Assessment Tool were applied as a post-test to the children in the experiment and control groups in the same environment and under the same conditions where pre-tests had been implemented. Six weeks after the application of the post-tests, the same scales were applied to the children in the experiment group as a follow-up test.

### 2.5. Data Analysis

In the study, whether the data obtained from the scales display a normal distribution was examined with ‘skewness, kurtosis coefficients’ and ‘Shapiro-Wilks test’. Accordingly, since experiment and control group values have a normal distribution for the comparisons of pre-test, post-test and follow-ups tests related to the assessment tools, Independent Samples t-Test and Dependent Samples t-Test were used. In the study, SPSS 22.00 software was used to analyze the data and in the analysis of data significance level of .05 was taken as the basis.

## 3. Findings

Findings obtained through data analysis are presented in

tables.

Table 2 shows that there is significant difference between the mean pre-test and post-test scores of the children in the experiment group in terms of the sub-scales of the Early Numeracy Assessment Scale, the sum of the scale and of the Number Development Assessment Tool. This difference observed was found to be in favor of the post-test score. According to this result, it can be said that the applied Early Numeracy Program has an effect on the development of number skills of the children in the experiment group.

Table 3 shows that there is a significant difference between the pre-test post-test mean scores of the children in the control group in terms of the sub-scales of the Early Numeracy Assessment Scale, the sum of the scale and of Number Development Assessment Tool. This difference observed was found to be in favor of the post-test score. A statistically significant increase in the scale scores of the children in the control group was thought to be due to the provision of acquisitions and indicators in the MONE’s Preschool Education Program (2013) applied to children and due to children’s number development in the course of the study.

**Table 2.** Dependent-samples t test results for the children in the experiment group according to their pre-test, post-test scores

Early Numeracy Assessment	Test	n	$\bar{X}$	sd	t	p
Count Objects-Circle Number	Pre-test	40	9.72	39	-11.5	0.00*
	Post-test	40	19.4			
Count Objects-Write Number	Pre-test	40	6.32	39	-13.8	0.00*
	Post-test	40	17.6			
Identify Number-Draw Circles	Pre-test	40	2.80	39	-16.7	0.00*
	Posttest	40	14.1			
Total of Early Numeracy Assessment	Pre-test	40	18.8	39	-22.5	0.00*
	Posttest	40	51.0			
Number Development Assessment Tool	Pre-test	40	5.37	39	-12.1	0.00*
	Post-test	40	10.9			

\*p<0.05

**Table 3.** Dependent-samples t-Test results for the children in the control group according to their pre-test, post-test scores

Early Numeracy Assessment	Test	n	$\bar{X}$	sd	t	p
Count Objects-Circle Number	Pre-test	38	10.3	37	-4.48	0.00*
	Post-test	38	13.3			
Count Objects-Write Number	Pre-test	38	6.1	37	-7.87	0.00*
	Post-test	38	10.8			
Identify Number-Draw Circles	Pre-test	38	3.1	37	-12.0	0.00*
	Post-test	38	7.3			
Total of Early Numeracy Assessment	Pre-test	38	19.6	37	-10.6	0.00*
	Posttest	38	31.5			
Number Development Assessment Tool	Pre-test	38	5.1	37	-5.61	0.00*
	Post-test	38	7.3			

\*p<0.05

Table 4 shows that there is a significant difference between the mean post-test scores of the children in the experiment and control groups in terms of the sub-scales of the Early Numeracy Assessment Scale, the sum of the scale and of the Number Development Assessment Tool. The difference observed was found to be in favor of the experiment group. This result shows that the mean scores of the children in the experiment group were higher than the mean scores of the children in the control group.

Figure 3 shows the differences between the mean post-test pre-test scores of the children in the experiment

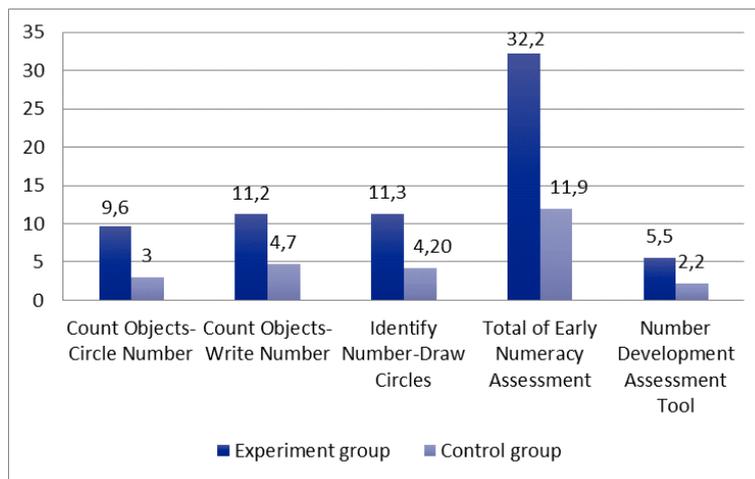
and control groups in terms of the sub-scales of the Early Numeracy Assessment Scale, the sum of the scale and of the Number Development Assessment Tool.

When Figure 3 is examined, it is seen that assessment tool-related post-test-pretest score differences of the children in the experiment group are much higher than the scores of the children in the control group. In line with this finding, it can be said that the applied program has a significant influence on the development of number concept in children within the experiment group.

**Table 4.** Independent Samples t-Test results for the post-test scores of children in the experiment and control groups.

Early Numeracy Assessment	Group	n	$\bar{X}$	sd	t	p
Count Objects-Circle Number	Experiment	40	19.4	76	6.48	0.00*
	Control	38	13.3			
Count Objects-Write Number	Experiment	40	17.6	76	7.91	0.00*
	Control	38	10.8			
Identify Number-Draw Circles	Experiment	40	14.1	76	7.90	0.00*
	Control	38	7.3			
Total of Early Numeracy Assessment	Experiment	40	51.1	76	9.73	0.00*
	Control	38	31.5			
Number Development Assessment Tool	Experiment	40	10.9	76	4.94	0.00*
	Control	38	7.31			

\*p<0.05



**Figure 3.** Post-test - Pre-test Differences of the Children in the Experiment and Control Groups

**Table 5.** Dependent-samples t test results for the children in the experiment group according to their post-test and follow-up test scores

Early Numeracy Assessment	Test	n	$\bar{X}$	sd	t	p
Count Objects-Circle Number	Post-test	40	19.4	39	-0.79	0.43
	Follow-up test	40	19.9			
Count Objects-Write Number	Post-test	40	17.6	39	-1.49	0.14
	Follow-up test	40	18.5			
Identify Number-Draw Circles	Post-test	40	14.1	39	1.06	0.29
	Follow-up test	40	13.2			
Total of Early Numeracy Assessment	Post-test	40	51.1	39	-0.35	0.72
	Follow-up test	40	51.6			
Number Development Assessment Tool	Post-test	40	10.9	39	-0.42	0.67
	Follow-up test	40	11.0			

Table 5 shows that there is no significant difference between mean post-test -follow-up test scores of the children in the experiment group in terms of the sub-scales of the Early Numeracy Assessment Measure, the sum of the measure and of Number Development Assessment Tool. The results of the follow-up test performed six weeks after the post-test demonstrate that there is no decrease in the related scores for the children in the experiment group. Thus, it can be claimed that the education given accordingly is permanent.

#### 4. Discussion and Conclusions

This study aims to determine the effect of Early Numeracy Program on the development of number concept in children at 48-60 months of age. Considering the effect of number skills acquired in preschool age on later mathematics achievement, it is considered important to develop education programs to support the number skills of children from an early age. In this context, two classes were selected as control and another two as experiment among 48-60 month-old children in independent kindergartens in the central district of a province in the Aegean region of Turkey Applying Early Numeracy Assessment and Number Development Assessment Tool to children in experiment. And control groups, it was aimed to determine the effect of Early Numeracy Program on the development of number concept. Additionally, scales were applied as follow-up tests so as to test whether the effect of the education given to the children in the experiment group still lasts six weeks after the post-test.

At the end of the study, the post-test mean scores of the children in both the experiment and control groups showed an increase compared to the mean scores of the pre-test. Given that the education process lasts 12 weeks, the increase in the mean scores is expected. However, as a result of the analyses, it was determined that the increase in the scores of the experiment group was significantly higher than the control group. According to this finding, it can be

said that while change in the experiment group is significant and the change in the control group may be random. A statistically significant increase in the scale scores of the children in the control group is believed to be due to the provision of acquisitions and indicators in the Ministry of National Education's Preschool Education Program (2013) applied to children and due to children's number development in the course of the study [48]. In the comparison of the post-test and follow-up test mean scores of the children in the experiment group, no statistically significant difference was found. According to these results, it is possible to say that the Early Numeracy Program has an impact on the development of number concept and that the effect is permanent.

When the literature is examined, it is possible to encounter many other studies suggesting that similar educational practices are effective in the development of the number skills of preschool children [25-26-27-33-34-41-49-50]. Young Loveridge (2004), based on the children's books and game method associated with the number concept, has developed an educational program and determined its effects on the counting skills of five-year-old children [34]. Kaufmann, Delazer, Pohl, Semenza and Dowker (2005) has determined the effects of the education program they developed on the number and operation skills for preschool children [51]. Baroody, Eiland and Thompson (2009) found that ten-week education program, which was based on play and materials they applied three times a week was effective on the basic number skills of preschool children [52]. Similarly, Saritas (2010) found that GEMS (Great Explorations in Math and Science) program which he adapted into Ministry of National Education's preschool education program has an effect on children's number concept and counting skills [53], Onkol (2012) found out Early Number Development Program is effective for the number development of 6 year-old children [42].

In addition to this, the use of educational materials to facilitate the acquisition of mathematical relations in educational programs developed, to embody the concepts

and to enable children to acquire hands-on experiences; increases the effect of the education that is given to children [54-55-56-57]. Ramani and Siegler (2008) found that the game-based educational materials they developed (number board games) were very effective in developing the number skills of children coming from low socio-economic levels [35]. Ojose and Sexton (2009), in their study with first-grade children, have found that manipulative, in other words, the use of educational materials is effective in improving the knowledge of finding and creating number values [58]. Erdogan, Parpuç and Boz (2017) found that educational materials they developed in relation to numbers and operations had an effect on children's mathematical skills in the 60-72 month age group [31]. These researches support the results of this study.

The limitations of the study should also be taken into consideration in the evaluation of the results of the study. The findings of this study are limited to 78 children at 48-60 months of age and to the activities and educational materials included in the Early Numeracy Program. Another limitation of the study is that the follow-up test was only applied to the experiment group. Accordingly, in order to test the effectiveness of the education program developed, pilot schools can be selected so that a larger sample group can benefit from this education and the results can be tested. In addition, longitudinal studies can be conducted to examine the effect of Early Numeracy Program on later mathematics achievement of children.

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