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The Effect of the Building Blocks Education Program on Turkish Preschool Children's Recognition of Geometrical Shapes

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Abstract:

This study examined the effect of the Building Blocks mathematical education program on 4-year-old Turkish preschool children's recognition level of geometrical shapes. A pretest-posttest control group experimental design was employed. The sample group was composed of randomly selected 39 preschool children (of whom 21 were in the experimental group, and 18 in the control group). A geometric shapes recognition test was used for data collection. Results indicated meaningful differences in the mean scores of the triangle and rectangle shapes in favor of the experimental group. When the children's responses to the geometric shapes recognition test were examined in detail, it was observed that in the post-test the children in the experimental group, as compared to the ones in the control group, were more inclined to define geometrical shapes with their qualitative features rather than visual features.

Keywords: Curriculum, geometric shapes, mathematics, preschool

Introduction

Early mathematics achievement is the strongest predictor of children's mathematics achievement in later school life (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004; Claessens & Engel, 2013; Duncan et al., 2007; Fuson, Clements, & Sarama, 2015; Jordan, Glutting, & Ramineni, 2010; Nguyen, et al., 2016; Watts, Duncan, Siegler, & Davis-Kean, 2014). The National Council of Teachers of Mathematics (NCTM) and the National Association for the Education of Young Children (NAEYC), two internationally recognized organizations in the field of early childhood, also report that providing high quality, challenging and accessible mathematics education for children aged 3-6 is of vital importance for their future mathematics learning (NAEYC, 2002).

Geometry and spatial reasoning are important and fundamental parts of mathematics learning in early childhood education (NCTM, 2006). These two areas also support number and arithmetic related concepts and skills (Arcavi, 2003; Gunderson, Ramirez, Beilock, & Levine, 2012).

However, geometry and spatial thinking are usually neglected or take up only a small portion of curricula (Hawes, LeFevre, Xu, & Bruce, 2015; Sarama & Clements, 2009). Clements (2004) reports that although the NCTM standards try to distance teachers from basic number sense in mathematics, most teachers still focus the curriculum on number skills. Similarly, there are studies emphasizing that early mathematics education should focus on basic skills such as spatial skills beyond number knowledge (Verdine, Irwin, Golinkoff, & Hirsh-Pasek, 2014). On the other hand, Ginsburg, Lee, and Boyd (2008) report that early childhood educators receive insufficient training to teach mathematics, they rarely teach mathematics, they do not believe that mathematics is important, or they are afraid to teach it. Verdine, Golinkoff, Hirsh-Pasek, and Newcombe (2014) emphasize the need to train teachers on the best methods for teaching geometry and spatial concepts.

Children need to acquire these skills from an early age to acquire both STEM careers (Verdine, Golinkoff, Hirsh-Pasek, & Newcombe, 2014) and the 21st century skills. It is reported that individuals who have a solid foundation in these concepts are generally more interested in STEM related disciplines - science and mathematics - and are more likely to obtain high-quality advanced degrees (Newcombe, 2010).

International studies show that there is a weakness in students' geometry achievement (Mullis et al. 1997). The same is true for Turkish students. Recent national (e.g., Ministry of National Education [MoNE], 2019; Monitoring and Evaluating of Academic Skills [ABIDE], 2018) as well as international evaluation programs (e.g., Programme for International Student Assessment [PISA], 2018; Trends in International Mathematics and Science) Study [TIMSS], 2019) indicate that Turkey is behind the OECD average in the field of mathematics. There has been an increasing awareness of the importance of mathematics throughout the world. Educators and business leaders express that they are very concerned about the success of students in mathematics because individuals with more complex skills are needed than in the past. In response, early intervention programs based on scientific studies are developed to increase the mathematical success of young children. One of these is Building Blocks, a research-based early intervention program developed and tested by Clements and Sarama (Clements & Sarama, 2007a). Hofer, Farran, and Cummings (2013) evaluated the effectiveness of the Building Blocks and report that this program has positive effects on children's geometry-related skills. Likewise, Canadian researchers Hawes, Moss, Caswell, Naqvi, and MacKinnon (2017) state that the early intervention programs such as the Building Blocks can be used by educators to increase children's geometric and spatial skills in line with the demands of the 21st century. Indeed, adapting and spreading research-based tools throughout an education system can buttress improvement efforts (National Council of Teachers of Mathematics [NCTM], 2013). Therefore, it is thought that adapting and testing the Building Blocks in Turkey will lead to more efficient results and will save a great deal of time and effort. Therefore, the aim of this study is to analyze the effect of the Building Blocks early math education program in a Turkish preschool, with specific interest in children's geometry outcomes.

With this overarching aim in mind, we address the following research questions:

(1) To what extent are there post-test differences in *shape recognition* between the children in Building Blocks classroom and their peers in business-as-usual classroom?
(2) To what extent are there post-test differences in *shape type* scores between the children in Building Blocks classroom and their peers in business-as-usual classroom?
(3) To what extent are there post-test differences in *shape classification* scores between the children in Building Blocks classroom and their peers in business-as-usual classroom?

(4) What are the criteria children employ to differentiate between the shapes (triangles, rectangles, squares, and circles)? Are there differences between groups?

Method

ResearchDesign

This study used a cluster randomized trial design to evaluate the effectiveness of the Building Blocks early math education program, with specific interest in children's geometry outcomes. One preschool in the district of the Directorate of National Education of Mentese in the province of Mugla, Turkey was randomly selected to serve as the study site. Two classrooms out of eight were randomly selected within this preschool and were randomly assigned one of two conditions using a randomized block design: one classroom was given the intervention (the BB curriculum) and the other (control) classroom received no intervention (business-as-usual math teaching) over the same period (30 weeks). The two groups underwent the same tests at the beginning (pre-test) and at the end (post-test) of this period (Karasar, 2020). Table 1 depicts the timing of the pre-test, the Building Blocks program implementation, and post-test.

Table 1. Symbolic view of research design

		Pre-test		Post-test
G_E	R	$O_{1.1}$	X	$O_{1.2}$
G_C	R	$O_{2.1}$		$O_{2.2}$

Note: **G_E:** the experimental group**, G_C:** the control group, **R:** the subjects were randomly assigned to the group, **$O_{1.1}$ and $O_{1.2}$:** the experimental group's pre- and post-test measurements, **$O_{2.1}$ and $O_{2.2}$:** the control group's pre- and post-test measurements, **X:** the independent variables (experimental variables) implemented on the experimental groups.

- **Participants**

Pre-school classrooms

The sampling process was composed of two steps. First, a preschool in the district of the Directorate of National Education of Mentese in the province of Mugla, Turkey was randomly selected to serve as the study site. Second, two classrooms were randomly selected within this preschool and were randomly assigned one of two conditions: (a) Building Block (BB) + business-as-usual math teaching condition, in which children received both the BB program and the math objectives of the regular pre-school education program (b) Business-as-usual math teaching classroom, in which children did not receive the BB program intervention. The children in both conditions continued to receive regular math instructions as a part of the pre-school education curriculum.

Teachers

The teachers of the selected classrooms are Early Childhood Education program graduates, and both have more than ten years of professional experience (Building Blocks, 16.9 years; control, 17.2 years of experience).

Children

There were twenty-three children whose parents volunteered to participate in the study in each classroom (forty-six total). Two inclusion criteria were used to guide the selection of children: those children who (a) had not participated in another intervention program that supported the development of mathematics skills and who (b) were typically developed. Seven children were excluded from the study: one was with severe cognitive delay, and six others were withdrawn from the school for various reasons. Therefore, the research continued with thirty-nine typically developing children, twenty-one of which were in the experimental classroom and eighteen were in the control classroom. The mean age of the children in the experimental group was 4.4, and the mean age of the children in the control group was 4.3. The gender distribution for the experimental and control classrooms are displayed in Table 2.

Table 2. Demographic characteristics of the children in the Building Blocks (experimental) and business-as-usual (control) classroom

	Classroom		**n**
Gender	Experimental	Female	12
		Male	9
	Control	Female	9
		Male	9

Intervention

The Building Blocks (BB) Program

The Building Blocks curriculum (Clements & Sarama, 2007a) is an early childhood mathematics program developed for preschool children. It covers topics including numbers, operations, and geometry. Throughout this study, the Building Blocks Program materials such as the Teacher's Edition, the Teacher's Resource Guide, Assessments and Manipulative Sets were used. In the Teacher's Edition (Clements & Sarama, 2007b), there are thirty weekly plans. Each unit includes whole and small group activities, a hands-on math center activity, home connection feature (i.e., parent letter), and sequence of math topics to cover throughout the academic year. Since there are no computers available in most of the Turkish preschool classrooms (Babayigit, 2014; Orcan-Kacan & Kimzan, 2017) (including the experimental and control group classrooms of this study), the on-computer activity sets of the Building Blocks were not used in this study.

The process of translating and adapting the Building Blocks Education Program into Turkish

First, the BB curriculum materials were translated into Turkish and then back translated for accuracy and quality. An expert in English and Turkish languages compared the equivalence of the original and translated BB text. The researchers also examined the English and Turkish texts through the lens of content experts in mathematics education. Then, the original and translated materials were shared with early math education experts to comment on the appropriateness of the BB content for Turkish culture. In line with the experts' suggestions, some revisions were made to make it more clear for Turkish users. This version was deemed as the final version for pilot implementation.

A pilot study of the BB program was carried out with 22 children for five days in a randomly selected preschool in the Mentese district of Mugla. The findings of the pilot implementation suggested that the BB program was age-appropriate, culturally relevant, comprehensible by the children (both in term of language and content) and it was ready for larger-scale implementation.

Implementation of the Building Blocks Curriculum

The first author observed Clements and Sarama's Building Blocks (BB) program at the University at Buffalo in the Early Math Laboratory for two years. During this period, she also observed implementation of the BB curriculum in classrooms at the Early Childhood Research Center every day for six months. The second and third authors also had the opportunity to observe the whole BB Education Program and its applications at http://triad-research.du.edu.

The researchers had face-to-face meetings with the BB and control classroom teachers from September 18 to October 6, 2017, providing them with information about the study. The BB teacher received further information about the aim, content, and implementation of the BB program. Also, a newsletter describing the BB program and its intended benefits for children was sent home to the families.

The experimental group's (BB classroom) teacher was trained by the first author prior to the implementation. She also had face-to-face meetings with the researchers to discuss BB materials every week. The business-as-usual (control) teacher implemented the Turkish National Preschool Curriculum. The BB program was implemented from October 9, 2017 to May 18, 2018 (for 30 weeks).

Fidelity of implementation

The teacher prepared the classroom in accordance with the BB curriculum with the guidance of the researchers before the start of the academic year. The whole group and hands on math center BB activities were implemented every day; the small group BB activities were implemented on Wednesdays and Fridays for 30 weeks. The research team members conducted one fidelity observations each week. The BB teacher was scored on how accurately she implemented the BB program on a 3-point scale. The fidelity score for the intervention was .98 Also, every Friday afternoons, the researchers briefed the teacher about the forthcoming week's BB activities.

Data Collection

Data collection included pre-test (September 25, 2017, and October 06, 2017) and post-test (between May 21, 2018, and June 02, 2018) performance on measures designed to assess children's shape recognition knowledge. Also, some basic demographic information about the children were collected during pre-test period.

- **General Information Form**

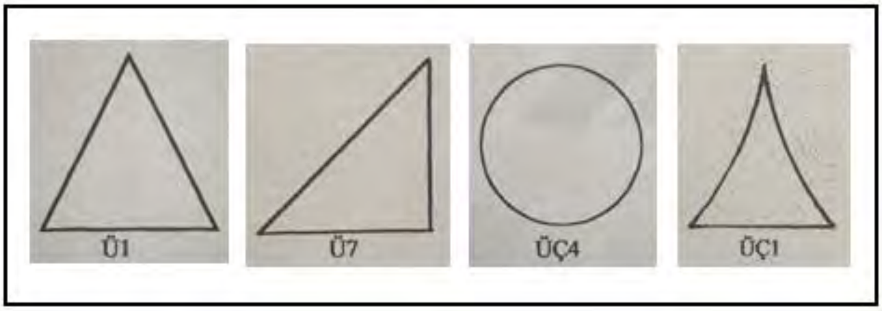
This form was used to collect demographic information, including children's genders and age.

- **Geometrical Shapes Recognition Test (GSRT)**

The Geometrical Shapes Recognition Test (GSRT), developed by Aslan (2004), is composed of four dimensions that assess knowledge of triangles, squares, circles, and rectangles. Each geometrical shape was presented to children on a paper (12 shapes in total), and they are asked to mark which shapes are the corresponding shape (e.g., triangle) and which shapes are not. If the child chooses the correct one, his/her answer is coded as "1" and if not, it is coded as "0". The GSRT also includes an Interview Form to record child's response for each shape when s/he was asked why s/he thinks so (e.g., Why do you think this one is a triangle?)

Each question in the GSRT included typical and non-typical examples of each shape. Non-typical examples were related to test the location, flatness, distortion, size, and edge variables of the shapes. Exemplary shapes also included obvious and non-obvious distractors. The obvious distractors are typical examples of other shapes than the tested one. The non-obvious distractors consist of shapes that do not fit the geometric definition of the tested shape (see Figure 1). The number of questions in each type and classification are given in Table 4 (additional information can be found in Aslan, 2004).

Figure 1. Sample item from triangle recognition test



U1: Typical example, U7: Non-typical example; UC4: Obvious distraction, UC1: Non-obvious distraction

Table 3. The number of questions in each type and classification in the GSRT

		Triangle	**Rectangle**	**Square**	**Circle**
Type of shape	**Typical example**	1	1	1	2
	Non-typical example	6	4	3	3
	Obvious distraction	2	4	6	4
	Non-obvious distraction	3	3	2	3
Classification of the shapes	**Distortion**	3	-	-	-
	Location	3	3	2	-
	Flatness	3	2	-	-
	Size	-	2	2	3
	Location-size	-	-	2	-
	Edge width	-	-	-	3
	Edge width-size	-	-	-	3

Aslan (2004) reported the discrimination index of each item in the GSRT was below .15 and item difficulties ranged between .31 and .99. In this study, reliability scores for the pre-test (KR-21) were computed as .75 for the triangle recognition test, .71 for the rectangle, .77 for the square, and .72 for the circle. The reliability values were slightly higher than .70 acceptable cut-off value (Buyukozturk, 2020).

- **Data Collection**

The data was collected during the 2017-2018 school year. The pre-tests were administered between September 25, 2017, and October 6, 2017. Implementation of the BB program began in October 2017 and ended in May 2018. Post-test administration began May 21, 2018 and ended on June 2, 2018.

Data Analysis

Firstly, independent t-tests were used to test if the experiment and the control group's performance on the GSRT were equal. All independent t-tests were non-significant, (t values from -.84 to .052 and for all comparisons, p> .05). We specified mixed ANOVAs to examine the extent to which BB students' scores were higher relative to their peers in the control group. We checked the normality and sphericity assumptions of the dependent variable, the GSRT score. Kurtosis and skewness values of both test scores ranged between -1 and +1, suggesting a normal distribution. The quantitative data were analyzed in the SPSS 22.0 package program.

In addition, descriptive methods (e.g., frequencies) were used to examine the answers given by the children to the questions about how they define the geometric shapes in the GSTR. To establish inter-coder reliability, another researcher (who is a specialist in the field of early math education) also coded the replies provided by the children for the geometrical shapes recognition test. The inter-coder reliability was found by calculating Cohen's Kappa reliability correlation coefficient. The correlation coefficient was calculated as 0.85. This score indicates a high rate of reliability between the two coders. The children's responses were grouped visually and qualitatively. The responses that do not fall into these two groups like "I know this (I pondered, I guessed)" and "I do not know" were presented as separate categories in the relevant tables.

Results

The aim of this study was to analyze the effect of the Building Blocks mathematical education program in a Turkish preschool, with specific interest in children's geometry outcomes. The following analysis shows that the BB program participation has strengthened geometrical shapes recognition in Turkish preschool children (x̄= 50 months).

- **Findings for the Geometrical Shapes Recognition Test and its Sub-Tests**

To find out if there was a meaningful difference between the mean scores of the experimental and control group children's levels of recognizing geometrical shapes (levels of recognizing triangles, rectangles, squares, circles) before the Building Blocks Education Program was implemented. As seen in Table 4, at the pre-test children's mean scores in the experimental and the control groups were close to each other.

Table 4. Descriptive statistics for the pre- and post-tests of the experiment and the control groups

		Pre-test		**Post-test**	
The Shapes Test	**Groups**	**M (SD)**	**Skewness (kurtosis)**	**M (SD)**	**Skewness (kurtosis)**
Triangle	**Control**	7.22 (1.56)	-.15(.55)	7.66 (1.53)	-.68(.22)
	Experiment	7.42 (1.80)	-.45(.69)	10.09 (1.58)	-.27(.17)
Rectangle	**Control**	7.05 (2.58)	-.35(-.38)	9.16 (1.38)	-.33(-.02)
	Experiment	7.57 (2.40)	-.04(-.84)	11.38 (1.35)	.41(.19)
Square	**Control**	8.33 (3.11)	-.61(-.76)	9.50 (1.38)	.32(.39)
	Experiment	8.38 (2.58)	-.04(-.97)	11.19 (.93)	-.79(-.52)
Circle	**Control**	8.22 (2.88)	-.07(-.31)	11.00 (1.06)	-.58(.27)

	Experiment	9.04 (3.15)	-.57(-.32)	11.90 (1.53)	. -41(-.80)

To test *the research question 1*, the effect of the programs on children recognition of the geometrical shapes, we applied a mixed ANOVA tests to the data (See Table 5). The mixed ANOVA tests revealed that there were statistically significant effects of the treatments, time, and the interaction of treatment*time in the triangulation test. The main effect of the treatment (F (1,37) = 15.65, p < .001, r= .54) was significant indicated that the experiment and control groups statistically differed. The main effect of time was significant (F (1,37) = 15.07, p <.001, r= .54), indicating that there was statistically significant difference between students' pre- and post-test regardless treatment groups. The interaction effect of treatment*time was statistically significant (F (1,37) = 7.59, p <.001, r= .42). This result showed that the students' scores on pre- and post-tests were statistically different across the treatment groups.

The mixed ANOVA tests revealed that there were statistically significant effects of the treatments, time, and the interaction of treatment*time in the rectangular test. The main effect of the treatment (F (1,37) = 6.50, p < .001, r= .38) was significant indicated that the experiment and control groups statistically differed. The main effect of time was significant (F (1,37) = 6.50, p <.001, r= .79), indicating that there was statistically significant difference between students' pre- and post-test regardless treatment groups. The interaction effect of treatment*time was statistically significant (F (1,37) = 5.68, p <.001, r= .36). This result showed that the students' scores on pre- and post-tests were statistically different across the treatment groups.

Table 5. Results of mixed ANOVAs

The Shapes	**Groups**	**SOS**	**F**	**r**
Triangle	**Group**	34.87	15.65	.54
	Time	45.48	15.07	.54
	Time*group	22.92	7.59	.42
	Error	111.70		
Rectangle	**Group**	34.67	6.50	.38
	Time	166.70	63.53	.79
	Time*group	14.91	5.68	.36
	Error	97.09		
Square	**Group**	13.72	2.51	.25
	Time	78.77	20.22	.59
	Time*group	12.21	3.13	.27
	Error	144.17		
	Group	13.59	2.39	.24

Circle	**Time**	156.92	38.07	.71
	Time*group	.01	.01	.01
	Error	152.54		

The mixed ANOVA tests revealed that there were statistically significant effects of the time, but the effects of treatment and the interaction of treatment*time were not in the square test. The main effect of time was significant (F (1,37) = 20.22, p <.001, r= .59), indicating that there was statistically significant difference between students' pre- and post-test regardless treatment groups. The main effect of the treatment (F (1,37) = 2.51, p =.12, r= .25) and treatment*time (F (1,37) = 3.13, p =.08, r= .27) were not significant indicated that the experiment and control groups statistically did not differ.

The mixed ANOVA tests revealed that there were statistically significant effects of the time, but the effects of treatment and the interaction of treatment*time were not in circle test. The main effect of time was significant (F (1,37) = 38.07, p <.001, r= .71), indicating that there was statistically significant difference between students' pre- and post-test regardless treatment groups. The main effect of the treatment (F (1,37) = 2.39, p =.13, r= .24) and treatment*time (F (1,37) = 0.01, p =.98, r= .01) were not significant indicated that the experiment and control groups statistically did not differ.

To test *the research question 2*, we compared the students at the experimental and control groups responses based on the shape types (typical example, non-typical example, obvious distraction and non-obvious distraction). Descriptive statistics for the experimental and control groups were displayed in the Table 6. The results of mixed ANOVAs showed that some interaction effects were statistically significant for shape types but other were not. In triangle, the interaction effect of treatment*time for non-obvious distraction was statistically significant (F (1,37) = 4.25, p <.001, r= .32), indicating that the experimental group statistically significantly increased their post score than the control group did.

In rectangle, the interaction effect of treatment*time for non-obvious distraction was statistically significant (F (1,37) = 17.77, p <.001, r= .56), indicating that the experimental group statistically significantly increased their post score than the control group did. In square, the interaction effect of treatment*time for non-typical distraction was statistically significant (F (1,37) = 5.11, p <.001, r= .34), indicating that the experimental group statistically significantly increased their post score than the control group did.

Table 6. Descriptive statistic for the triangle, rectangle, square and circle recognition test based on the shape type

			Pre-test M (SD)	**Post-test M (SD)**	**Pre-test M (SD)**	**Post-test M (SD)**
Triangl	**Sets an Example**	**Typical Example**	.86 (.36)	1.00 (.0)	.83 (.38)	1.00
		Non-Typical Example	3.29 (2.10)	5.24 (1.13)	3.56(1.72)	4.05 (1.73)
	Doesn't Set an Example	**Obvious Distraction**	1.64 (.73)	1.95 (.22)	1.44 (.92)	2.00 (.0)

e		**Non-Obvious Distraction**	1.66 (1.15)	1.90 (.89)	1.39 (1.14)	.61 (.61)
Rectangle	**Sets an Example**	**Typical Example**	.76 (.36)	1.00 (.0)	.67 (.48)	.94 (.23)
		Non-Typical Example	2.67 (1.39)	3.71 (.72)	2.33 (1.45)	3.61 (.78)
	Doesn't Set an Example	**Obvious Distraction**	2.61 (1.32)	4.00 (.0)	12.44 (1.72)	3.67 (.59)
		Non-Obvious Distraction	1.52 (1.36)	2.67 (.73)	1.67 (1.37)	.94 (1.10)
Square	**Sets an Example**	**Typical Example**	.76 (.43)	1.00 (.0)	.83 (.38)	1.00 (.0)
		Non-Typical Example	1.90 (1.13)	2.52 (.75)	2.27 (.95)	1.88 (1.02)
	Doesn't Set an Example	**Obvious Distraction**	4.42 (1.77)	5.90 (.30)	3.77 (2.18)	5.33 (.83)
		Non-Obvious Distraction	1.28 (.78)	1.76 (.62)	1.44 (.85)	1.33 (.76)
Circle	**Sets an Example**	**Typical Example**	1.52 (.87)	2.00 (.0)	1.44 (.92)	2.00 (.0)
		Non-Typical Example	2.24 (1.22)	3.00 (.0)	2.11 (1.18)	2.83 (.51)
	Doesn't Set an Example	**Obvious Distraction**	3.05 (1.39)	3.95 (.21)	2.78 (1.48)	3.79 (.42)
		Non-Obvious Distraction	2.23 (.13)	2.95 (.21)	1.89 (1.18)	2.44 (.78)

The students at the experimental and control groups responses based on their classification (triangle: distortion, location, and flatness; rectangle: location, flatness, and size; square: location, size, and location + size; circle: size, edge width and edge width + size) were compared (*the research question 3*). Descriptive statistics for the experimental and control groups were displayed in the Table 7. The results of mixed ANOVAs showed that all interaction effects were not statistically significant for shape classification.

Table 7. Descriptive statistics for in the triangle, rectangle, square and circle recognition test based on their classification

		Experimental		**Control**	
		Pre-test	**Post-test**	**Pre-test**	**Post-test**
		Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Triangle	**Distortion**	1.81 (.93)	2.81 (.40)	1.94 (.93)	2.28 (.67)
	Location	2.52 (.92)	3.00 (.0)	2.61 (.98)	2.89 (.47)
	Flatness	1.52 (1.03)	2.43 (.81)	1.50 (.85)	1.89 (.93)
Rectangle	**Location**	2.19 (1.21)	2.90 (.43)	2.22 (1.26)	2.94 (.23)
	Flatness	1.29 (.72)	1.90 (.30)	1.05 (.80)	1.77 (.54)
	Size	1.05 (.80)	1.72 (.57)	1.48 (.87)	1.90 (.30)
Square	**Location**	1.57 (.68)	1.81 (.40)	1.67 (.68)	1.72 (.46)
	Size	1.33 (.73)	1.95 (.21)	1.56 (.70)	1.66 (.48)
	Location+ Size	1.28 (.71)	1.76 (.43)	1.56 (.61)	.150 (.51)
Circle	**Size**	2.23 (1.30)	3.00 (.0)	2.11 (1.27)	2.89 (.32)
	Edge Width	2.28 (1.23)	3.00 (.0)	2.17 (1.30)	3.00 (.0)
	Edge Width + Size	2.28 (1.23)	3.00 (.0)	2.16 (1.38)	2.94 (.23)

When the children's definitions of the shapes in the triangle and rectangle recognition test were examined closely, it was found that while the visual expressions decreased, the qualitative expressions increased in the post-tests in both the experimental and control groups. However, the increase was found to be higher in the experimental group. They emphasized the number and features of edges and vertices more. Although the qualitative responses for square and circle shapes also increased in the post-test, they still focused more on the visual features of shapes even after the BB program implementation.

Discussion

The pre-test scores of the experimental and control group children's levels of the geometrical shapes recognition indicate that there was no statistical difference between the two groups. Therefore, it can be argued that before the implementation of the BB both groups' levels of recognizing geometrical shapes were close to each other. In addition, measurements taken before the BB program was implemented show that children had higher averages in square and circle shapes than in triangle and rectangular shapes. The high averages obtained in square and circle shapes are similar to the results of the study conducted by Clements, Swaminathan, Hannibal and Sarama (1999).

A comparison of the shape types in the answers provided by the students in the pre- and post-tests reveals that there is a significant difference in favor of the experimental group in the non-obvious distractions of the triangle shape. The non-obvious distractions in the triangle recognition test are triangle shapes with inwardly or outwardly curved sides. It was observed that the control group students were not well-informed about their edge features and thus were inclined to regard these shapes with curved sides as triangles. Kesicioglu, Alisinanoglu and Tuncer (2011) in their descriptive study where they used the same assessment tool also found that in the triangle recognition test among the shapes that the obvious distraction shapes group was the one the students made frequent mistakes. The fact that the experimental group students scored higher with these shapes indicates that the Building Blocks education program had a significant effect on the experimental group students' ability to identify the triangle's edge features. Additionally, the fact that the children in the experimental group used the qualitative expressions related to the edge properties of the shapes more in the posttest while defining the shapes in the triangle recognition test, also supports this result. The responses given by the children in both the experimental and control groups in the triangle recognition test show that the most repeated response in the pre-test was "looks like it" (i.e., "It looks like a triangle."), which was a visual response, however, it was the "number of edges" in the posttest, which was a qualitative response. In Aslan's study (2004), it was also found that the most common answer in the triangle test in the 3-4-year-old group was "looks like it", and "stating the number of vertices" in the 6-year-old group. Considering that the study group of this research consists of children aged 4 years, the pre-test results in both studies support each other. However, the post-test responses of the 4-year-olds in the current study are similar to the responses provided by 6-year-olds in Aslan' study (2004). Therefore, it can be deduced that the BB program intervention had a positive effect of on the children in the experimental group.

In the square recognition test, there was a significant difference in favor of the experimental group in the non-typical examples. This group of shapes consisted of three square shapes of which one was 45 degrees rotated, another one decreased in size at 1/3 rate, and the last one was both rotated and decreased in size. The experimental group students were more successful than the control group in identifying these shapes as squares. Similarly, in Kesicioglu, Alisinanoglu and Tuncer (2011)'s study, it was observed that in the square recognition test one of the shapes that the students most frequently misidentified was the both rotated and size-reduced shape of the typical square. The results obtained in this study demonstrate that teaching the experimental group students different shape features like location, flatness, and size had a positive effect on their achievements. Thus, it was noticed that the control group students had problems in identifying the square shape when its size and location changed. The reason for this might be that in the control group while teaching the square shape the teachers usually concentrated on the typical examples. Moreover, the answers given by the children for the shapes in the square recognition test show that while "I know / I don't know" type of answers in the experimental group decreased significantly in the post-test, these types of answers were still present in the control group's post-test responses. All these results indicate that the implemented BB program had a positive effect on the children's definitions of the square shape through its qualitative features.

There was no significant difference in any of the shape types in the circle recognition test. In the circle recognition tests both experimental and control groups increased their scores similarly. Clements (1999) noted that pre-school children predominantly correctly identified the circle shape, and that only very few children of that age group made mistakes with the circle shape. Also, other studies concluded that among geometrical shapes children scored the highest in identifying the circle shape (Kesicioglu, Alisinanoglu & Tuncer 2011; Maričić & Stamatovic, 2017). Likewise, in this study, both groups of students increased their scores in the circle recognition tests and there was no significant difference between the groups. Therefore, it can be argued that the provided BB education did not have any effect on experimental group's ability to recognize the circle shape. When the children's responses in the circle recognition test were examined, it was seen that although the visual responses increased slightly, the qualitative responses increased significantly in the post-test for the experimental group.

Another result obtained in the circle shape is that, from the pretest to the posttest, "resembling an object" type of responses (i.e., "Looks like a ball.") increased slightly in both the experimental and control groups unlike other shapes. When the children's answers were examined, it was seen that most of the children tend to explain the shape by likening an object in the pre-test because a child of this age can recognize shapes and their names but cannot understand the relationships and connections between shapes. Also, the child's reasoning is general and undifferentiated, therefore, the child identifies geometric shapes with objects that have the same properties (Maričić & Stamatović, 2017). While there was a significant decrease in these types of responses given for the triangle, rectangle, and square shapes in the post-test for the experimental group, it was observed that there was a slight increase in the circle recognition test. The reason for this can be explained by the fact that when defining the circle shape, children cannot focus clearly on the edge and vertex features as in other shapes, and they tend to explain the shape by its similarity to a real-life object, just like what they did before the intervention.

Conclusion

Several studies demonstrate that mathematical skills acquired in early childhood has a positive effect on children's future success in school and mathematics (Claessens & Engel, 2013, Duncan et al., 2007, Fuson, Clements & Sarama, 2015, Watts, Duncan, Siegler & Davis-Kean, 2014). Also, recent studies emphasize that there is a positive correlation between children's spatial skills and mathematics knowledge in early childhood years (Rittle-Johnson, Zippert, & Boice, 2019). The findings of this study also support the importance of quality mathematical education programs.

Overall, it can be argued that the GSRT results reveal that the Building Blocks Education Program, which was implemented on the experimental group, were largely effective on 4-year-old children's ability to recognize and identify geometrical shapes. On the other hand, although the control group children, who did not undergo any special education program, also increased their levels of recognizing some geometrical shapes by the end of the 30-week period. It is interesting to note that this increase generally occurred with the typical examples of geometrical shapes.

References:

Arcavi, A. (2003). The role of visual representations in the learning of mathematics. Educational Studies in Mathematics, 52(3), 215-241. https://doi.org/10.1023/A:1024312321077

Aslan, D. (2004). An analysis of the criteria 3-6-year-old preschool children use to identify and differentiate between basic geometrical shapes [Unpublished master's thesis]. Cukurova University.

Aunola, K., Leskinen, E., Lerkkanen, M.-K., & Nurmi, J.-E. (2004). Developmental dynamics of math performance from preschool to grade 2. *Journal of Educational Psychology, 96*(4), 699–713. https://doi.org/10.1037/0022-0663.96.4.699

Babayigit, O.-C. (2014). Teachers' opinions about using serious games in pre-school education (Ankara province example) [Unpublished master's thesis]. Gazi University.

Buyukozturk, S. (2020). Manual of data analysis for social sciences (27th ed.). Ankara: Pegem Akademi.

Can, E., & Kilic, Ş. (2019). Pre-school education: Basic problems and solution suggestions. Milli Eğitim, 48 (1), 483-519. Retrieved from https://dergipark.org.tr/tr/download/article-file/929132

Claessens, A., & Engel, M. (2013). How important is where you start? Early mathematics knowledge and later school success. Teachers College Record, 115, 1–29. Retrieved from https://www.tcrecord.org/Content.asp?ContentId=16980

Clements, D.-H. (1999). Geometric and spatial thinking in young children. In J. V. Copley (Ed.), Mathematics in the early years (pp. 66-79). National Council of Teachers of Mathematics.

Clements, D.-H. (2004). Geometric and spatial thinking in early childhood education. In D.-H. Clements, J. Sarama, & M.-A. DiBaise (Eds.), *Engaging young children in mathematics: Standards for early childhood mathematics education* (pp. 267- 298). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Clements, D.-H., & Sarama, J. (2000). Young children's ideas about geometric shapes. Teaching Children Mathematics, 6(8), 482-488. https://doi.org/10.5951/TCM.6.8.0482

Clements, D.-H., & Sarama, J. (2007a). Effects of a preschool mathematics curriculum: Summative research on the Building Blocks project. Journal for Research in Mathematics Education, 38(2), 136-163. https://doi.org/10.2307/30034954

Clements, D.-H., & Sarama, J. (2007b). Building Blocks—SRA real math teacher's edition, grade Pre-K. SRA/McGraw-Hill.

Clements, D., Swaminathan, S., Zeitler Hannibal, M.-A. & Sarama, J. (1999). Young children's concepts of shapes. Journal for Research in Mathematics Education, 30(2), 192-212. doi:10.2307/749610

Duncan, G.-J., Dowsett, C.-J., Claessens, A., Magnuson, K., Huston, A.-C., Klebanov, P., . . . & Sexton, H. (2007). School readiness and later achievement. Developmental Psychology, 43, 1428–1446. https://doi.org/10.1037/0012-1649.43.6.1428

Ertor, E. (2015). Opinions of kindergarten teachers working in primary school about the administrative problems they face [Unpublished master's thesis]. Ataturk University.

Fuson, K.-C., Clements, D.-H., & Sarama, J. (2015). Making early math education work for all children. Phi Delta Kappan, 97(3), 63–68. https://doi.org/10.1177/0031721715614831

Ginsburg, H., Lee, J., & Boyd., J. (2008). Mathematics education for young children: What it is and how to promote it. Social Policy Report, 22(1), 3-22.

Guclu, M., & Altan, A.-E. (2020). An overall assessment on the problems of preschool education in Turkey. The Journal of International Social Research, 13(69), 1051-1061. http://dx.doi.org/10.17719/jisr.2020.4019

Gunderson, E.-A., Ramirez, G., Beilock, S.-L., & Levine, S.-C. (2012). The relation between spatial skill and early number knowledge: The role of the linear number line. *Developmental Psychology, 48*(5), 1229–1241. https://doi.org/10.1037/a0027433

Hawes, Z., Moss, J., Caswell, B., & Poliszczuk, D. (2015). Effects of mental rotation training on children's spatial and mathematics performance: A randomized controlled study. *Trends in Neuroscience and Education, 4*, 60-68. doi:10.1016/j.tine.2015.05.001

Hawes, Z., Moss J., Caswell, B., Naqvi, S., & MacKinnon, S. (2017). Enhancing Children's Spatial and Numerical Skills through a Dynamic Spatial Approach to Early Geometry Instruction: Effects of a 32-Week Intervention, *Cognition, and Instruction, 35*, 236-264.

Hofer, K.-G., Farran, D.-C., & Cummings, T.-P. (2013). Preschool children's math-related behaviors mediate curriculum effects on math achievement gains, *Early Childhood Research Quarterly, 28*(3), 487-495. https://doi.org/10.1016/j.ecresq.2013.02.002.

Jordan, N.-C., Glutting, J., & Ramineni, C. (2010). The Importance of number sense to mathematics achievement in first and third grades. *Learning and individual differences*, *20*(2), 82–88. https://doi.org/10.1016/j.lindif.2009.07.004

Karasar, N. (2020). Scientific research method (35th ed.). Nobel Academic Publishing.

Kesicioglu, O.-S., Alisinanoglu, F., & Tuncer, A.-T. (2011). An analysis of preschool children’s recognition levels of geometrical shapes. Ilkogretim Online, 10(3), 1093-1111. Retrieved from http://ilkogretim-online.org.tr/index.php/io/issue/view/114

Kilic, S. (2019). Basic problems and solution suggestions in pre-school education [Unpublished master’s thesis]. Kirklareli University.

Maričić, S.-M., & Stamatović, J.-D. (2017). The effect of preschool mathematics education in development of geometry concepts in children. Eurasia Journal of Mathematics, Science and Technology Education, 13(9), 6175-6187. https://doi.org/10.12973/eurasia.2017.01057a

Ministry of Education (2019). PISA 2018 Turkey preliminary report. Education analysis and evaluation reports (Series, No: 10) http://www.meb.gov.tr/meb_iys_dosyalar/2019_12/03105347_PISA_2018_Turkiye_On_Raporu.pdf

Monitoring and Evaluating of Academic Skills (2018). Evaluation framework workshop report. Ministry of Education Measurement, Evaluation and Examination Services General Directorate. http://abide.meb.gov.tr/haber1.asp

Mullis, I.-V.-S., Martin, M.-O., Beaton, A.-E., Gonzalez, E.-J., Kelly, D.-L., & Smith, T.-A. (1997). Mathematics achievement in the primary school years: IEA’s third international mathematics and science study (TIMSS). Center for the Study of Testing, Evaluation, and Educational Policy, Boston College.

National Council of Teachers of Mathematics (2006). Principles and standards for school mathematics. Author.

National Council of Teachers of Mathematics (2013). Mathematics in early childhood learning. https://www.nctm.org/Standards-and-Positions/Position-Statements/Mathematics-in-Early-Childhood-Learning/

Newcombe, N. (2010). Picture this: Increasing math and science learning by improving spatial thinking. *American Educator, 34*(2), 29-35.

Nguyen, T., Watts, T.-W., Duncan, G.-J., Clements, D.-H., Sarama, J.S., Wolfe, C., & Spitler, M.-E. (2016). Which preschool mathematics competencies are most predictive of fifth grade achievement? Early Childhood Research Quarterly, 36, 550-560. https://doi.org/10.1016/j.ecresq.2016.02.003.

Orcan-Kacan, M., & Kimzan, I. (2017). An analysis of the views of teachers on using technology in preschool education. The Journal of International Educational Sciences, 4(12), 203-215. http://dx.doi.org/10.16991/INESJOURNAL.1464

Pekince, P., & Avci, N. (2016). Pre-school teachers' applications related to early childhood mathematics: A qualitative look at activity plans. Kastamonu Egitim Dergisi, 24(5), 2391-2408. Retrieved from https://dergipark.org.tr/tr/download/article-file/309265

Programme for International Student Assessment [PISA] (2018). PISA 2018 results. Retrieved from https://www.oecd.org/pisa/publications/pisa-2018-results.htm

Rittle-Johnson, B., Zippert, E.-L., & Boice, K.-L. (2019). The roles of patterning and spatial skills in early mathematics development. Early Childhood Research Quarterly, 46, 166-178. https://doi.org/10.1016/j.ecresq.2018.03.006

Sabanci, A., Altun, M., & Altun, S.-U. (2018). Problems encountered in pre-school education according to the views of school managers, teachers, and parents. Kuram ve Uygulamada Egitim Yonetimi, 24(2), 339-385. https://doi.org./10.14527/kuey.2018.009

Sarama, J., & Clements, D.-H. (2009). Early childhood mathematics education research: Learning trajectories for young children. Routledge.

The National Association for the Education of Young Children (NAEYC) (2002). Position statement: Early childhood mathematics: Promoting good beginnings. Retrieved from https://www.naeyc.org/positionstatements/mathematics

The Trends in International Mathematics and Science Study (TIMSS) (2019). International database. Retrieved from https://timss2019.org/international-database/

Verdine, B., Golinkoff, R., Hirsh-Pasek, K, & Newcombe, N. (2014). Finding the missing piece: Blocks, puzzles, and shapes fuel school readiness. Trends in Neuroscience and Education, 3, 7-13. Doi: 10.1016/j.tine.2014.02.005

Verdine, B.-N., Irwin, C.-M., Golinkoff, R.-M. & Hirsh-Pasek, K. (2014). Contributions of executive function and spatial skills to preschool mathematics achievement. *Journal of Experimental Child Psychology,* 126, 37–51. https://doi.org/10.1016/j.jecp.2014.02.012

Watts, T.-W., Duncan, G.-J., Siegler, R.-S., & Davis-Kean, P.-E. (2014). What's past is prologue: Relations between early mathematics knowledge and high school achievement. Educational Researcher, 43, 352–360. https://doi.org./10.3102/0013189X14553660

Yi-Ling Cheng & Kelly S. Mix. (2014). Spatial Training Improves Children's Mathematics Ability, Journal of Cognition and Development, 15:1, 2-11, DOI: 10.1080/15248372.2012.725186

Conflicts of interest

The authors of this paper certify that they have NO affiliations with or involvement in any organization or entity with any financial or non-financial interest (such as honoraria; educational grants; membership, employment; affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript.