Southeast Asia Early Childhood Journal, Vol. 12 (1), 2023 (106-124)
eISSN 2821-3149
http://ejournal.upsi.edu.my/index.php/SAECJ

EXAMINATION OF MOVEMENT SKILLS, GEOMETRY AND SPATIAL PERCEPTIONS: CHILDREN IN THE PRESCHOOL PERIOD

Zeynep Kılıç[1*], Alper Yorulmaz[2]

[1]Department of Preschool Education, Faculty of Education, Maltepe University, İstanbul, TURKEY

[2]Department of Elementary Education, Faculty of Education, Muğla Sıtkı Koçman University, Muğla, TURKEY

zeynep.kilic02@gmail.com[1], alperyorulmaz@mu.edu.tr[2]

*Corresponding Author
Received: 09 January 2023; **Revised:** 11 March 2023; **Accepted:** 05 April 2023; **Published:** 13 April 2023

To cite this article (APA): Kılıç, Z., & Yorulmaz, A. (2023). Examination of Movement Skills, Geometry and Spatial Perceptions: Children in The Preschool Period. *Southeast Asia Early Childhood Journal*, *12*(1), 106–124. https://doi.org/10.37134/saecj.vol12.1.8.2023

To link to this article: https://doi.org/10.37134/saecj.vol12.1.8.2023

ABSTRACT

The aim of the study is to determine the movement skills, geometry and spatial perceptions of five-year-old children. The study group consisted of 222 children, 110 girls and 112 boys, who received preschool education in the spring semester of the 2021-2022 academic year in İstanbul, Türkiye. The correlational survey model, one of the quantitative research methods, was used in the study. The CHAMPS Motor Skills Protocol and the Test for Geometry and Spatial Perceptions were used as data collection instruments. In the data analysis, Kolmogorov-Smirnov, t-test, Mann Whitney U test and Spearman Brown test was used. It was seen that the average scores of manipulative skills of the children in the scope of fine motor development were higher than the average scores of locomotor skills in the scope of gross motor development. It was determined that the children got the highest score in the field of "recognition of shapes" for their geometry and spatial perceptions. In addition, it was revealed that girls scored higher than boys in recognizing shape, symmetry, mental appearance of shapes and discovering the properties of shapes, and the areas in which children were most successful in recognizing/distinguishing geometric shapes, without gender differences, while the dimension in which they got the lowest score was symmetry. A low negative correlation was determined between movement skills and geometry and spatial perception. It may be conducting longitudinal studies in which the effect of the relationship between movement skills, geometry and spatial perception on individuals' academic achievement or career choices.

Keywords: movement skills, geometry, spatial perception, preschool

INTRODUCTION

Regardless of their age, people, throughout their lives, are faced with spatial tasks such as rotating and sliding the pieces of the puzzle to place it in the appropriate place (Kandır & Orçan, 2011), using maps to find place and direction, applying instructions for assembling furniture or toys and interpreting diagrams (Ehrlich et al., 2006; Erdoğan, 2018). In the fulfilment of these spatial tasks, cognition comes into play and spatial visualization, mental rotation and geometry information are actively used. The fastest period of cognitive development in the process is the first years of life.

In this context, education, and development in early childhood, which is expressed as the first years of life, have a great impact on the development of cognitive processes. When viewed holistically, cognitive development has a structure that develops in interaction with other areas of development. Therefore, we examined the relationship between movement development and geometry and spatial perceptions of children attending preschool education in early childhood.

The Relationship between Brain Development, Motor Development and Movement Development

Motor development and movement skills that emerge depending on motor development occur in a certain order depending on the maturation of the brain (Aamondt & Wang, 2011). In the first five weeks after birth, the areas with the highest energy use in the brain are the somatosensory cortex, motor cortex, thalamus, brainstem, and cerebellum. These parts, which mature most during birth, are the areas responsible for basic functions such as breathing, movement and touch. By two or three months after birth, energy use also increases in the basal ganglia and the temporal, parietal, and occipital lobes of the cerebral cortex, which, among other things, control vision, spatial reasoning, and movement. Between the 6th and 12th months, as babies begin to control their movements, energy use also increases in areas connected to the frontal cortex (Aamondt & Wang, 2011; Gabbard, 2008; Süzen, 2017).

Since infants learn body movements according to the sequential developmental map of the primary motor cortex (Aamondt & Wang, 2011; Gabbard, 2008), the development of movement skills follows cephalocaudal and proximodistal patterns. The fastest period of brain development is in the first two years after birth, and it is known that myelination in the parts that govern motor movements is not completed until the age of 6 (Todd et al., 1995, as cited in Bee & Boyd, 2007/2009). In other words, the nerves related to the muscle cells in the infant's hand myelinate before the nerves related to the muscle cells in his foot. This allows us to explain that the infant is in a better position to use his hands before his feet. In addition, this myelination process also explains why children's reaching a certain maturity in their movement skills depends on age (Kılıç, 2020). Along with all these myelination processes, rapid development is observed in different parts of the brain.

For a movement to occur, two types of nerve cells on the job exist between the brain and the body. These are afferent nerves and efferent nerves. Afferent nerves are the nerves that carry signals from the body to the brain. Efferent nerves carry signals from the brain, where the central nervous system is located, to the muscles (Edwards, 2010). In other words, while the afferent nerves allow us to receive information about the swelling, pain, tension, etc. of the muscle, they are the efferent nerves that carry information from the brain to the muscle to enable the muscle to perform the movement (Kılıç, 2020). A movement begins with the transfer of sensory information, that is, from the sensory nerves, to the motor cortex in the brain, which is responsible for movement. After the decision on what to do in the motor cortex, the task is transmitted to the muscles through the motor nerves and movement occurs (Edwards, 2010; Langford, 2016/2018). This whole process is referred to as innervation, that is, the transmission of information through the nerve and the decision to act. At the end of this innervation process, movement output is provided in the effectors, that is, in organs such as hands and feet. After the movement output is provided, both internal and external feedback processes are processed in the brain (Kılıç, 2020).

When we look at the process of processing feedback, after the decision is made in the motor cortex of the brain with the notifications from the sensory and motor nerves, the information about the movement is transmitted to the cerebellum region, which works as a "motion error control mechanism" for the evaluation of the movement. This region contains permanent information on how to do a move correctly. If the movement of the individual does not comply with the "correct movement" scheme in the cerebellum, information is sent to the pons region of the brain to reorganize the movement and to perform it correctly (Gabbard, 2008). It is possible to say that this system, which is activated when the movement is done incorrectly, processes information in the location, direction and dimension points of the space and works so that the person can move by his body.

The Relationship between Movement, Geometry and Spatial Perception

The concept of geometry, one of the branches of mathematics that stands out with its visual aspect (Boz-Yaman, 2021), is defined as the branch of mathematics that deals with the measurements and relationships of lines, angles, surfaces and solids, the measurements and relationships of lines, angles, etc in a particular object or shape (Cambridge Dictionary, 2022; Oxford Dictionary, 2022) The National Council of Teachers of Mathematics (NCTM) states that geometry makes it possible for us to recognize, understand and analyze the world (NCTM, 2001). Due to the fact that geometric concepts are directly in real life, besides understanding the world, mental skills such as spatial skills, which are a part of geometric thinking, are also actively involved in this understanding process (Kesicioğlu &Mart, 2022; Ünlü & Ertekin, 2020). It can be said that mental rotation, spatial visualization, and information about shapes and angles should be processed in the mind to understand geometry and perform the necessary geometric operations in line with the explanations and definitions specified.

Geometry for children includes shape and space studies (Clements, 2004). Children start their first experimental studies and intuitive learning about geometry with manipulative games such as "körebe", which enables them to use their sense of place and direction, or the game of marbles, which requires shooting vertically on a line in a row (Boz-Yaman, 2021). For example, block games that children play are not only games, but also an important process in which they make discoveries about shape and geometry (Copley, 2000; Ompok, 2021). Like block games, in Tetris also, all the skills of perceiving the shape, rotating it, spatially perceiving it, and perceiving its position in the space are all actively engaged to place the moving and different shaped visuals in the appropriate place (Clements et al., 1997).

Spatial cognition, which is necessary to understand and apply geometry, is a concept that expresses the ability to perceive objects from different perspectives, to notice the relationships between two or three-dimensional objects, and to create open and closed states of objects in the mind (Van De Walle et al., 2014). In brief, spatial cognition can be expressed as the ability of objects or spaces to understand images, arrange them by moving them, rotate them (Carroll, 1993, as cited in Demirkaya & Masal, 2017; Lean & Clements, 1981). According to Ekstrom et al. (1976), spatial skill has two components: mental rotation and spatial visualization. They expressed the mental rotation component as the ability to rotate objects in the plane and determine their position in space relative to a particular object. They explained the spatial visualization component as determining the new state of an object and the structures that make up the object (as cited in Demirkaya & Masal, 2017).

In order to develop spatial cognition, playing with blocks from early childhood (Borriello & Liben, 2018), making three-dimensional designs (Brosnan, 1998), physical education studies (Jansen et al., 2018) and the active use of these skills by having advanced mathematical skills are emphasized. In addition to these, there are many research results in the literature stating that spatial perception develops when an appropriate teaching environment is provided (Casey et al., 2008; Yolcu, 2008; Eryaman, 2009; Özcan et al., 2016).

Spatial perception in preschool children also develops when they crawl in a tunnel, climb a ladder, pass under a table, run or walk between obstacles, in short, when they use their body. Since when children move their bodies in space, they experience features such as distance, direction and position between their bodies and other objects (California Department of Education, 2010, as cited in Erdoğan, 2018). In other words, moving affects not only the motor development of the child, but also many different areas in the cognitive development dimension positively (Can-Yaşar et al. 2022). The child's gains in spatial perception through movement activities can be listed as awareness of the body, awareness of space and direction sensitivity (Sevimay-Özer & Özer, 2014). Looking at these concepts in detail;

- ***Body Awareness*** means that the child not only knows the body parts and their functions correctly, but also knows how to move all the body parts effectively (Sevimay-Özer & Özer, 2014), and this actually provides the child with intuitive learning in terms of kinesiology and biomechanics, how to use the body parts most functionally and to obtain information about the movement capacity of the body parts (Kılıç, 2017).

- ***Awareness of Space*** is closely related to perceptual motor development and is related to how much space the child's body occupies and to reflect his body effectively (Sevimay-Özer & Özer, 2014). In this dimension, it is possible to say that the child intuitively learns mathematical and spatial perceptions such as the mass, shape and volume of the body. The child's ability to calculate whether his body can fit under a table can be given as an example of what this dimension brings to the child (Kılıç, 2017).

- ***Direction Sensitivity*** is about children's ability to direct objects and their bodies (Sevimay-Özer & Özer, 2014). This dimension is about how the object's position will change as the child directs the object and what its final appearance will be, and it also requires the child's ability to use the concepts of place and direction effectively. From this point of view, it can be noticed that the dimension of directional sensitivity is closely related to mathematics and mental rotation, which is seen as a sub-dimension of spatial perception (Kılıç, 2017).

It is understood that the child's active and good use of his body also affects the child's spatial perception, and he performs a mental operation before reaching the appropriate conclusion by making appropriate changes in his mind (turning left and right, changing direction, etc.) on both his body and objects.

While examining the relationship between motion and spatial perception, it is necessary to look at the relationship between the naturally occurring concept of mathematics and mathematical skills and spatial perception. At this point, when we look at the relationship between mathematical skills and spatial perception, it is stated that spatial perception and thinking are included in geometry, which is the most important mathematical subject after numbers and operations (Aktaş-Arnas, 2012) perceiving and creating simple geometric shapes, and creating more complex geometric shapes by using some geometric shapes are extremely effective and important in solving problems related to the concepts of space and number (Kurt, 2002). There are research studies (Gilligan et al., 2017; Verdine et al., 2014) revealing behavioural connections between spatial cognition and mathematical skills in children in early childhood and primary school years. However, despite the studies (Hubbard et al., 2005; Cutini et al., 2014; Winter et al., 2015) revealing the relationship between spatial cognition and mathematical skills in brain development and behavioral dimension, positive results were not obtained in all studies that tried to transfer spatial cognition gains to mathematics (Cheng & Mix, 2014; Hawes et al., 2015; Hawes et al., 2017; Lowrie et al., 2017).

In preschool years, children learn the concepts of shape, space, time, measurement and number in relation to mathematics. When we look at the factors that affect children's mathematical success, the importance of the environment (Güven, 2000) and general arousal (Arı, 2005) draw attention in addition to the factors such as intelligence (Ercan, 2000), maturity and readiness (Güven, 2000; Selçuk, 2001). In other words, the individual can be more successful in mathematics as well as physiologically and in line with the opportunities provided to him. At this point, it is possible to say that children improve their mathematics skills even by just moving and playing games as Tural (2005) determined that teaching mathematics through games is more effective than teaching with normal mathematics activities. It is possible to say that the child's mathematics skills can be improved with appropriate activities in the preschool years when teaching through games is effective. Dağlı (2007) in his study comparing the academic achievements of children who received preschool education and primary school first-year children who did not, determined that the mathematics achievement of children who received preschool education was at a higher level. When we look at the research studies in general, we come across the studies that establish a relationship between mathematics and games (Dağlı, 2007; Tural, 2005; Uğurel & Morallı, 2008), but there are no studies examining the relationship between movement skills and mathematics. Although it is thought that there is a relationship between movement and motor development and mathematics as stated, the lack of such studies in the literature constitutes the problem of this research. Based on this problem, the aim of the research was to examine the relationship between children's movement skills, their geometry and spatial perceptions. In line with this general purpose, answers were sought to the following questions:

i. Are preschool children's movement skills related to their gender and duration of preschool education?
ii. Are the geometry and spatial perception skills of preschool children related to their gender and duration of preschool education?
iii. Is there a relationship between preschool children's movement skills, their geometry and spatial perception skills?

METHODOLOGY

Research Design

In the research, correlational survey model, one of the quantitative research methods, was used in order to reveal the relationship between the movement skills of preschool children and their geometric and spatial perceptions. Correlational survey model is used in studies aiming to determine the existence or level of change between two or more variables (Karasar, 2016). Survey studies aim to quantitatively explain common trends through a representative sample (Creswell, 2013).

Participants

The study group of the research consisted of children who received preschool education in the spring semester of the 2021-2022 academic year in the province of İstanbul in Türkiye. Random sampling method was used in this study, which was carried out in İstanbul, and in this context, a total of 222 children, 110 girls and 112 boys, were included in the study group, who received education in 12 different randomly selected preschool education institutions. Istanbul was selected as the focus of this research due to its status as the most populous city in Turkey and the presence of numerous socio-cultural differences. During the selection of the study group, children and their families who volunteered to participate were informed about the study and were given the option to withdraw from the study at any time. Consent was obtained from the families, and they were informed that all participant information and research data would be kept confidential. No financial incentives were offered for participation, and all participants took part in the study on a voluntary basis. The ages of the preschool children in the study group ranged from 48 to 79 months (M = 63.6, SD = 5.31). Considering the preschool education status of the children, it was determined that 74.3% (N=165) of them were in the first year of preschool education, and 25.7% (N=57) were in preschool education in two or more years. It was seen that 11.3% (N=25) of the mothers of the children in the study group were primary school graduate, 8.1% (N=18) secondary school graduate, 39.2% (N=87) high school graduate, 41.5% (N=92) university graduate; 14.4% (N=32) of the fathers were primary school graduate, 7.7% (N=17) secondary school graduate, 27% (N=60) high school graduate, and 50.9% (N=113) university graduate. (Table 1)

Table 1
Demographic characteristics of the participants.

		n	%
Preschool education status of the children	Preschool education in one year	165	74.3
	Preschool education in two or more years	57	25.7
Mother education status	Primary school	25	11.3
	Secondary school	18	8.1
	High school	87	39.2
	University	92	41.5
Father education status	Primary school	32	14.4
	Secondary school	17	7.7
	High school	60	27
	University	113	50.9

Data Collection Tools

The data of the study were collected with 3 different data collection tools. The first tool is the "Demographic Information Form", which is used to determine the child's gender, age (months), preschool attendance (years), and parents' educational status. Other data collection tools, detailed below, are “CHAMPS Motor Skills Protocol” and “The Test for Geometry and Spatial Perceptions of 5–6-Year-Old”.

CHAMPS Motor Skills Protocol

The measurement tool developed by Williams et al. (2009) was adapted into Turkish by Kılıç (2018). The adapted measurement tool was prepared to be used in measuring the motor skills of children aged 4-5. CHAMPS motor skills protocol consisted of two subscales, locomotor and object control. The locomotor subscale consisted of 6 dimensions: run (6 items), jump (5 items), slide (7 items), gallop (7 steps), leap (3 items) and hop (7 items). The object control subscale included throwing (6 items), rolling (6 items), kicking (7 items), catching (5 items), striking (7 items) and dribbling (5 items). Regarding the items in the measurement tool, " Eyes focused forward" in the running dimension and " Ball held in fingertips " in the rolling dimension were given as an example. In the study, the Cronbach Alpha reliability value was determined as .847 in the whole measurement tool, .719 in the locomotor subscale and .814 in the object control subscale.

The Test for Geometry and Spatial Perceptions of 5–6-Year-Old (GUZAL-T)

Developed by İvrendi, Erol, and Atan (2018), the test (the Turkish abbreviation is GUZAL-T) was created to evaluate children's geometry and spatial perception skills. The test consisted of four dimensions and 24 items: recognition of shapes (7 items), symmetry (2 items), mental appearance of shapes (7 items), and finding out features of shapes (8 items). A score was made to determine whether the questions in the test are answered, and the lowest 0 and the highest 40 points can be taken from the entire test. The KR-20 reliability value of the developed test was found to be .840 and this value showed that the test was reliable.

GUZAL-T consists of two forms in which questions directed to children and evaluations are made. In the form with the questions, there is a question on each page and the practitioner moves on to the next question (page) after the child answers each question. The questions in the form are asked to the children by the researchers. The evaluation form is filled by the practitioner and the evaluation score that is appropriate for the answers given by the children to each question is determined and filled during the application. If the children do not want to answer any question, 0 points are recorded in the evaluation form for the question that is not answered.

Data Collection Process

The data of the research were collected in the spring semester of the 2021-2022 academic year in March. Before the data collection process, detailed information about the research was given to the families, teachers and school administrators of the children, and permission forms were obtained from the families in order for the children to be included in the research. The demographic information form, which was used as the first data collection tool within the scope of the research, was filled by the researchers before the other two forms were applied. Since two different measurement tools were used in the research, the application process for data collection was carried out over two days, that is, in two stages. In the first stage, the CHAMPS Motor Skills Protocol was used, and in the second stage, the Test for Geometry and Spatial Perceptions Skills was administered to the children. These stages are described in detail below.

Stage 1: During the implementation of the CHAMPS Motor Skills Protocol, each child participating in the study studied individually with the researchers. The application was carried out in a large gym suitable for movement or in an empty classroom, in line with the facilities of the institutions. The application process took approximately 30 minutes for each child. The practitioner who is also the researcher, demonstrated each movement skill twice at different angles so that the child could see it more clearly. Immediately after the practitioner showed the movement, the child was asked to do the same movement he saw. Each movement skill was performed twice by the child and the two measurements were scored separately. In the evaluation of the movement, for the movement form, which is divided into certain stages for the analysis of movement in the measurement tool, each stage performed correctly by the child was scored as 1 point, and if the specified stage of the movement could not be performed correctly or incompletely by the child, 0 points were given. During the implementation of the CHAMPS Motor Skills Protocol, no positive or negative feedback was given to the children for any movement skill, but motivating words were said that did not contain information about how the child performed the movement in order to maintain child's motivation. During the implementation of movement skills, adjustments could be made according to the needs of the children and short breaks of 10-15 seconds were given for the children to rest when they were tired. Evaluations of each movement skill in the measurement tool were stated as a total score in the form.

Stage 2: The Test for Geometry and Spatial Perceptions of 5–6-Year-Old (GUZAL-T) was administered on a different day from the day the first measurement tool was applied, taking into consideration the fact that the children's fatigue and attention might be distracted and they would not be able to reflect their real performance when the second measurement tool was applied. While applying GUZAL-T, the researcher worked with each child individually in a quiet environment. Implementation of GUZAL-T with a child took an average of 20 minutes.

Data Analysis

Since the CHAMPS Motor Skills Protocol and the Test for Geometry and Spatial Perceptions of 5–6-Year-Old were measurement tools with standardized quantitative results, statistical package programs (SPSS 23 and jamovi) were used to analyze the data.

In the data analysis, firstly, Kolmogorov-Smirnov test was performed to determine whether the data showed a normal distribution, and the kurtosis and skewness values were examined. The t-test and Mann-Whitney U test was used to determine whether there was a significant difference according to the variables of gender and duration of preschool education of children receiving preschool education. Spearman Brown correlation test was used to determine the relationship between preschool children's motor skills and geometry and spatial perception skills.

RESULTS

Descriptive Analysis regarding Children's Movement Skills

Descriptive analyzes were conducted to determine the mean, standard deviation and median values of the movement skills (locomotor and object control) of 5-year-old children in preschool education. According to the findings in Table 2, it was determined that the movement skill average score ($\bar{x}$) of 5-year-old children who received preschool education was 7.52. It was observed that the locomotor score average was ($\bar{x}$) 7.36, and the object control mean score was ($\bar{x}$) 7.68. It was revealed that the mean of the object control scores of the students participating in the research was higher than the mean of the locomotor score.

Table 2
Descriptive statistics.

	Mean	SD	Skewness	Kurtosis
Locomotor	7.36	1.77	0.32	-0.87
Object control	7.68	2.03	0.51	-0.73
Total	7.52	1.70	0.33	-0.82

Children's Movement Skills and Gender

In the evaluation of movement skills according to gender, the highest average score was observed in terms of girls. Similarly, girls' average scores were found to be higher in locomotor and object control dimensions. Whether the children's movement skill scores changed according to gender was determined using the independent groups t-test. Although the average of movement skill scores was higher in girls than boys, it was not statistically significant. Although the mean score of girls in the object control sub-dimension was higher than that of boys, this difference was not statistically significant, and a statistically significant difference was found in favor of girls in the locomotor dimension (Table 3). It is seen that the size of the significant difference (Cohen's d) is .31. These findings can show that the ability to move is better acquired by girls.

Table 3
The Comparison between Movement Skills and Gender

	Girl (n=110)		Boy (n=112)		*t*	Cohen's *d*
	Mean	*SD*	Mean	*SD*		
Locomotor	7.64	1.88	7.08	1.61	2.36*	0.31
Object control	7.80	2.01	7.57	2.05	0.85	0.11
Total	7.72	1.73	7.32	1.65	1.73	0.23

Note. *p<.05. df=220

Children's Movement Skills and Preschool Education Duration

In the evaluation of movement skills according to the duration of attendance at the preschool education institution, the highest average score was determined in those who were in their first year in the preschool education. Similarly, it was observed that the mean scores of those who were in their first year were higher in the dimensions of locomotor and object control. The independent groups t-test was used to test whether the movement skill scores of the children changed according to the duration of attendance at preschool education. Although the scores of the children with the first year of movement skills and its subdimensions were higher than those with the second year and above, when the t-test results were examined, it was seen that this difference was not statistically significant (Table 4).

Table 4
The Comparison between Movement skills and pre-school attendance.

	1 year (n=165)		2 years and above (n=57)			
	Mean	*SD*	Mean	*SD*	*t*	Cohen's *d*
Locomotor	7.44	1.84	7.12	1.52	1.19	0.18
Object control	7.78	2.06	7.41	1.91	1.19	0.18
Total	7.61	1.73	7.26	1.58	1.33	0.20

Descriptive Analysis regarding Children's Geometry and Spatial Perception Skills

Descriptive analyzes were conducted to determine the mean, standard deviation and median values of the geometry and spatial perception skills (recognition of shapes, symmetry, mental appearances of shapes, finding out features of shapes) of 5-year-old preschoolers. According to the findings in Table 5, it was determined that the geometry and spatial perception skill average score of 5-year-old children in pre-school education was ($\bar{x}$) 1.16. It was seen that the recognition of shapes mean score was ($\bar{x}$) 1.63, the symmetry mean score was ($\bar{x}$) .90, the mental appearances of shapes mean score was ($\bar{x}$) .92, and the finding out the features of shapes mean score was ($\bar{x}$) 1.19. It was revealed that the children who participated in the study had the highest mean of recognition of shapes, and the lowest mean of symmetry scores.

Table 5
Descriptive statistics.

	Mean	SD	Skewness	Kurtosis
Recognition of shapes	1.63	0.61	-0.48	-0.43
Symmetry	0.90	0.26	-2.43	5.72
Mental appearances of shapes	0.92	0.33	-0.78	-0.49
Finding out features of shapes	1.19	0.35	-1.12	0.35
Total	1.16	0.30	-0.62	-0.37

Children's Geometry and Spatial Perception Skills and Gender

When the mean scores of geometries and spatial perception skills were compared according to gender, it was determined that the mean score of girls ($\bar{x}$ =1.18) was higher than that of boys ($\bar{x}$ =1.12). It was observed that the average score of girls was higher than boys in the dimensions of shape recognition of shapes, symmetry, mental appearances of shapes, and finding out the features of shapes (Table 6).

Table 6
Descriptive Statistics regarding Geometry and Spatial Perception Skills and Gender

	Girl (n=110)		Boy (n=112)	
	Mean	*SD*	Mean	*SD*
Recognition of shapes	1.68	0.56	1.56	0.65
Symmetry	0.92	0.21	0.86	0.28
Mental appearances of shapes	0.94	0.31	0.89	0.34
Finding out features of shapes	1.19	0.34	1.17	0.36
Total	1.18	0.28	1.12	0.32

Whether the children's geometry and spatial perception skill scores changed according to gender was analyzed using the Mann-Whitney U test. The difference between boys and girls in movement skills and sub-dimensions was not statistically significant (p=.17; p>.05) (Table 7).

Table 7
The Comparison between Geometry and Spatial Perception Skills and Gender

	Girl (n=110)		Boy (n=112)				
	Median	*SD*	Median	*SD*	*U*	*Z*	Size Effect (r)
Recognition of shapes	116.20	0.56	106.88	0.65	5643	-1.08	0.08
Symmetry	116.48	0.21	106.61	0.28	5612	-1.78	0.08
Mental appearances of shapes	115.81	0.31	107.26	0.34	5685	-1.01	0.07
Finding out features of shapes	111.78	0.34	111.23	0.36	6129	-0.65	0.00
Total	117.42	0.28	105.69	0.32	5509	-1.36	0.10

Children's Geometry and Spatial Perception Skills and Duration of Preschool Education

When the mean scores of geometries and spatial perception skills were compared according to the duration of preschool education, it was determined that the mean score of the children who attended school for two or more years ($\bar{x}$ =1.20) was higher than the children who were in their first year ($\bar{x}$ =1.14). It was also seen that the average scores of those who attended school for two or more years were higher in the dimensions of recognition of shapes, symmetry, and mental appearances of shapes. In the dimension of finding out the features of shapes, it was revealed that the average score of the children in their first year was higher (Table 8).

Table 8
Descriptive Statistics regarding Geometry and Spatial Perception Skills, Duration of Preschool Education

	1 year (n=165)		2 years and above (n=57)	
	Mean	*SD*	Mean	*SD*
Recognition of shapes	1.59	0.64	1.69	0.48
Symmetry	0.87	0.27	0.95	0.14
Mental appearances of shapes	0.89	0.34	0.98	0.30
Finding out features of shapes	1.19	0.35	1.16	0.37
Total	1.14	0.31	1.20	0.25

Whether the children's geometry and spatial perception skill scores changed according to the duration of their preschool education was analyzed using the Mann-Whitney U test. In terms of movement skills and its sub-dimensions, the difference between the children in the first year of preschool education and the children in the two years and over was not statistically significant (p=.32; p>.05) (Table 9).

Table 9
The Comparison between Geometry and Spatial Perception Skills and Duration of Preschool Education

	1 year (n=165)		2 years and above (n=57)				
	Median	*SD*	Median	*SD*	*U*	*Z*	Size Effect (r)
Recognition of shapes	109.81	0.64	116.39	0.48	4423	-0.67	0.05
Symmetry	108.49	0.27	120.20	0.14	4206	-1.85	0.10
Mental appearances of shapes	107.71	0.34	122.46	0.30	4077	-1.52	0.13

continued

Finding out features of shapes	111.77	0.35	110.72	0.37	4658	-0.10	0.00
Total	108.99	0.31	118.77	0.26	4288	-0.99	0.08

The Relationship Between Children's Movement Skills and Geometry and Spatial Perception Skills

The correlation between movement and geometry and spatial perception skills was determined by using the Spearman Brown test. It was found that the relationship between children's movement skills and their geometry and spatial perception skills was negative at a low level (r= -.20). This finding showed that as children's movement skills increase, their geometry and spatial perception skills will decrease. It was observed that there was a negative relationship between geometry and spatial perception skills and locomotor (r= -.29) and object control (r= -.15). There was a negative relationship between the dimension of finding out the features of shapes and symmetry and the movement skill and locomotor. A negative correlation was determined between mental appearances of shapes and locomotor (r= -.38), object control (r= -.26), and movement skill (r= -.35) (Table 10).

Table 10
The Relationship between Children's Movement Skills and Their Geometry and Spatial Perception Skills

	Locomotor	Object control	Movement skill
Recognition of shapes	-.04	-.07	-.07
Symmetry	-.19**	-.08	-.16*
Mental appearances of shapes	-.38**	-.26***	-.35***
Finding out features of shapes	-.16*	-.09	-.14*
Geometry and Spatial Perception Skills	-.29**	-.15*	-.20**

* p < .05, ** p < .01, *** p < .001

DISCUSSION AND CONCLUSION

When the descriptive analysis results of children's movement skills were examined, it was seen that the average scores of manipulative skills within the scope of fine motor development were higher than the average scores of locomotor skills within the scope of gross motor development. When examined on the basis of developmental principles, this result is seen as an opposite result to the principle of proximodistal development. Contrary to the developmentally expected result, there may be several reasons why children's manipulative skills scores are high. The first one may be the city in which the children in the study group live. As Venetsanou and Kambas (2010) stated, environmental factors affecting children's motor development are listed in order of importance as family, educational institutions and movement programs. At this point, it is necessary to consider the opportunities that the family, which is in the first place, can provide for their child. The province of İstanbul is the most crowded city in Türkiye, the densest in traffic and the highest density of buildings and people. Due to the reasons stated, it is thought that children's playgrounds are restricted and there is less opportunity to go out and play on the streets. Çelik and Şahin (2013) stated that children who cannot move freely in big cities and stay in narrow and closed spaces in apartments will adopt a more sedentary lifestyle and this will have a negative effect on motor development. Taşçı (2010) stated that children cannot play on the streets as before due to traffic density, and it is difficult to go the playgrounds designed to solve this problem. As a result of these situations, the researcher stated that instead of playing outside, children develop a more indoor and sedentary game understanding, and as a result, the child's development is adversely affected. Tüfekçioğlu and Ayça (2008) also stated that the motor development of children who are stuck in apartments in city life and who do not play in natural areas will be adversely affected by this situation. Another reason for the emergence of the result is thought to be the inadequacy of movement activities in the education provided by teachers in institutions. When we look at the results of the research, it is seen that even the infants who receive movement training have a higher level of gross motor skills than those who do not receive training (Kobal, 2000). While it is expected that children developmentally first mature in gross motor development and then mature in fine motor development (Bee & Boyd, 2007/2009) the opposite result was found in this study, suggesting that the teachers of children receiving preschool education provided insufficient movement training. Because it is known that movement programs prepared by field expert teachers have a positive effect on children's motor skills (Robinson et al., 2012). Fjortoft (2004) and Giagazoglou, Karagianni, Sidiropoulou, and Salonikidis (2008) revealed that the appropriate educational environment has a positive effect on the development of children's motor skills, which supports the fact that children's chances of developing their motor skills decrease due to the environment.

As a result of the analysis of children's movement skills and gender, it was determined that girls’ total scores on displacement, object control and motor skills were higher than boys. The reason for the emergence of this situation can be explained by the fact that girls experience this process earlier than boys in the muscle development process, as in many aspects of physical development (Bee & Boyd, 2007/2009).

When the descriptive analysis results regarding the geometry and spatial perception skills of the children in the study were examined, it was seen that they got the highest score in the field of "recognition of shapes". It is thought that this situation may be due to the fact that the geometric shape concepts in the Ministry of National Education (MoNE [in Turkish,MEB]) Preschool Education Curriculum (MEB, 2013) are included in the mathematics activities by the teachers and that the children acquire these basic concepts in educational environments. It is thought that due to the lack of a special emphasis in the Preschool Education Curriculum in the field of "symmetry", where children get the lowest score, teachers may not have designed the activities necessary for children to learn this concept and may not have introduced children to this concept. Hu and Zhang (2019) state that, in their study with children aged 4-6, the concept of general symmetry was first acquired by children and their ability to think about the symmetrical form from different angles developed over time. The result of this study reveals the importance of introducing children to the concept of symmetry in the development of symmetry perception.

When the geometry and spatial perception scores of the children were compared according to the genders, it was determined that the scores of the girls were higher than the scores of the boys, although there was no statistically significant difference. This result is in contrast to the conclusion in some studies in the literature that boys are more successful in spatial cognition tests than girls (Linn & Petersen, 1985; Geary et al., 2000; Halpern, 1986, as cited by Bee & Boyd, 2007/2009). Contrary to this research result, there are also research findings in the literature stating that spatial perception does not change according to genders, it has a biological development infrastructure and it develops with experience (Örnkloo & von Hofsten, 2007; Vasilyeva & Lourenco, 2012).

As a result of the research, it is not an expected result that there is a negative relationship between children's movement skills and their geometry and spatial perception skills because there are studies in the literature showing that regularly performed movement activities have an effect on mental rotation skill, which is a dimension of geometric thinking (Frick et al., 2009; Jansen & Heil, 2010; Blüchel et al., 2013). It is also stated that spatial perception develops with the use of the body (Sevimay-Özer & Özer, 2014; Kılıç, 2017). Considering the situations that may lead to the emergence of the stated result, it is thought that the changing game habits of children and the materials used in the studies conducted to understand geometry in schools may be effective. Children included in the study group live in İstanbul, the most populous city of Türkiye. Parents prefer their children to spend more time at home (Aksoy, 2001; Bal, 2005) due to the crowdedness of the city and the problems that children have in finding a safe place to play (Taşçı, 2010; Çelik and Şahin, 2013).

Considering that these disadvantages of city life lead children to play indoors, it can be said that the positive relationship between children's movement skills and spatial perceptions will be inhibited, as stated in the literature. In addition, with the effect of changing living conditions and developing technology, children's games are changing from active outdoor games to indoor games such as digital games played on tablets and phones (Tuğrul et al, 2014; Özyürek et al., 2018; Sapsağlam, 2018; Kaya, 2019). It is thought that this transformation in children's play preferences does not support the development of their perceptions of body-space, as it requires them to use their fingers, that is, fine motor skills, rather than using their gross motor skills. From this point of view, it is thought that the opposite relationship between spatial perception and unexpected movement skills obtained in the research can be explained. In addition to the disadvantage of living in a big city for children, in the studies on geometric concepts that children do within the scope of mathematics activities in preschool education institutions, three-dimensional models including tangrams, multi-square sets, multi-cube sets, find-place toys and concrete geometric shapes presented by teachers to concretize the concepts (Ünlü & Ertekin, 2020) are thought to be effective tools in teaching and facilitate children's perception and understanding of geometric shapes. In line with this idea, Olkun and Altun (2003) state that this situation can be developed with appropriate material selection and activities.

These materials are generally two- or three-dimensional objects and their pictures, and it is stated that there are contents such as playing with these materials, drawing pictures of the materials, creating new shapes using the specified materials (Küçük-Demir, 2020). Anning and Ring (2004) state that two- or three-dimensional art activities positively support children's mathematical comprehension skills. In line with the results obtained, studies should be conducted on the relationship between children living in rural areas and big cities with different mobility areas in the size of their living environment, children who have higher physical activity opportunities with family and teacher support, and children who continue their lives without any special support. In addition, it may be recommended to conduct longitudinal studies in which the effect of the relationship between movement skills, geometry and spatial perception on individuals' academic achievement or career choices.

ACKNOWLEDGEMENT

The authors would like to thank all participants who voluntarily took part in the study and shared their time and experiences. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this study.

AUTHOR CONTRIBUTIONS

The author was responsible for the conception and design of the study, data collection, data analysis, interpretation of the findings, and preparation of the manuscript.

DECLARATION OF GENERATIVE AI USE

No generative artificial intelligence (AI) tools were used in the design, data collection, analysis, interpretation of the findings, or writing of this manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the author upon reasonable request.

REFERENCES

Aamodt, S. & Wang, S. (2011). *Welcome to your children's brain - How the mind grows from conception to collage.* Bloomsbury Publication.

Aksoy, Y. (2011). Çocuk oyun alanları üzerine bir araştırma İstanbul, Isparta, Eskişehir, Erzurum, Kayseri, Ankara, Zonguldak ve Trabzon illeri örneği. [Research on children's playgrounds the example of Istanbul, Isparta, Eskişehir, Erzurum, Kayseri, Ankara, Zonguldak and Trabzon provinces]. *İstanbul Aydın Üniversitesi Dergisi, 3*(11), 82-106.

Aktaş-Arnas, Y. (2012). *Okul öncesi dönemde matematik eğitimi [Mathematics education in preschool period]*. Vize Yayıncılık.

Anning, A., & Ring, K. (2004). *Making sense of children's drawings*. McGraw-Hill Education.

Arı, M. (2005). *Gelişim ve öğrenme [Development and learning*]. Nobel Akademik Yayıncılık.

Bal, A., (2005). *Zonguldak kenti yeşil alan sistemindeki çocuk oyun alanlarının durumunun peyzaj mimarlığı ilkeleri açısından irdelenmesi [State of the playgrounds in green space system of Zonguldak city examine from the point of view landscape architecture principle]*. Unpublished master's thesis. Zonguldak Karaelmas Üniversitesi, Fen Bilimleri Enstitüsü, Bartın.

Bee, H. ve Boyd, D. (2009). *Çocuk gelişim psikolojisi [Child developmental psychology]* Gündüz, O. (çev.). Kaknüs Yayınları (original published date 2007).

Blüchel, M., Lehmann, J., Kellner, J., & Jansen, P. (2013). The improvement in mental rotation performance in primary school-aged children after a two-week motor-training. *Educational Psychology, 33*(1), 75-86. https://doi.org/10.1080/01443410.2012.707612

Borriello, G. A., & Liben, L. S. (2018). Encouraging maternal guidance of preschoolers' spatial thinking during block play. *Child Development, 89*(4), 1209-1222. https://doi.org/10.1111/cdev.12779

Boz-Yaman, B. (2021). *Origami ile geometri öğreniyorum [I'm learning geometry with origami]*. Egem Basın Yayın.

Brosnan, M. J. (1998). Spatial ability in children's play with Lego blocks. *Perceptual and Motor Skills, 87*(1), 19-28. https://doi.org/10.2466/pms.1998.87.1.19

Can-Yaşar, M., Karaca, N. H., & Uzun, H. (2022). Relationship between motor creativity and science process skills of preschool children. *Southeast Asia Early Childhood Journal, 11(*2), 152–165. https://doi.org/10.37134/saecj.vol11.2.10.2022

Cambridge Dictionary. (2022). https://dictionary.cambridge.org/tr/s%C3%B6zl%C3%BCk/ingilizce-t%C3%BCrk%C3%A7e/geometry

Casey, B. M., Andrews, N., Schindler, H., Kersh, J. E., Samper, A. ve Copley, J. (2008). The development of spatial skills through interventions involving block building activities. *Cognition and Instruction, 26*(3), 269-309. https://doi.org/10.1080/07370000802177177

Cheng, Y. L., & Mix, K. S. (2014). Spatial training improves children's mathematics ability. *Journal of Cognition and Development, 15*(1), 2– 11. https://doi.org/10.1080/15248372.2012.725186

Clements, D. H. (2004). Geometric and spatial thinking in early childhood education. *Engaging young children in mathematics: Standards for early childhood mathematics education*, 267-297. https://www.researchgate.net/publication/258933055_Geometric_and_spatial_thinking_in_early_child hood_education

Clements, D. H., Battista, M. T., Sarama, J., & Swaminathan, S. (1997). Development of students' spatial thinking in a unit on geometric motions and area. *The Elementary School Journal, 98*(2), 171-186. https://www.journals.uchicago.edu/doi/abs/10.1086/461890

Cutini, S., Scarpa, F., Scatturin, P., Dell'Acqua, R., & Zorzi, M. (2014). Number-space interactions in the human parietal cortex: Enlightening the SNARC effect with functional near-infrared spectroscopy. *Cerebral Cortex*, *24*(2), 444– 451. https://doi.org/10.1093/cercor/bhs321

Dağlı, A. (2007). *Okul öncesi eğitimi alan ve almayan ilköğretim birinci sınıf öğrencilerinin türkçe ve matematik derslerindeki akademik başarılarının karşılaştırılması [To compare academical success in Turkish and maths lessons of primary school first class students who are trained at preschools and who are not trained at these schools]*. Unpublished master's thesis. Selçuk Üniversitesi, Sosyal bilimler Enstitüsü, Konya.

Demirkaya, C. ve Masal, M. (2017). Geometrik-mekanik oyunlar temelli etkinliklerin ortaokul öğrencilerinin uzamsal düşünebilme becerilerine Etkisi [The effect of geometric-mechanic games based activities on the spatial skills of secondary school students). *Sakarya University Journal of Education, 7*(3), 600-610. Doi: 10.19126/suje.340730

Edwards, W. H. (2010). *Motor learning and control: From theory to practice*. Wadsworth Publishing.

Ehrlich, S. B., Levine, S. C., & Goldin-Meadow, S. (2006). The importance of gesture in children's spatial reasoning. *Developmental Psychology, 42*(6), 1259–1268. https://doi.org/10.1037/0012-1649.42.6.1259 Ercan, A. R. (2000). *Çocuklar nasıl öğrenir? [How do children learn?]* Galeri Kültür Yayınevi.

Erdoğan, S. (2018). Okul öncesi dönemde uzamsal düşünme ve geometri [Spatial thinking and geometry in preschool]. İ. Ulutaş (Ed*.). Okul öncesinde matematik eğitimi [Preschool mathematics education*] (p. 125-146). Hedef Yayıncılık.

Eryaman, Z. (2009). *A study on sixth grade students' spatial reasoning regarding 2D representations of 3D objects*. Unpublished master's thesis. Ortadoğu Teknik Üniversitesi, İlköğretim Fen ve Matematik Alanları Eğitimi Bölümü, Ankara.

Fjortoft, I. (2004). Landscape as playscape: The effects of natural environments on children's play and motor development. *Children, Youth and Environments, 14*(2), 21-44. https://www.jstor.org/stable/10.7721/chilyoutenvi.14.2.0021

Frick, A., Daum, M. M., Walser, S., & Mast, F. W. (2009). Motor processes in children's mental rotation. *Journal of Cognition and Development, 10*(1-2), 18-40. https://doi.org/10.1080/15248370902966719

Gabbard, C. P. (2008). *Lifelong motor development*. Pearson Publishing.

Geary, D. C., Saults, S. J., Liu, F., & Hoard, M. K. (2000). Sex differences in spatial cognition, computational fluency, and arithmetical reasoning. *Journal of Experimental Child Psychology, 77*(4), 337-353. https://doi.org/10.1006/jecp.2000.2594

Giagazoglou, P., Karagianni, O., Sidiropoulou, M. & Salonikidis, K. (2008). Effects of the characteristics of two different preschool-type setting on children's gross motor development. *European Psychomotricity Journal, 1*(2), 54-60. http://ikee.lib.auth.gr/record/231494/files/Giagazoglou%20et%20al.pdf

Gilligan, K. A., Flouri, E., & Farran, E. K. (2017). The contribution of spatial ability to mathematics achievement in middle childhood. *Journal of Experimental Child Psychology, 163*, 107– 125. https://doi.org/10.1016/j.jecp.2017.04.016

Güven, Y. (2000). *Erken çocukluk döneminde sezgisel düşünme ve matematik [Intuitive thinking and mathematics in early childhood*]. Ya-Pa Yayınları.

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*(3), 236–264. https://doi.org/10.1080/07370008.2017.1323902

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*(3), 60– 68. https://doi.org/10.1016/j.tine.2015.05.001

Hu, Q., & Zhang, M. (2019). The development of symmetry concept in preschool children. *Cognition*, *189*, 131-140. https://doi.org/10.1016/j.cognition.2019.03.022

Hubbard, E. M., Piazza, M., Pinel, P., & Dehaene, S. (2005). Interactions between number and space in parietal cortex. *Nature Reviews Neuroscience, 6*(6), 435– 448. https://doi.org/10.1038/nrn1684

İvrendi, A., Erol, & A. ve Atan, A. (2018). 5-6 yaş çocuklarına yönelik geometri ve uzaysal algı testinin geliştirilmesi [Developing a test for geometry and spatial perceptions of 5–6-year-old]. *Kastamonu Education Journal, 26*(6), 1823-1833. https://doi.org/10.24106/kefdergi.2097

Jansen, P., Ellinger, J., & Lehmann, J. (2018). Increased physical education at school improves the visual-spatial cognition during adolescence. *Educational Psychology, 38*(7), 964-976. https://doi.org/10.1080/01443410.2018.1457777

Jansen, P., & Heil, M. (2010). The relation between motor development and mental rotation ability in 5-to 6-year-old children. *International Journal of Developmental Science, 4*(1), 67-75. https://doi.org/10.3233/DEV-2010-4105

Kandır, A. ve Orçan, M. (2018). Okul öncesi dönemde matematik eğitimi [Mathematics education in preschool period]. Morpa Yayınları.

Kaya, İ. (2019). X, Y, Z kuşaklarının çocukluk oyunlarının incelenmesi [Investigation of childhood games in the lives of X, Y, Z Generations]. *FSM İlmî Araştırmalar İnsan ve Toplum Bilimleri Dergisi, 14*, 313-326. https://doi.org/10.16947/fsmia.667318

Kesicioğlu, O. S., & Mart, M. (2022). The preschool teachers' opinion on teaching geometry. *Southeast Asia Early Childhood Journal, 11*(2), 21–36. https://doi.org/10.37134/saecj.vol11.2.2.2022

Kılıç, Z. (2017). Oyun yoluyla fiziksel becerilerin desteklenmesi ve riskli oyunlar [Supporting physical skills through play and risky games]. Alev Önder ve Hande Arslan-Çiftçi (Ed.), *Erken Çocuklukta Oyun ve Oyun Yoluyla Öğrenme [Play and learning through play in early childhood]* (p. 169-190). Nobel Akademik Yayıncılık.

Kılıç, Z. (2020). Çocuk ve hareket [Child and movement]. E. Görgü & T. Sezer (Ed.s) *Erken çocuklukta güncel konular [Current issues in early childhood]* (p. 269-296). (1st ed.). Nobel Akademik Yayıncılık.

Kobal, G. (2000). *Erken eğitim programına devam eden down sendromlu bebeklere verilen motor beceri eğitiminin büyük kas gelişimlerine etkisinin incelenmesi [A Research on the effects of motor skills training on the gross motor development of infants with down's syndrome, attending the early intervention program].* Unpublished doctoral thesis. Ankara Üniversitesi, Fen Bilimleri Enstitüsü, Ankara.

Kostelnik, M. J., Soderman, A. K., Whiren, A. P. & Rupiper, M. L. (2019). Bilişsel alan. Akşin-Yavuz, E. (Çev.) Gelişime Uygun eğitim programı Erken Çocukluk Eğitiminde En İyi Uygulamalar. E. Ahmetoğlu ve İ. H. Acar (Çev. Ed.s) (p.341-377). Nobel Akademik Yayıncılık. (original published date 2019).

Kurt, M. (2002). Görsel-uzaysal yeteneklerin bileşenleri [Components of visuospatial abilities). *Klinik Psikiyatri, 5*(2), 120-125. https://jag.journalagent.com/kpd/pdfs/KPD_5_2_120_125.pdf

Küçük-Demir, B. (2020). Geometri ve geometrik düşünce [Geometry and geometric thinking]. Ağırman-Aydın ve B. Küçük-Demir (Ed.s) *Geometri ve öğretimi [Geometry and its teaching]* (p. 1-10). PEGEM Akademik Yayıncılık.

Langford, K. (2018). Anatomi 101: Kaslar ve kemiklerden organlar ve sistemlere kadar insan vücudu hakkında bilmeniz gereken her şey [Anatomy 101: Everything you need to know about the human body, from muscles and bones to organs and systems]. Asuman-Uzun, B. (Çev.). Say Yayıncılık.

Lean, G. & Clements, M.A. (1981). Spatial ability, visual imagery and mathematical performance. *Educational Studies in Mathematics, 12*(3), 267-299. https://link.springer.com/article/10.1007/bf00311060

Linn, M. C., & Petersen, A. C. (1985). Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development, 56*(6), 1479–1498. https://doi.org/10.2307/1130467

Lowrie, T., Logan, T., & Ramful, A. (2017). Visuospatial training improves elementary students' mathematics performance. *British Journal of Educational Psychology, 87*(2), 170– 186. https://doi.org/10.1111/bjep.12142

Milli Eğitim Bakanlığı (2013). *Okul öncesi eğitim programı [Preschool education program]*. Milli Eğitim Bakanlığı Yayınları

Olkun, S., & Altun, A. (2003). İlköğretim öğrencilerinin bilgisayar deneyimleri ile uzamsal düşünme ve geometri başarıları arasındaki ilişki [The relationship between primary school students' computer experiences and their spatial thinking and geometry achievements.] *The Turkish Online Journal of Educational Technology, 2*(4), 86-91. http://www.tojet.net/volumes/v2i4.pdf

Ompok, C. S., Mei Teng, L., & Sapirai, J. (2021). Effect of games towards children's mathematics performance. *Southeast Asia Early Childhood Journal, 10*(1), 1–17. https://doi.org/10.37134/saecj.vol10.1.1.2021

Oxford Dictionary. (2022). https://www.oxfordlearnersdictionaries.com/definition/english/geometry?q=geometry (Retrieval date: 13.10.2022).

Örnkloo, H., & von Hofsten, C. (2007). Fitting objects into holes: On the development of spatial cognition skills. *Developmental Psychology, 43*(2), 404–416. https://doi.org/10.1037/0012-1649.43.2.40

Özcan, K. V., Akbay, M. & Karakuş T. (2016). Üniversite öğrencilerinin oyun oynama alışkanlıklarının uzamsal becerilerine etkisi [Effects of gaming habits of university students on their spatial skills]. *Kastamonu Eğitim Dergisi, 24*(1), 37-52. https://dergipark.org.tr/en/download/article-file/210019

Özyürek, A., Tezel-Şahin, F., & Gündüz, Z. B. (2018). Nesilden nesile kültürel aktarımda oyun ve oyuncakların rolü [The role of plays and toys on cultural transformation from one generation to another]. *Journal of the Cukurova University Institute of Social Sciences, 27*(1), 1-12. https://dergipark.org.tr/en/download/article-file/456445

Robinson, L. E., Webster, E. K., Logan, S.W., Lucas, W. A. & Barber, L. T. (2012). Teaching practices that promote motor skills in early childhood settings. *Early Childhood Education Journal, 40*, 79-86. DOI 10.1007/s10643-011-0496-3

Sapsağlam, Ö. (2018). Okul öncesi dönem çocuklarının değişen oyun tercihleri [Changing game preferences of preschool children]. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi, 19*(1), 1122-1135. https://dergipark.org.tr/en/download/article-file/1478929

Sevimay-Özer, D. & Özer, M. K. (2014). *Çocuklarda motor gelişim [Motor development in children]*. (8. Baskı). Nobel Akademik Yayıncılık.

Süzen, L.B. (2017). *Hareket sistemi anatomisi ve kinesiyoloji [Movement system anatomy and kinesiology]*. (2. Baskı). Nobel Tıp Kitabevi.

Taşçı, B. (2010). *Sokağın günümüz koşullarında çocuk oyun alanı olarak ele alınması ve değerlendirilmesi [An evaluation of street as children play space]*. Unpublished master's thesis. Dokuz Eylül Üniversitesi, Fen Bilimleri Enstitüsü, İzmir.

Tepeli, K. (2007). *Büyük Kas Becerilerini Ölçme Testi (BüKBÖT)'nin Türkiye standardizasyonu [Standardization of test of gross motor skills for Turkey]*. Unpublished doctoral thesis. Selçuk Üniversitesi, Sosyal Bilimler Enstitüsü, Konya.

Tuğrul, B., Ertürk, H. G., Özen Altınkaynak, Ş., & Güneş, G. (2014). Change of the play in three generations. *The Journal of Academic Social Science Studies, 27*(1), 1-16. http://dx.doi.org/10.9761/JASSS2388 Tural, H. (2005). *İlköğretim matematik öğretiminde oyun ve etkinliklerle öğretimin erişi ve tutuma etkisi [The effects of teaching mathematics in elemantary school by games and activities on achievement and attitude]*. Unpublished master's thesis. Dokuz Eylül Üniversitesi, Eğitim Bilimleri Enstitüsü, İzmir.

Uğurel, I. & Morallı, S. (2008). Matematik ve oyun etkileşimi [The interaction of mathematics & game]. *Gazi Üniversitesi Eğitim Fakültesi Dergisi, 28*(3), 75-98. https://dergipark.org.tr/en/download/article-file/77106

Ünlü, M. & Ertekin, E. (2020). Geometri öğretimi [Geometry teaching]. E. Ertekin & M. Ünlü (Eds.), *Geometri ve Ölçme Öğretimi Tanımlar, Kavramlar ve Etkinlikler [Geometry and measurement teaching definitions, concepts and activities]* (p.37-62). PEGEM Akademik Yayıncılık.

Winter, B., Matlock, T., Shaki, S., & Fischer, M. H. (2015). Mental number space in three dimensions. *Neuro-science & Biobehavioral Reviews, 57*, 209– 219. https://doi.org/10.1016/j.neubiorev.2015.09.005

Van De Walle, J. A., Karp, K. S. ve Bay-Williams, J., M. (2014). *İlkokul ve ortaokul matematiği, gelişimsel yaklaşımla öğretim [Primary and secondary school mathematics, teaching with a developmental approach]*. Nobel Yayın Dağıtım.

Vasilyeva, M., & Lourenco, S. F. (2012). Development of spatial cognition. *Wiley Interdisciplinary Reviews: Cognitive Science, 3*(3), 349-362. https://doi.org/10.1002/wcs.1171

Venetsanou, F. & Kambas, A. (2010). Environmental factors affecting preschoolers' motor development. *Early Childhood Education Journal, 37*, 319-327. https://doi.org/10.1007/s10643-009-0350-z

Verdine, B. N., Golinkoff, R. M., Hirsh-Pasek, K., Newcombe, N. S., Filipowicz, A. T., & Chang, A. (2014). De-constructing building blocks: Preschoolers' spatial assembly performance relates to early mathematical skills. *Child Development, 85*(3), 1062– 1076. https://doi.org/10.1111/cdev.12165

Yolcu, B. (2008). *Altıncı sınıf öğrencilerinin uzamsal yeteneklerini somut modeller ve bilgisayar uygulamaları ile geliştirme çalışmaları [The study of improving the spatial ability of sixth grade students? with concrete models and computer practising*]. Unpublished master's thesis. Eskişehir Osmangazi Üniversitesi, Fen Bilimleri Enstitüsü, Eskişehir.