European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available on-line at: www.oapub.org/edu

doi: 10.5281/zenodo.845498 Volume 3 │ Issue 9 │ 2017

INVESTIGATING KINDERGARTNERS' GEOMETRIC AND SPATIAL THINKING SKILLS: IN CONTEXT OF GENDER AND AGE

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Abstract:
The purpose of this study was to investigate kindergartners' geometric (shape, area and symmetry) and spatial (spatial orientation and spatial visualization) thinking skills, in the context of gender and age. Whether kindergartners' geometric and spatial thinking skills vary by their age or gender was questioned. A total of 73 kindergartner (40 boys and 33 girls) aged between 4-5 (◎ = 4,6) participated this study. Survey Design was used for this study. Participants were selected according to Convenience Sampling method. Accessibility of educational institutions and willingness of teachers, were decisive. "Geometric and Spatial Thinking Skills Test" (GEOST-ST) was used to collect the data. MANOVA (Multivariate ANOVA) was performed for data analysis. According to the results of this study, difference between children's mean scores of relevant geometric and spatial thinking skills, aren't statistically significant for gender and age.

Keywords: kindergartner, geometry, spatial, child, skill

1. Introduction

Geometry is a mathematical learning area which defines and classifies our world according to shapes, sizes, directions, positions, statements and movements of objects (Copley, 2000). Geometric thinking in early years may be defined as, understanding the features of real world by hands on experiences; especially by tactual, visual, linguistic and cognitive processes (Hyun & Fang, 2010).

Spatial thinking consists of space, various visual representations and decision-making processes related to both space and visual representations (Uhlenwinkel, 2013).

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Spatial thinking is a cognitive process, related to objects positions, locations and interactions between them, and also related to our perception about them and their relations (Gersmehl & Gersmehl, 2007).

Geometric and spatial thinking skills are important skills for preschool age children's future learnings and mathematical achievements. We should help children to develop their geometric and spatial thinking skills and to understand geometric and spatial relations better, by providing appropriate educational programs or facilities (Carter, Larussa & Bodner, 1987; Conor & Serbin, 1980; Çalışkan-Dedeoğlu & Alat, 2012; Delialioğlu & Aşkar, 1999; Dominguez, Martin-Gutierrez & Roca, 2013; Levine, Ratliff, Huttenlocher & Cannon, 2011; Tartre, 1990; Zhang, Koponen & Rasanen, 2014).

For geometric thinking skills, preschool age children are expected to develop understandings of identifying, naming, classifying, composing, decomposing and knowing about features of geometric shapes for shape (Clements & Sarama, 2000; Copley, 2000; Ontario Learning, 2005). And they are expected to develop understandings of area and to gain experiences about the concept of area for area as a geometric thinking skill (Clements, 1999). They are also expected to develop understanding of basic symmetrical features and symmetrical transformations, for symmetry (Clements & Sarama, 2000).

Again, preschool age children are expected to develop understandings of their environment and location, (Bergqvist, 2015). Additionally, to tell about the locations of objects, to put the objects into correct places and locate themselves to the correct spaces are expected (MONE, 2013) for spatial orientation. For spatial visualization, they are expected to develop understandings of mental images, transformations and movements of objects, and to match and combine them (Sarama & Clements, 2009).

Whether kindergartners' geometric and spatial thinking skills vary by their gender or age" was questioned, in this study. Shape, area, symmetry considered as geometric thinking skills and, spatial orientation, spatial visualization as spatial thinking skills.

2. Purpose

Purpose of this study was to investigate kindergartners' geometric and spatial thinking skills, in the context of gender and age. For this purpose, "*Whether kindergartners' geometric and spatial thinking skills vary by their gender or age*" was questioned.

3. Material and Methods

This study was conducted according to quantitative research methods. *Survey Design* which ensures us to describe the situations or features that target populations have, was used in this study (Creswell, 2012). Children's geometric and spatial thinking skills were investigated and evaluated by using GEOST-ST.

3.1. Participants

A total of 73 kindergartners (40 boys and 33 girls) aged between 4 and 5 (◎ = 4,6) who are attending a public kindergarten, participated this study. 26 of them were 4 years old and 47 of them were 5 years old (shown on Table 1). *Convenience Sampling* was used to select the participants. They were selected according to their and their teachers' willingness and also accessibility of educational institutions they are already attending (Creswell, 2012).

Table 1: Frequencies of participants for gender and age

		f	%
	Boys	40	54,79
Gender	**Girls**	33	45,21
	Total	73	100
	Age 4	26	35,62
Age	**Age 5**	47	64,38
	Total	73	100

3.2. Data Collection Tools

Geometric and Spatial Thinking Skills Test (GEOST-ST) was used to collect the data. This test is for evaluating 48 to 66-month-old children's geometric and spatial thinking skills. It was developed by Korkmaz (2017).

GEOST-ST consists of two sub tests as they are; geometric thinking and spatial thinking. *Shape*, *Area* and *Symmetry* skills for geometric thinking and *Spatial Orientation* and *Spatial Visualization* skills for spatial thinking, are considered in this test. It consists of 5 components. Cronbach's Alpha coefficient of whole is **.90** and **.93** for geometric thinking sub test, **.82** for spatial thinking sub test. It has 12 items for geometric thinking and 13 for spatial, totally 25. It requires to be implemented one by one for each child, based on games and tasks (Korkmaz, 2017).

3.3. Data Collection

GEOST-ST was used by implementing one by one for each child. Implementational sessions were lasted average minutes of 18 for each child, according to the willingness of children.

3.4. Data Analysis

Data obtained by GEOST-ST were firstly analyzed to understand whether data meet the assumptions of parametric tests. MANOVA was used to investigate whether children's geometric and spatial thinking skills vary by their age and gender. We may use MANOVA when we will compare mean scores of two or more groups for multiple variables (Büyüköztürk, 2012). In this study, it was tried to compare mean scores of groups (for gender and age) in context of different variables as they are; shape, area, symmetry, spatial orientation and spatial visualization.

4. Results

Firstly, *Reliability Analysis* was performed. Cronbach's Alpha coefficient for whole test was calculated as **.93** and **.92** for geometric thinking sub test, **.88** for spatial thinking sub test. Than data were analyzed to be sure that the assumptions of MANOVA were met. It was understood that the assumptions were met for whole and for each variable. Results of analyses were presented for gender and age.

4.1. Results for Gender

Descriptive statistics of children's mean scores of shape, area, symmetry, spatial orientation and spatial visualization for gender were shown on **Table 2**.

Table 2: Descriptive Statistics for Gender

Descriptive Statistics				
		Mean	**Std. Dev.**	**N**
Shape	**Boys**	304,00	87,541	40
	Girls	341,58	110,093	33
	Total	320,99	99,461	73
Area	**Boys**	24,90	13,992	40
	Girls	26,82	13,075	33
	Total	25,77	13,526	73
Symmetry	**Boys**	88,65	33,845	40
	Girls	93,15	27,518	33
	Total	90,68	31,018	73

S_Orient.	Boys	374,40	58,564	40
	Girls	361,82	57,088	33
	Total	368,71	57,845	73
S_Visual.	Boys	67,60	20,537	40
	Girls	67,64	20,140	33
	Total	67,62	20,217	73

We may see that, covariance matrices of scores of shape, area, symmetry, spatial orientation and spatial visualization are equal across all groups, for gender ($p > .05$). It was shown on **Table 3**.

Table 3: Box's Test Results for Gender

Box's Test of Equality of Covariance Matrices[a]	
Box's M	8,241
F	,507
df1	15
df2	18713,735
Sig.	,939

According to the multivariate tests results of MANOVA shown on **Table 4**, difference between children's mean scores of shape, area, symmetry, spatial orientation and spatial visualization are not statistically significant for gender ($\Lambda = .911$, $F(5,67) = 1,302$, $p > .05$).

Table 4: Multivariate Tests Results for Gender

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	,978	593,493[b]	5,000	67,000	,000	,978
	Wilks' Lambda	,022	593,493[b]	5,000	67,000	,000	,978
	Hotelling's Trace	44,291	593,493[b]	5,000	67,000	,000	,978
	Roy's Largest Root	44,291	593,493[b]	5,000	67,000	,000	,978
Gender	Pillai's Trace	,089	1,302[b]	5,000	67,000	,274	,089
	Wilks' Lambda	,911	1,302[b]	5,000	67,000	,274	,089
	Hotelling's Trace	,097	1,302[b]	5,000	67,000	,274	,089
	Roy's Largest Root	,097	1,302[b]	5,000	67,000	,274	,089

If we look at the Leneve's test results shown on **Table 5**, we may see that error variances of shape, area, symmetry, spatial orientation and spatial visualization are equal for gender ($p > .05$).

Table 5: Leneve's Test Results for Gender

Levene's Test of Equality of Error Variances[a]				
	F	**df1**	**df2**	**Sig.**
Shape	2,303	1	71	,134
Area	,213	1	71	,645
Symmetry	2,780	1	71	,100
S_Orient.	,873	1	71	,353
S_Visual.	,000	1	71	,993

Results for each variable shown on **Table 6.** Difference between children's mean scores of shape, area, symmetry, spatial orientation and spatial visualization are not statistically significant for gender ($F(1,71) = 2,64$, $p > .05$; $F(1,71) = .360$, $p > .05$; $F(1,71) = .378$, $p > .05$; $F(1,71) = .854$, $p > .05$; $F(1,71) = .001$, $p > .05$).

Table 6: Results of Tests of Between-Subjects Effects for Gender

Tests of Between-Subjects Effects							
Source	**Dependent Variable**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	**Shape**	25530,926[a]	1	25530,926	2,640	,109	,036
	Area	66,532[b]	1	66,532	,360	,550	,005
	Symmetry	366,411[c]	1	366,411	,378	,541	,005
	S_Orient.	2862,450[d]	1	2862,450	,854	,359	,012
	S_Visual.	,024[e]	1	,024	,000	,994	,000
Intercept	**Shape**	7536079,967	1	7536079,967	779,149	,000	,916
	Area	48365,710	1	48365,710	262,005	,000	,787
	Symmetry	597648,822	1	597648,822	615,799	,000	,897
	S_Orient.	9800859,162	1	9800859,162	2923,141	,000	,976
	S_Visual.	330702,928	1	330702,928	797,843	,000	,918
Gender	**Shape**	25530,926	1	25530,926	2,640	,109	,036
	Area	66,532	1	66,532	,360	,550	,005
	Symmetry	366,411	1	366,411	,378	,541	,005
	S_Orient.	2862,450	1	2862,450	,854	,359	,012
	S_Visual.	,024	1	,024	,000	,994	,000
Error	**Shape**	686726,061	71	9672,198			
	Area	13106,509	71	184,599			
	Symmetry	68907,342	71	970,526			
	S_Orient.	238052,509	71	3352,852			
	S_Visual.	29429,236	71	414,496			
Total	**Shape**	8233608,000	73				
	Area	61641,000	73				
	Symmetry	669608,000	73				
	S_Orient.	10165176,000	73				

	S_Visual.	363184,000	73
Corrected Total	Shape	712256,986	72
	Area	13173,041	72
	Symmetry	69273,753	72
	S_Orient.	240914,959	72
	S_Visual.	29429,260	72

4.2. Results for Age

Descriptive statistics of children's mean scores of shape, area, symmetry, spatial orientation and spatial visualization for age were shown on **Table 7**.

Table 7: Descriptive Statistics for Age

Descriptive Statistics				
		Mean	**Std. Dev.**	**N**
Shape	**Age4**	303,46	96,251	26
	Age5	330,68	100,893	47
	Total	320,99	99,461	73
Area	**Age4**	29,88	14,586	26
	Age5	23,49	12,485	47
	Total	25,77	13,526	73
Symmetry	**Age4**	99,69	27,386	26
	Age5	85,70	32,049	47
	Total	90,68	31,018	73
S_Orient.	**Age4**	372,92	60,423	26
	Age5	366,38	56,899	47
	Total	368,71	57,845	73
S_Visual.	**Age4**	64,62	23,226	26
	Age5	69,28	18,403	47
	Total	67,62	20,217	73

Table 8 shows us that, covariance matrices of scores of shape, area, symmetry, spatial orientation and spatial visualization are equal across all groups, for age ($p > .05$).

Table 8: Box's Test Results for Age

Box's Test of Equality of Covariance Matrices[a]	
Box's M	10,096
F	,615
df1	15
df2	10835,075
Sig.	,865

According to the multivariate tests results of MANOVA shown on **Table 9**, difference between children's mean scores of shape, area, symmetry, spatial orientation and spatial visualization are not statistically significant for age (Λ = .859, $F(5,67) = 2,208$, $p > .05$).

Table 9: Multivariate Tests Results for Age

Multivariate Tests[a]							
Effect		**Value**	**F**	**Hypothesis df**	**Error df**	**Sig.**	**Partial Eta Squared**
Intercept	**Pillai's Trace**	,977	563,734[b]	5,000	67,000	,000	,977
	Wilks' Lambda	,023	563,734[b]	5,000	67,000	,000	,977
	Hotelling's Trace	42,070	563,734[b]	5,000	67,000	,000	,977
	Roy's Largest Root	42,070	563,734[b]	5,000	67,000	,000	,977
Gender	**Pillai's Trace**	,141	2,208[b]	5,000	67,000	,064	,141
	Wilks' Lambda	,859	2,208[b]	5,000	67,000	,064	,141
	Hotelling's Trace	,165	2,208[b]	5,000	67,000	,064	,141
	Roy's Largest Root	,165	2,208[b]	5,000	67,000	,064	,141

According to Leneve's test results shown on **Table 10**, error variances of shape, area, symmetry, spatial orientation and spatial visualization are equal for age ($p > .05$).

Table 10: Leneve's Test Results for Age

Levene's Test of Equality of Error Variances[a]				
	F	**df1**	**df2**	**Sig.**
Shape	,301	1	71	,585
Area	1,762	1	71	,189
Symmetry	1,723	1	71	,193
S_Orient.	,178	1	71	,674
S_Visual.	1,663	1	71	,201

ANOVA results for each variable shown on **Table 11.** Difference between children's mean scores of shape, area, symmetry, spatial orientation and spatial visualization are not statistically significant for age ($F(1,71) = 1,258$, $p > .05$; $F(1,71) = 3,892$, $p > .05$; $F(1,71) = 3,525$, $p > .05$; $F(1,71) = .212$, $p > .05$; $F(1,71) = .888$, $p > .05$).

Table 11: Results of Tests of Between-Subjects Effects for Age

Tests of Between-Subjects Effects							
Source	**Dependent Variable**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	**Shape**	12402,312[a]	1	12402,312	1,258	,266	,017
	Area	684,643[b]	1	684,643	3,892	,052	,052
	Symmetry	3276,385[c]	1	3276,385	3,525	,065	,047
	S_Orient.	716,006[d]	1	716,006	,212	,647	,003
	S_Visual.	363,702[e]	1	363,702	,888	,349	,012
Intercept	**Shape**	6731656,011	1	6731656,011	682,924	,000	,906
	Area	47687,821	1	47687,821	271,118	,000	,792
	Symmetry	575362,741	1	575362,741	618,976	,000	,897
	S_Orient.	9149489,705	1	9149489,705	2704,482	,000	,974
	S_Visual.	300094,113	1	300094,113	733,056	,000	,912
Gender	**Shape**	12402,312	1	12402,312	1,258	,266	,017
	Area	684,643	1	684,643	3,892	,052	,052
	Symmetry	3276,385	1	3276,385	3,525	,065	,047
	S_Orient.	716,006	1	716,006	,212	,647	,003
	S_Visual.	363,702	1	363,702	,888	,349	,012
Error	**Shape**	699854,674	71	9857,108			
	Area	12488,399	71	175,893			
	Symmetry	65997,368	71	929,540			
	S_Orient.	240198,953	71	3383,084			
	S_Visual.	29065,558	71	409,374			
Total	**Shape**	8233608,000	73				
	Area	61641,000	73				
	Symmetry	669608,000	73				
	S_Orient.	10165176,000	73				
	S_Visual.	363184,000	73				
Corrected Total	**Shape**	712256,986	72				
	Area	13173,041	72				
	Symmetry	69273,753	72				
	S_Orient.	240914,959	72				
	S_Visual.	29429,260	72				

5. Discussion

According to the results of this study, difference between children's mean scores of shape, area and symmetry are not statistically significant for gender. Similar to the results of this study, Halat & Yeşil-Dağlı (2016) state, preschool age children's understandings of geometric shapes don't vary by their gender. According to Spelke, Gilmore & McCharty, (2011) difference between 5 to 6 years old children's geometric thinking skills, are not statistically significant for gender. There aren't many studies on preschool age children's skills of area and symmetry as geometric thinking skills, in current studies, as for gender and age.

The results of this study show us, difference between children's mean scores of shape, area and symmetry are not statistically significant for age. In contrast, many researchers state, preschool age children's geometric thinking skills vary by age (Altun & Kırcal, 1999; Aslan, 2004; Gagatsis, Sriraman, Elia & Modestou, 2006; Hannibal, 1999; Saltlow & Newcombe, 1998).

Saltlow & Newcombe (1998) state, 3 to 5 years old children's shape related skills vary by their age and their recognition degree of shapes and their features increase by age. Similarly, Aslan (2004) states, 3 to 6 years old children's shape related skills, especially understanding of features of shapes increase by age. According to Hannibal (1999) children's classifying and distinguishing skills of shape increase by age. Finally, according to Gagatsis, Sriman, Elia & Modestou (2006) 4 to 8 years old children's skills of composing shapes become more complex and meaningful by age. There is no current study related to development of preschool age children's skills of area and symmetry, in context of age.

As another result of this study, differences between children's mean scores of spatial orientation and spatial visualization are not statistically significant for gender. Similar to the results of this study, Spelke, Gilmore & McCharty (2011) state, difference between 5 to 6 years old children's spatial visualization skills, are not statistically significant, for gender. Klein, Adi-Japha & Hakak-Benizri (2010) state, kindergartners' levels of spatial thinking skill don't vary by their gender, too. In contrast with results of this study, Linn & Petersen (1985) state, preschool age children's spatial thinking skills vary by gender especially for mental rotation and rarely spatial perception. Similarly, Tzuriel & Egozi (2010) state, 6 years old children's spatial thinking skills vary by gender, but it is possible to equalize by various educational programs.

Considering another result of this study, differences between children's mean scores of spatial orientation and spatial visualization are not statistically significant for age. In contrast, some researchers state, preschool age children's spatial thinking skills vary by age (Ellemberg, Lewis, Liu & Maurer, 1999; Frick & Newcombe, 2012; Gibson, Leichtman, Kung & Simpson, 2007; Moroleda, Broglio, Rodrígues & Gómez, 2013; Shutts, Örnkloo, Von Hofsten, Keen & Spelke, 2009; Uttal, 1996; Verdine, Golinkoff, Hirsh-Pasek & Newcombe, 2017; Vinter, Puspitawati & Witt, 2010).

Shutts, Örnkloo, Von Hofsten, Keen & Spelke (2009) state, 15 to 30-month-old children's understanding and representing spatial relations becomes more consistent by age. Verdine, Golinkoff, Hirsh-Pasek & Newcombe (2017) state, 3 to 4 years old children's spatial rotation and spatial transformation skills increase by age. Similarly, Frick & Newcombe (2012) state, 3 to 6 years old children's spatial scaling skills increase by age, despite it depends on individual differences. Gibson, Leichtman, Kung & Simpson, (2007) state, 3 to 7 years old children's spatial orientation skills become more consistent by age. According to Uttal's (1996) study, 4 to 7 years old children's usage of spatial visualization skills becomes more consistent by age. Similar to Uttal's (1996) study, Vinter, Puspitawati, & Witt's (2010) study state, 3 to 9 years old children's spatial visualization skills increase by age. Finally, according to Moroleda, Broglio, Rodrigues & Gomes's study, 6 to 10 years old children's spatial orientation skills increase by age.

6. Suggestion

Preschool age children's skills of area and symmetry as geometric thinking skills, should be comprehensively investigated in more studies. Longitudinal studies and large scaled studies by age should be conducted. Correlation between geometric thinking skills and spatial thinking skills of preschool age children should be investigated, too. Thus, we may develop more effective educational programs for children to have better abilities of geometric and spatial thinking.

7. Acknowledgements

This study was produced from first author's Phd Thesis titled "*The Effects of Inquiry-Based Activities Implemented in Natural Outdoors on Children's Geometric and Spatial Thinking Skills*"

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