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The Effect of The Manipulative Materials on The Early Mathematical Skills

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Abstract

The aim of this study is to examine the effect of the manipulative materials on the early mathematical skills of the preschool children. The research is a quantitative study in experimental design. The study group of the research was composed of 45 children, 22 experimental group and 23 control group, who are 60-72-month and attending the preschool education in the 2015-2016 educational year. The Demographic Information Form and the Test of Early Mathematics Ability-Third Edition (TEMA-3) were used as the data collection tool. For the children in the experimental group, a learning environment was established outside the classroom environment and the children interacted with the manipulative mathematical materials for six weeks. As a result of the analyses performed, a statistically significant difference was found between the pretest-posttest average scores of the children in the experimental group in favor of the posttest; a statistically significant difference was found between the posttest average scores of the children in the experimental and control group in favor of the experimental group. According to this result, it was determined that the manipulative mathematical materials had positive effects on the early mathematical skills of preschool children.

Manipülatif Materyallerin Erken Matematik Becerilerine Etkisi

Makale Bilgisi

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Öz

Bu çalışmanın amacı, manipulatif materyallerin okul öncesi dönemdeki çocukların erken matematik becerilerine etkisinin incelenmesidir. Araştırma deneysel desende nicel bir çalışmadır. Araştırmanın çalışma grubunu 60-72 aylık olan ve 2015-2016 eğitim-öğretim yılında okul öncesi eğitime devam eden 22'si deney, 23'ü kontrol grubunda olmak üzere toplam 45 çocuk oluşturmaktadır. Veri toplama aracı olarak Demografik Bilgi Formu ve Erken Matematik Yeteneği Testi-3 (TEMA-3) kullanılmıştır. Deney grubundaki çocuklar için, sınıf ortamının dışında bir öğrenme ortamı oluşturulmuş ve bu ortamda çocukların altı hafta boyunca manipulatif matematik materyalleri ile etkileşim kurmaları sağlanmıştır. Yapılan analizler sonucunda, deney grubunu oluşturan çocukların öntest-sontest puan ortalamaları arasında son test lehine; deney ve kontrol grubundaki çocukların sontest puan ortalamaları arasında da deney grubu lehine istatistiksel olarak anlamlı bir fark bulunmuştur. Bu sonuca göre, manipülatif matematik materyallerinin okul öncesi dönemdeki çocukların erken matematik becerileri üzerinde olumlu etkisinin olduğu belirlenmiştir.

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Introduction

Change is effective also in education as it is in every field. In order to raise the individuals needed by the society and to bring them the knowledge and the skills of our age, the teachers' role also has become different and the teacher is not the only source of education together with this changing sense of education. Together with the change of the description of "learning", information is not conveyed only by teachers, the learning environments also play an important role in facilitating learning. The interaction of the individual with his/her environment, having rich experiences is provided by arranging the learning environments. These environments provide opportunities for individuals to test, correct and reproduce the information they have constructed (Yaşar, 1998). These learning environments, affecting the learning in the explanation of the information by the learner, differentiates based on the developmental level and needs. Akyol (2011) have emphasized that the learning environments are important for the learners, according to the constructivist approach. The studies have revealed that the learning environments have parallels with the cognitive, affective learning products of the students and the academic achievement of the students increase when they are in the learning environments they like (Fraser & Fisher, 1983; McRobbie & Fraser, 1993). And the educational materials have great importance in establishing the learning environments and presenting the information. The instructional materials are tools that help learners construct knowledge, establish new knowledge, and perform instruction more effectively in the teaching environments. The instructional materials present multiple learning environments for learners' needs, which are remarkable, provide remembrance, materialize, save time, and facilitate understanding of content (Yalın, 2004). The inclusion of more than one sensory organ in the process allows learning permanent (Ergün & Özdaş, 1997). When learning environments are prepared, this principle should be taken into consideration and it should be allowed that the presentation of information is performed with the teaching materials addressing multiple senses for permanent and meaningful learning. Moreover, if the knowledge is abstract, more concrete materials need to be included in the learning environment (Kutluca & Akın, 2013). The preschool children, due to their ages, are in the preoperational stage, one of the cognitive developmental stages, and therefore, they have difficulty in perceiving and constructing the abstract concepts. For this reason, it is important to establish a learning environment based on concrete, that is, physical knowledge, and to include the concrete materials in the process. The concretization of the abstract concepts is only possible with the teaching materials (Toptaş, 2008). As it contains abstract concepts, mathematics is one of the branches of science in which the use of teaching materials becomes important.

Mathematics is an important part of our daily life. Many basic mathematical concepts develop in the preschool period, and some experimental researches reveal that there are differences in the mathematical competences of the children when they start the elementary school. The mathematical skills of the children are among the important factors for their success and it is seen that these skills form the basis of their professional careers in adulthood (Dağlıoğlu, Genç & Dağlı, 2017). However, as the preschool children are in the preoperational stage, it is seen that they do not have enough maturity to explain the abstract mathematical concepts and problems. Piaget (1952) has emphasized that the individual constructs the knowledge himself; he/she needs a cognitive maturity to understand the abstract mathematical concepts and the concrete materials and experience is important. The active interaction of the learners with the concrete materials is necessary for the construction of complex knowledge. The children in the preschool period also gain reasoning skills through concrete experiences. Skemp (1987) has stated that the interaction of the children with the concrete objects will form the basis for their abstract learning. In many studies, the concrete materials are recommended as a solution for explaining the mathematical concepts and relationships (Castro, 2006; Gürbüz, 2007; Kutluca & Akın, 2013; Remillard, 2000; Sowell, 1989). At this point, it is necessary to refer the manipulative materials in mathematics education.

Manipulative materials, which are concrete teaching materials, are the objects that encourage conscious or unconscious mathematical thinking and that the individual deals with the affective behavior (Swan & Marshall, 2010). Hynes (1986) has described the term "manipulative" as "the concrete models putting the mathematical concepts together, addressing various emotions and that can be touched and moved by the students". In NCTM (1989), the decisions on using the manipulative materials in mathematics have been made and it has been supported in 2000 that the manipulatives are sources to use in order to improve the mathematics education. The manipulatives, "the concrete materials" are considered to be very important for improving the mathematical

education and it will continue to play an important role as an important instrument in order to perform and motivate the change in learning and teaching (Ball, 1992).

For the preschool children, the physical knowledge is important in understanding the mathematical concepts. In explaining the two-dimensional representations and abstract concepts, the literature has revealed that the manipulative materials serve as a bridge from concrete to abstract and support learning (Boggan, Harper & Whitmire, 2010; Cope, 2015; Laski, Jor'dan, Daoust & Murray, 2015). The manipulative materials provide interaction and learning experience. Heddens (1986) has also described the pedagogical effects of using the manipulative materials as helping learning.

Today, the manipulative materials involve an important part of the educational material industry. For this reason, we may classify the manipulatives as the commercial-industrial products and the handmade products by the teachers, experts, educators. In this study, the manipulative materials produced by researchers were provided to the preschool children. Based on the fact that the use of the manipulatives supports the explanation of the abstract concepts and the symbols by the children, in this research, it was aimed to examine the effects of the manipulative mathematical materials on the early mathematical skills of the preschool children. The research questions are as follows:

1. Is there a statistically significant difference between the pretest scores and the posttest scores obtained by the children in the experimental group in the Test of Early Mathematics Ability-3?
2. Is there a statistically significant difference between the posttest scores obtained by the children in the experimental and the control groups in the Test of Early Mathematics Ability-3?

Method

Research Design

The research is a quantitative study in experimental design. The experimental designs are the studies, also known as "the scientific method", performed to determine the cause and effect relationships between the variables by examining all the phenomenon, event, object, subject, and factors, and measure them by comparing the results (Ersoy, 2013). In the research, the pretest-posttest model with a control group was used in order to determine the effect of the manipulative mathematical materials on the early mathematical skills of the preschool children. In this model, there are two groups, an experimental and a control group, formed with the random method. In both groups, a pretest is applied before the intervention and the posttest is applied after the intervention (Karasar, 2013). The required ethical permits were taken for the research.

Study Group

The study group of the research was composed of 60-72 month children attending an independent preschool and an institutional preschool affiliated to the Ministry of Education in the 2015-2016 educational year. An experimental and a control group was included in the study. Totally 45 children, 22 (12 girls, 10 boys) in the experimental group and 23 (9 girls, 14 boys) in the control group, were included in the research. The age average of the children included in the experimental and the control group is 63 months. When the ages and the educational levels of the parents of the children included in the experimental group were examined, it was observed that 36% of the mothers and 41% of the fathers were at the age of 31-35, 68% of the mothers and 73% of the fathers were university graduates. When the ages and the educational levels of the parents of the children included in the control group were examined, it was observed that 70% of the mothers and 74% of the fathers were at the age of 36-40, 74% of the mothers and the fathers were university graduates. The teacher of the children in the experimental group had 16, the teacher of the children in the control group had 11 years of professional experience and both teachers were pre-school education graduates.

According to the results of the Mann Whitney-U Test performed to reveal whether there was a significant difference between the pretest scores of the experimental and the control group, no statistically significant difference was observed between the scores of the experimental group (Median:24) and the scores of the control group (Median:21) ($U=225$, $p<.05$). According to this finding, it may be said that the early mathematical skills of the children in the experimental and the control groups were similar, before starting the application.

Data Collection Tools

The data of the research were obtained using The Demographic Information Form and the Test of Early Mathematics Ability-Third Edition (TEMA-3). The Demographic Information Form was formed by the researchers to obtain information about the children.

The Test of Early Mathematics Ability (TEMA). The test is a norm-based parallel form test, developed by Ginsburg and Baroody in 1983 and used to define the mathematical skills of the children between three years and eight years and eleven months (Bliss, 2006; Ginsburg & Baroody, 2003). The test was published as the Test of Early Mathematics Ability-Second Edition (TEMA-2) by being reviewed in 1990 and as the Test of Early Mathematics Ability-Third Edition (TEMA-3) in 1993 in its developed form and the adaptation studies of TEMA-3 for the children of 60-72 months were performed by Erdoğan and Baran (2006) in Turkey. TEMA-3, consisting of two forms, A and B forms, and 72 items, is applied to the children individually and after the calculation of the chronological ages of the children the application is started from the item corresponding to the age of the child (Ginsburg & Baroody, 2003). In TEMA-3, used to in determining the children, who are ahead of or fall behind their peers in the mathematical thinking, in determining the weaknesses and strengths of the children in mathematics, in determining the progression in learning mathematics and to direct the teaching practices; pictures, mathematical symbols, countable little objects are used as the materials (Bliss, 2006; Ginsburg & Baroody, 2003). As a result of the validity and the reliability studies performed by Ginsburg and Baroody (2003), the correlation among the forms has been found as .82 from Form A to Form A, as .93 from Form B to Form B, as .93 from Form A to Form B; as a result of the validity and the reliability studies performed by Erdoğan and Baran (2006), the correlation among the forms has been found as .90 from Form A to Form A, as .88 from Form B to Form B, as.88 from Form A to Form B. The value of the KR-20 test performed to test the reliability of the test was found as .94 for Form A, as .96 for Form B by Ginsburg and Baroody (2003); and it was found as .92 for Form A, as .93 for Form B by Erdoğan and Baran (2003). In this research, the required permissions for the use of this scale were received.

Data Collection

The application was performed in November-December 2015. Various manipulative mathematical materials were developed by the researchers in order to improve the number concepts and operations, geometry, matching, comparing, ordering, classification and pattern skills of the children depending on the learning outcomes and the indicators included in the Republic of Turkey Ministry of Education 2013 Preschool Education Program (Figure 1). The materials developed are the materials which are not included in the classrooms of the children in both the experimental and the control groups, sensous, give a chance to trial-and-error, are clear and comprehensible without feeling a need to adult guidance, can be played individually or in group and are presented from simple to complex. For example, a material named "Let's count" was developed related to the indicators such as counting rhythmically, telling the number of the objects related with the "He/She counts the objects" learning outcome provided by the program for the cognitive development (Figure 2). In this material, numbers from 1 to 9 were written on the paper cups and the child was asked to put tongue depressors in each cup in the number written on them. The application was performed for 6 weeks, 2 days per week and 45 minutes per day. For this application, an environment was determined in the school outside the classroom and all the materials were placed in the way to be used by the children individually or with pairs. The children were included in this learning environment in groups of 11 people (Figure 3). In the first week of the application, 10 different materials, with which, they could use individually or in pairs, were provided to the children and observation was performed during her application and in this direction, the materials which the children lost interest in were removed from the environment and new and manipulative mathematical materials were included in the environment serving the same purpose. When the manipulatives were provided to the children, a completed example was provided showing how they would be used. In the process, there was no teacher and/or research guidance, only when the child asked for help, firstly the researchers asked questions to the child regarding the use of the material (*Did you examine the example?, How are you requested to do it? etc*.) and then if the child still could not understand what to do, he/she was informed. The children explored the materials by trial and error and performed the activities. Each child was allowed to play each of the manipulative mathematical materials. During the research application, the classroom teachers continued to apply the Republic of Turkey Ministry of Education 2013 Preschool Education Program in both the experimental and the control groups.

Figure 1. *The manipulative mathematics materials used in the application*

Figure 2. *The material named "Let's Count"*

Figure 3. *The application environment*

Data Analysis

The data of the research were analyzed using the SPSS 22 program. The Wilcoxon Signed Ranks Test was used in the comparison of the pretest-posttest score of the experimental group and Mann Whitney-U Test was used in the comparison of the posttest scores of the groups.

Findings

The results of the Wilcoxon Signed Ranks Test performed to reveal whether there was a significant difference as statistically between the pretest scores and the posttest scores taken by the children in the experimental group in the Test of Early Mathematics Ability-3 were demonstrated in Table 1.

Table 1. The Wilcoxon Signed Ranks Test Results of the Children, in the Experimental Group, of the Pretest-Posttest Averages Related to the Test of Early Mathematics Ability-3

Pretest-Posttest	***n***	**Mean Rank**	**Rank Total**	**z**	***p***
Negative Rank	0	-	-		
Positive Rank	22	11.50	253.00	-4.122[b]	.000
Equal	0	-	-		

Based on the Negative Sequences

In Table 1, it was observed that the posttest scores that the children in the experimental group took in the Test of Early Mathematics Ability-3 were statistically different from the pretest scores and this difference was statistically significant in favor of the posttest scores (Z=-4,122 [b], p<.05).

The results of the Mann-Whitney U Test performed to reveal whether there was a significant difference between the pretest scores and the posttest scores taken by the children in the experimental and the control groups in the Test of Early Mathematics Ability-3 were demonstrated in Table 2.

Table 2. The Mann-Whitney U Test Results of the Children, in the Experimental and Control Groups, of the Posttest Averages Related to the Test of Early Mathematics Ability-3

Groups	***n***	**Mean Rank**	**Rank Total**	**U**	**z**	***p***
Experimental	22	29.09	640.00	119.000	-3.052	.002*
Control	23	17.17	395.00			

*$p<.05$

In Table 2, it was observed that the posttest scores that the children in the experimental group took in the Test of Early Mathematics Ability-3 were statistically different from the posttest scores of the children in the control group and this difference was statistically significant in favor of the control group (U=119, p<.05).

Discussion and Conclusion

In this research examining the effect of the manipulative material on the early mathematical skills of the preschool children, it was determined that there was a significant difference (p<.05) between the posttest and pretest scores of the children in the experimental group taken in the Test of Early Mathematics Ability-3 in favor of the posttest (Table 1). When the differential scores rank sums are taken into consideration, it may be said that the use of the manipulative mathematical materials in the mathematics education in the preschool period has a positive effect on the improvement of the early mathematical skills of the children. This effect may also be attributed to the characteristics of the manipulative materials. Because the manipulative materials are concrete materials that enable children to understand concrete concepts and materialize these concepts (Kontaş, 2016). Also in a study performed by Swan and Marshall (2010), the teachers have stated that the manipulative materials attract the children's interest, these materials are entertaining and motivating for the children and help the children understand the concepts. Marshall and Swan (2008) have also stated in another study that teachers have stated the use of the manipulative material in the classroom provides an opportunity of visualization, concretization, better explanation and learning by practicing. It was also determined that there was a significant difference between the posttest results of the children in the experimental and the control groups, taken in the Test of Early Mathematics Ability-3, in favor of the experimental group (p<.05) (Table 2). Accordingly, as a result of the application performed, it is possible to state that the positive change in the early mathematical skills of the children in the experimental group, compared to the children in the control group, is due to the application performed by using the manipulative materials in the experimental group. This result also reveals the importance of using the manipulative materials in the development of the early mathematical skills of the preschool children. Also at the end of the experimental research performed by Erdoğan, Parpucu and Boz (2017) examining the effect of the educational materials related to the numbers and mathematical operations on the mathematical skills of the preschool children, a significant increase has been observed in the mathematics scores of the children in the experimental group, compared to the children in the control group, and this result has been explained by the effect of the educational materials on the mathematical skills. In another study by Ojose and Sexton (2009), the effect of the manipulative materials on the mathematical success has been examined and first-year students at the age of 6-7 have been included in the research. It has been stated that the research results have supported the hypotheses stating that the use of the manipulative materials in the mathematics education affects the success of the students positively and the manipulative materials increase the interest of the children in mathematics, allow them to enjoy mathematics and have fun while learning. Similarly, Liggett (2017) have also revealed in his study performed with the children at the age of 6-8 that the manipulative materials affect the mathematics success.

When the research results are taken into consideration, preparing appropriate learning environments and including the manipulative materials in these environments are important in enabling the preschool children to gain and improve the early mathematical skills. In this direction, the teachers should actively use the manipulative materials in the preschool mathematics education and provide appropriate learning opportunities for children. The research in which the opinions of the preschool teachers on the effects of the manipulative materials on the early mathematical skills will be revealed may be performed and therefore, the current situation is determined and the teachers may be supported with various training programs. In addition, teachers may design their own mathematical materials with the children in their classroom, and the effects of these materials may be examined

with longer use of them. The longitudinal research in which the effect of the early mathematical skills acquisitions of the children or supporting these skills on their mathematical success in the following years is examined may be planned.

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