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Investigating Spatial Thinking Skills of Prospective Preschool Teachers*

Okul Öncesi Öğretmen Adaylarının Uzamsal Düşünme Becerilerinin İncelenmesi

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ABSTRACT: The aim of this study was to investigate prospective preschool teachers' spatial thinking skills in terms of gender, class standings, type of high school they previously graduated from and whether they attend a course on early mathematics education or not. Survey Method was used in this study. A total of 132 prospective preschool teachers who were attending a preschool teacher training program at a state university in Turkey participated in this study. Santa Barbara Sense of Direction Scale (SBSOD) and Spatial Ability Self-Report Scale (SASRS) were used as the data collection tools. Correlation Analysis was used to investigate correlation between the scores of two scales. ANOVA, Independent-Samples T-Test, Kruskal Wallis-H Test and Mann Whitney-U Test were used according to the assumptions of parametric tests. A positive correlation was found between the scores of two different scales. Differences between the mean scores of participants in terms of gender, class standings, high school types and whether they attended a course on early mathematics education or not, were not statistically significant for each assessment scale, as other results of this study.

Keywords: preschool education, prospective teachers, spatial thinking skills, early mathematics education.

ÖZ: Bu araştırmanın amacı, okul öncesi öğretmen adaylarının uzamsal düşünme becerilerinin cinsiyet, sınıf düzeyi, mezun olunan lise türü ve erken çocukluk matematik eğitimi dersini alıp almama durumları açısından incelemektir. Araştırmada Tarama Yöntemi kullanılmıştır. Araştırmaya Türkiye'de bir devlet üniversitesindeki okul öncesi öğretmen eğitimine yönelik bir programa devam eden 132 okul öncesi öğretmen adayı katılmıştır. Veri toplama araçları olarak Santa Barbara Yön Hissi Ölçeği (SBSOD) ve Uzamsal Beceri Öz-Değerlendirme Ölçeği (SASRS) kullanılmıştır. İki ölçeğin sonuçları arasındaki ilişkinin incelenmesi için Korelasyon Analizi, parametrik testlerin varsayımlarını karşılama durumlarına göre ANOVA, T-testi, Kruskal Wallis-H Testi ve Mann Whitney-U testi uygulanmıştır. Araştırmanın bir sonucu olarak, kullanılan iki ölçme aracı puanları arasından pozitif yönde bir ilişki bulunmuştur. Araştırmanın diğer sonuçları olarak her iki ölçme aracı için, katılımcıların cinsiyet, sınıf düzeyi, lise türü ve erken matematik eğitimi dersini alma durumları açısından ortalama puanları arasında istatistiksel olarak anlamlı bir farklılığın olmadığı ortaya çıkmıştır.

Anahtar kelimeler: okul öncesi eğitimi, öğretmen adayı, uzamsal düşünme becerileri, erken matematik eğitimi.

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Introduction

Spatial thinking is a complex way of thinking. It is a combined understanding of "space", "representation" and "reasoning". We may also consider this style of thinking as a tool for determining problems about space, finding appropriate solutions for them and explaining these solutions (National Research Council, 2006). Understanding of spatial relationships begins at very early years of human life, and early years are critical for development of brain structures and functions for spatial reasoning (Gersmehl & Gersmehl, 2007). Children have a great potential of spatial knowledge and thinking when they are at ages of school entry (Bryant, 2009). Spatial thinking is essential for some learning areas, especially geometry (Bryant, 2009; Fuson, Clements, & Backmann-Kezez, 2010). This thinking skill predicts students' success in Mathematics, Engineering and Science (Newcombe, 2010; Newcombe & Fick, 2010). Besides art, architecture, graphics, computer sciences, Biology, Physics, Chemistry, Geology, Geography, and Medicine require one to gain this skill (Ontario Ministry of Education, 2014). As a summary, spatial thinking skills are essentials and predictors of STEM (Science, Technology, Engineering, Mathematics) learning and achievements (Twyman, Friedman, & Spetch, 2007). Spatial thinking even contributes to socializing in preschool educational environments (Alaswad, 2013) and children's social skills (Newcombe, 2013).

We may provide some examples of spatial thinking such as composing objects physically, visually or both physically and visually, orientation, non-verbal reasoning processes, finding our way, imagining the amount or proportion of objects, creating and reading maps, tables or graphs, visualization, locating an object, remembering the locations of objects, perspective taking, decomposing objects physically, visually or both physically and visually, creating or designing an object, manipulating objects, imagining the routes or movements of objects in space, understanding the relationships and connections between objects' 2- or 3-dimensional representations, comparing the characteristics of objects and creating diagrams with objects (Ontario Ministry of Education, 2014). In prekindergarten through grade 2, all children are expected to (National Council of Teachers of Mathematics, 2000);

> (…) describe, name and interpret relative positions in space and apply ideas about relative positions. Describe, name and interpret direction and distance in navigating space and apply ideas about direction and distance, in terms of specific locations and describing spatial relationships. For using visualization and spatial reasoning, they are expected to create mental images of geometric shapes using spatial memory and spatial visualization.

According to recent studies, opportunities that are offered to children, some special teaching strategies or special programs contribute to children's spatial awareness, as well as their usage and development of spatial thinking skills (Adak-Özdemir & Güven, 2014; Casey et al., 2008; Clements & Sarama, 1995; Collier, Perlman, & Fisette, 2009; Davis & Hyun, 2005; Ehrilch, Levine, & Goldin-Meadow, 2006; Gabrielli, Rogers, & Scaife, 2000; Hacısalihoğlu-Karadeniz, 2005; Keren, Ben-David, & Fridin, 2012; Olver, 2013; Shutts et al., 2009; Twyman, Friedman, & Spetch, 2007; Üstün & Akman, 2003; Van Nes & Van Eerde, 2010).

Considering the nature of early childhood education, activities, plans, programs and teaching-learning processes should be combinations of games, fun activities, hands-on experiences, concrete and creative learning experiences. In summary, appropriate activities for children should be offered. Educators should prepare safe, comfortable and easeful environments which contain rich, high-quality and appropriate manipulatives to support children's experiences in spatial thinking (Brillante & Mankiw, 2015). Educators should be aware of children's spatial thinking skill levels. They should also support children. They should consider and act responsibly towards children's proximal developmental zones for them to design appropriate educational activities and plans (Cohen & Emmons, 2016). They should also be aware of the essential nature of early years, contribution of spatial thinking skills on cognitive development, the critical nature of individual differences and contribution of critical and motor activities to spatial thinking skills for them to offer effective, rich, quality and appropriate learning experiences (Newcombe & Fick, 2010). This is because they have dual roles and responsibilities of both offering appropriate educational practices and guiding parents to support children's spatial skills (Singh, Chhikara, Kaur, & Sangwan, 2005).

Some studies show us that early childhood educators have inadequate knowledge and skills on spatial thinking (Atit, Miller, Newcombe & Uttal,2018; Marchis, 2017), while one reported these levels to be average (Abay, Tertemiz, & Gökbulut, 2018), even one says lower then prospective early science and mathematics teachers (Erkek, Işıksal, & Çakıroğlu, 2011; Erkek, Işıksal, & Çakıroğlu, 2017). Considering that educators' levels of spatial thinking skills and knowledge affect children's achievement in spatial thinking (Akerson, 2011), these levels should be improved. Dillaha (2018) revealed that preschool teachers' spatial abilities affect their usage of mathematical tasks in some other basic mathematical skills.

Educators' insufficient knowledge or skills on spatial thinking cause them to feel anxiety about spatial thinking (Dursun, 2010), and their anxiety about spatial relationships affect both their own spatial skills and children's achievement in spatial thinking skills (Erkek, Işıksal, & Çakıroğlu, 2011; Gunderson, Ramirez, Beilock & Levine, 2013). According to another study, educators' pedagogical knowledge on spatial relationships and their spatial thinking skills are directly linked to early geometry instructions (Otumfuor & Carr, 2017).

It was revealed that early childhood educators rarely include activities on spatial thinking in their activity plans (Helenius et al., 2014; Zambrzycka, 2014). In addition to this, their level of considering spatial conditions when they create learning environments vary by their characteristics such as age, type of school they work for, age group they work with and year of service (Pedük, Yıldızbaş, & Aygün, 2014). Learning environments have their own spatial characteristics, such as their visuality and architecture (Løkken & Moser, 2012) as a spatial frame (Shmis, Kotnik, & Ustinova, 2014), and they reflect these characteristics onto these. Therefore, educators and teacher training programs have important roles on spatial thinking skills in early childhood education (Newcombe & Fick, 2010; Uttal et al., 2013; Verdine, Golinkoff, Hirsh-Pasek & Newcombe, 2014). Implementing special training programs on spatial teaching for early childhood educators positively affects their knowledge and skills on spatial thinking (Akerson, 2011; Berciano & Gutierrez, 2015).

In this study, it was aimed to investigate prospective preschool teachers' spatial thinking skills in terms of gender, class standings, types of high schools they previously graduated from and having taken a course on early mathematics education which is offered during their preschool teacher training programs. "Whether prospective preschool teachers' spatial thinking skills vary by their gender, class standings, high school types and attending early mathematics education course or not" was questioned. It may be useful to modify or develop a preschool teacher training program for better "spatial teaching".

Method

In this study, prospective preschool teachers' spatial thinking skills were investigated by using two different assessment scales for data triangulation. Survey Method was used in this study. This method ensures us to investigate events, facts or situations on a descriptive level and as exactly how they are (Şimşek, 2012).

Participants

A total of 132 prospective preschool teachers (11 male and 121 female) participated in this study. They were selected by using *Convenience Sampling* method. Participants' proximity to our institution and their practicality to work with were decisive (Creswell, 2012). Participants were on four different class levels of a preschool teacher training program at a state university in Turkey. Some demographic information about participants is shown in Table 1.

Table 1

Demographic Information about Participants

Demographics	Categories	*n*	%
Gender	Male	11	8.33
	Female	121	91.66
	Total	132	100
Class Standings	Freshman	34	25.75
	Sophomore	36	27.27
	Junior	35	26.51
	Senior	27	20.45
	Total	132	100
High School Type	Vocational High School	44	33.33
	Non-Vocational High School	88	66.66
	Total	132	100
Early Mathematics Education Course	Have Attended	98	74.25
	Have not Attended	34	25.75
	Total	132	100

Data Collection Tools

Two different assessment scales were used as data collection tools. One of them was "Santa Barbara Sense of Direction Scale" (SBSOD) which was developed by Hegarty et al. (2002) and adapted to Turkish language and culture by Turgut (2014). Cronbach's Alpha value was reported as .888 in the validation study of SBSOD. It was found to be .774 in our study. SBSOD has Likert-type items about directions, remembering the locations of objects, intuition of direction, using a map and creating a mental image.

The other assessment scale was "Spatial Ability Self-Report Scale" (SASRS) which was developed by Turgut (2015). Cronbach's Alpha value was reported as .808 and .818 for split-half analysis in the validation study of SASRS. It was found to be .861 for the whole scale, in our study. SASRS has Likert-type items about mental rotation, creating a mental image, creating an appropriate figure for mental images, navigation, creating a mental map and remembering the characteristics of objects.

Data Collection Procedures

Participants were firstly informed about the aim of this study. They were informed that the data would be used only for this study based on ethical and scientific principles. Thereafter, they were kindly requested to participate in this study. They were not requested to provide their personal information such as their real names. However, they were expected to provide some information about their gender, class standings, types of high school they previously graduated from and whether they attended an early mathematics education course or not. Participants were given written forms of assessment scales separately to prevent interaction between them during the data collecting procedures. Fully filled and matched forms of the assessment scales were considered as the data to be analyzed.

Data Analysis

Participants were given pseudonyms as G1TC1 through G1TC34 for freshmen, G2TC1 through G2TC36 for sophomores, G3TC1 through G3TC35 for juniors and G4TC1 through G4TC27 for seniors. These pseudonyms were also used as codes. SBSOD is a seven-point Likert-type scale. Participants were expected to reflect their ideas by marking one of the seven different points from absolutely agree to absolutely disagree. SASRS is a five-point Likert-type scale scored from absolutely disagree to absolutely agree. Participants' levels of answers were scored from "0" to "6" for SBSOD and from "0" to "4" for SASRS.

ANOVA and Independent-Samples T-Test were used to analyze the data obtained by using SBSOD. Kruskal-Wallis Test and Mann-Whitney U Test were used to analyze the data obtained by using SASRS. These analysis methods were used according to the assumptions of parametric or non-parametric tests for the scores of each scale.

Results

The results of this study were presented under five different subtitles as results for gender, class standings, high school type, attending an early mathematics education course and correlation between the scores of the assessment scales.

Results for Gender

As a result of this study, difference between the mean scores of participants according to the T-Test results of the SBSOD scores for gender was not statistically significant. ($t(130) = .851$, $p = .396$). T-Test results are shown in Table 2.

Table 2

T-Test Results of SBSOD Scores for Gender

Groups	*n*	$\bar{x}$	*ss*	*df*	*t*	*p*
Male	11	50.73	15.666	130	.851	.39*
Female	121	54.34	13.283			

*$p > .05$

Besides, Mann-Whitney U Test results of SASRS scores for gender showed us the same result. According to SASRS results, difference between the mean scores of participants for gender was not statistically significant (*U*=460.500, *p*=.091). Mann-Whitney U test results are also shown in Table 3.

Table 3

U Test Results of SASRS Scores for Gender

Groups	*n*	$\bar{x}$	*ss*	*df*	*U*	*p*
Male	11	85.14	936.50	130	460.500	.91*
Female	121	64.81	7841.50			

*$p > .05$

Results for Class Standings

Prospective teachers were from four different class standings of a preschool teacher training program. As another result of this study, there were no statistically significant differences between the mean scores of participants by class standings according to ANOVA results of SBSOD (F(3.128)=.581, *p*=.629). Table 4 shows ANOVA results.

Table 4

ANOVA Results of SBSOD Scores for Class Standings

	S.S	*df*	*M.S.*	*F*	*p*	*η2*
Between Groups	319.084	3	106.361	.581	.629	.001
Within Group	23437.726	128	183.107			
Total	23756.811	131				

*$p > .05$

Kruskal-Wallis Test results showed us the same result. According to SASRS test results, difference between the mean scores of participants from different class standings was not statistically significant (χ^2=3.142, df=3, *p*=.370). Kruskal Wallis Test results are also shown in Table 5.

Table 5

Kruskal-Wallis Test Results of SBSOD Scores for Class Standings

Groups	*n*	*M.R.*	*df*	χ^2	*p*
Freshman	34	69.62	3	3.142	.370
Sophomore	36	68.06			
Junior	35	57.06			
Senior	27	72.74			

*$p > .05$

Results for High School Type

We had two groups regarding the types of high school participants graduated from. These were vocational high schools and non-vocational high schools (other types of high schools). According to T-Test results, difference between the mean scores of the two groups for SBSOD was not statistically significant (t(130)=1.121, *p*=.264). T-Test results are presented in Table 6.

Table 6

T-Test Results of SBSOD Scores for High School Type

Groups	*n*	$\bar{x}$	*ss*	*df*	*t*	*p*
Vocational	44	52.18	13.274	130	1.121	.26*
Non-Vocational	88	54.97	13.541			

*$p > .05$

Considering the results for SASRS, we may see the same results for difference between the mean scores of two groups. Mann Whitney U Test results showed us that difference between the two groups was not statistically significant (*U*=1785.000, *p*=.466). Mann-Whitney U test results are also shown in Table 7.

Table 7

U Test Results of SASRS Scores for High School Type

Groups	*n*	$\bar{x}$	*ss*	*df*	*U*	*p*
Vocational	44	63.07	2775.00	130	1785.000	.46*
Non-Vocational	88	68.22	6003.00			

*$p > .05$

Results for Attending an Early Mathematics Education Course

Another result of this study for the facts we may accept as variables was about taking a course on early mathematics education. We had two groups as participants attended an early math education course and those who did not. According to T-Test results, difference between the mean scores of two groups for SBSOD was not statistically significant (t(130)=1.293, *p*=.198). T-Test results may be seen in Table 8.

Table 8

T-Test Results of SBSOD Scores for Early Mathematics Education Course

Groups	*n*	$\bar{x}$	*ss*	*df*	*t*	*p*
Have attended	98	51.47	12.529	130	1.293	.19*
Haven't attended	34	54.93	13.726			

*$p > .05$

Again, we faced similar results for SASRS scores. Difference between the mean scores of two groups was not statistically significant according to Mann-Whitney U Test results (*U*=1560.000, *p*=.581). These results may be seen in Table 9.

Table 9

U Test Results of SASRS Scores for Early Mathematics Education Course

Groups	*n*	$\bar{x}$	*ss*	*df*	*U*	*p*
Have attended	98	69.62	2367.00	130	1560.000	.58*
Haven't attended	34	65.42	6411.00			

*$p > .05$

Results for Correlation between Scores of Assessment Scales

Two different assessment scales were used to obtain the data. A positive correlation between the scores of SBSOD and SASRS was found in this study (r(130)=.001, *p*<.01). Therefore, we may consider that the data obtained by using two different assessment scales were consistent.

Discussion and Conclusions

In Turkey, female students are attending preschool teacher training programs tens of times more than male students. It is the reality. However, gender is being widely investigated in terms of whether it is an influential factor on spatial thinking skills or not (Abay, Tertemiz, & Gökbulut, 2018; Dursun, 2010; Erkek, Işıksal, & Çakıroğlu, 2017; Hacıömeroğlu & Hacıömeroğlu, 2017; Maiorana, 2014; Newcombe, 2013; Vander Heyden, van Atteveldt, Huizinga, & Jolles, 2016). This is why we aimed to investigate gender as a factor for prospective preschool teachers. As a result of this study, there was no statistically significant difference between the mean scores of male and female prospective preschool teachers. Similar to the results of this study, Maiorana reported that there was no statistically significant difference between spatial thinking skills of college students in terms of gender (Maiorana, 2014). In the studies by Abay, Tertemiz, and Gökbulut and Newcombe, it was revealed that there is no statistically significant difference between male and female teachers' spatial thinking skills (Abay, Tertemiz, & Gökbulut, 2018; Newcombe, 2013). Similarly, Hacıömeroğlu and Hacıömeroğlu could find no statistically significant difference between male and female elementary teachers' spatial thinking skills (Hacıömeroğlu & Hacıömeroğlu, 2017). However, some studies revealed that, male preservice teachers had higher levels of spatial thinking skills than females, and female preservice teachers had higher levels of anxiety than male preservice teachers (Dursun, 2010; Erkek, Işıksal, & Çakıroğlu, 2017; Ramirez, Gunderson, Levine & Beilock, 2012). In addition to these studies, Vander Heyden et al. revealed that children's choices for activities which require spatial thinking skills may vary by gender, but there are no statistically significant differences between boys' and girls' spatial thinking skills (Vander Heyden, van Atteveldt, Huizinga, & Jolles, 2016). The numbers of male and female participants (11 to 121) might not be enough, or there may be some other factors to be investigated related to gender as a factor influencing spatial abilities.

As a result of this study, it was found that difference between the mean scores of participants was not statistically significant in terms of their class standings. We were expecting a significant difference between the mean score of freshmen and other class standings. Freshmen did not attend a course on early mathematics education, the results were not the ones we were expecting. Whitley-Morris (2018) studied with students in grades from 2 to 8. They revealed that there was no statistically significant difference between children's spatial thinking skills in terms of their grade level. On the other hand, Farrell (2017) studied older groups. Participants between the ages of 40 years and 70 years participated in their study. It was revealed that there was no statistically significant difference between the age groups. They explained that task difficulties or other reasons may cause slight differences. Nevertheless, Maiorana's (2014) study revealed that college students' spatial thinking skills vary by their class standing. Van der ven, Van der maas, Straatameier & Jansen (2013) studied elementary school children. In their study, it was found that children were getting well on spatial thinking skills and activities which require spatial thinking skills by grade levels. They also studied elementary school children in the same theme. They revealed that spatial thinking skills vary by grade levels. Maybe, spatial thinking skills are more changeable in early years of life and become more constant by the years by the help of experiences on spatial thinking skills. Close ages of participants of our study may be the reason for these results.

As a result of this study, no statistically significant difference was found between the mean scores of participants in terms of the types of high schools (vocational, non-vocational) they graduated from. In Turkey, most students who attend preschool teacher training programs previously graduate from vocational high schools. They are offered vocational courses more than mathematics and science courses. Considering the relationship between spatial thinking skills, mathematics and science (Newcombe, 2010; Newcombe & Fick, 2010), we aimed to investigate that, whether prospective preschool teachers' spatial thinking skills varied by high school type or not. The results of this study showed they did not. In contrast, Kayhan (2005) revealed that students' spatial thinking skills vary by their high school type. Indeed, there is a lack of studies on students' spatial thinking skills in terms of high school types. Every high school has its own curriculum or course types. We thought it may affect students' spatial thinking skills. Participants' closer ages and their lack of reception of any spatial education may have caused these results.

Prospective preschool teachers who attend a preschool teacher training program in Turkey are offered a course on early mathematics education. This course contains some sections such as essential mathematical skills, mathematics teaching strategies, children's cognitive development in early childhood period. We were wondering whether this course affects prospective teachers' spatial thinking skills or not. In this study, it was found that there was no statistically significant difference between participants' mean scores of spatial thinking skills in terms of attending an early mathematics education course. Wei, Yuan, Chen & Zhou (2012) reported that undergraduate students' spatial thinking skills are strongly correlated with their mathematical performances. Turgut and Yılmaz (2012) stated that prospective primary mathematics education teachers' academic successes and spatial thinking skills are positively correlated. Early mathematics education course's lack of inclusion of some special sections on spatial thinking or prospective teacher's closer scores for entering the teacher training program, may have caused this result.

Recommendations

Preschool teachers' spatial thinking skills and their implementations, teachers' anxieties, beliefs, views and attitudes towards spatial thinking should be studied more. The effects of teachers' spatial thinking skills on preschool children's spatial abilities are an important theme. Finally, studies should be conducted on creating special learning environments, materials (manipulatives) and instructions to develop children's spatial thinking skills.

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