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INVESTIGATION OF THREE DIMENSIONAL SPATIAL ABILITY LEVELS

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Abstract:
Spatial ability is an important factor affecting student achievement in science and mathematics education. In this study, it is aimed to investigate the spatial ability levels of students studying in chemistry department. Molecular model spatial ability test prepared for chemistry education was used in the study. The test measures spatial ability in two dimensions: rotation in space and visualization in the mind. In the research, t-test was used to determine whether there is a difference between the gender, class levels and the spatial ability and sub-dimensions of the molecular model. One-way analysis of variance was used to determine whether there was a difference between the achievement levels of the students and the spatial ability and sub-dimensions of the molecular model. No correlation was found between the gender and molecular model spatial ability and sub-dimensions of the students. There was a significant difference between students' class levels and spatial ability and sub-dimensions. As students' class levels increase, their ability to visualize increases. There was also a significant difference between the students' school achievements and the rotation of the molecular model in space with spatial ability and sub-dimensions and visualization in mind. The higher the grade point average, the more the ability to rotate and model the molecular model in space with its spatial ability and sub-dimensions.

Keywords: spatial ability, molecular model, spatial ability test, rotation in space, visualization of mind, personal variables

1. Introduction and Literature Review

According to Gardner, in terms of intelligence, learning and the discovery of new discoveries; to solve problems or create something of cultural value (Topçu, 1999: 367). In 1983, Gardner introduced the concept of multiple intelligence while defining the concept of intelligence. One of the kinds of intelligence in Gardner's multiple

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intelligence theory is visual intelligence. Visual intelligence; also known as spatial intelligence (Gurel and Tat, 2010: 337).

Spatial intelligence; it is defined as the ability to perceive the world visually correctly and to recreate what the individual experiences visually. Spatial intelligence; "*shape, color and forms through the eyes of the mind*" means to see (Basaran, 2004: 10). What makes it possible to visualize the mind by using spatial intelligence is spatial ability and comes from birth (Sorby, 1999: 21).

There are different definitions and classifications for spatial ability. McGee (1979) defines spatial visualization as "*the ability to move, rotate or reverse the given shape*" (Turğut and Yenilmez, 2012: 244; Kurt, 2002: 121). Mental animation is the degree to which different people recall familiar scenes in the form of mental pictures and the characteristics of the mental views of different people (Harle and Towns, 2011).

Maier (1994) suggested that there are five components of spatial ability. These components; spatial perception, spatial visualization, mental rotations, spatial relations and spatial orientation (et al. Sorby, 1999: 22). Person; thanks to these components can rotate and change two or three-dimensional objects in the mind (Kurt, 2002: 121).

Spatial ability contributes greatly to mathematics (Kirby and Boulter, 1999) and success in science (Sarı, 2016: 649). According to research, spatial ability is directly related to the success shown in geometry, mathematics and science (Ertekin, 2017).

The main objective of chemistry courses is to develop students' ability to form cognitive representations of molecular structures and to manipulate them mentally (Merchant et al., 2013). Spatial ability in organic chemistry is important for reasoning about three-dimensional spatial relations and to be able to diagram spatial information (Stieff et al., 2012: 854). In researches, it was determined that there is a positive relationship between spatial ability and chemistry success (Yavuz & Büyükekşi, 2018: 62). In short, chemistry courses encourage students to use and develop their spatial abilities.

When the researches about spatial ability are examined; Turğut and Yenilmez (2012) found that the students of mathematics teaching department had low spatial abilities and found that spatial ability did not differ according to gender, pre-school education, GPA and faculty. Sorby (1999) found that spatial ability is more advanced in men than in women. In particular, he emphasizes that spatial ability is important for engineering. In particular, it was found that female students with poor performance in visual spatial ability find it difficult to perceive important spatial information shown in diagrams and apply spatial problem-solving strategies (Stieff et al., 2012: 854).

It was observed that students whose spatial abilities were found to be poor improved their understanding of the 3-D structure of molecules when they engaged in 3-D virtual world related activities compared to students working only with 2-D images (Merchant et al., 2013: 579). The use of technology-supported learning techniques in the field of mathematics has been found to improve spatial ability (Turgut et al., 2009: 325).

Although it is stated that spatial ability is innate, spatial ability can be improved. In this regard, making inferences about the level of spatial ability will allow the discovery of contributions, methods and suggestions for its development.

2. Material and Methods

For the purpose of the research, the question "*is there a difference between the gender and spatial abilities of the students?*" was searched for answers. The relationships with the variables that are thought to affect students' spatial abilities were examined.

This research was applied to 132 students in 2018-2019 academic year. The research group consists of students of chemistry program studying at Kocaeli Vocational School. Since it is aimed to measure the three-dimensional understanding of the molecular models of the students, one hour of lecture is given to the students so that they do not have any test anxiety.

Molecular Model Spatial Ability Test was developed by Yavuz and Büyükekşi (2018). Responsible author was contacted, test questions were reached with the permission of the author and the research was started. Molecular model spatial ability test; the first 14 measuring the rotation of the three-dimensional object in space; It consists of a total of 28 items and the last 14 items that measure the visualization of the three-dimensional state of the two-dimensional object.

In addition, students were asked questions about gender, grade level and grade point average to learn their personal information.

3. Results

The analyses performed in order to measure the spatial abilities of the molecular model of chemistry students are shown in the tables below. Whether there is a difference between the students' gender and grade levels and spatial abilities, t-test; the difference between students' school performance and spatial abilities was measured by one-way analysis of variance. In addition, Pearson correlation coefficients related to spatial ability test and its sub-dimensions were calculated. The significance level used in the analysis was accepted as 0.05. The reliability of the scale was calculated as 0.732. Data were analyzed using SPSS 21 program.

Table 1: Correlation Coefficients between Spatial Ability and Sub-dimensions

Dimensions	Rotation in space	Mind animation	Spatial ability
Rotation in space	1	0,381**	0,726**
Visualization in the mind		1	0,912**
Spatial ability			1

p**<0,01

It is seen that there is a high and correct relationship between spatial ability and rotation in space (r = 0.726), and there is a high and correct relationship between spatial ability and visualization in mind (r = 0.912).

Table 2: The Relationship between Students' Gender and Spatial Ability

Dimension	Variables	N	Mean	Std. deviation	Mean difference	t	F	p
Rotation in space	Male	62	4,91	2,17	-0,01154	-	2,660	0,973
	Female	70	4,92	1,68	-0,01154	0,034		
Visualization in the mind	Male	62	6,40	3,56	0,35350	0,442	0,090	0,537
	Female	70	6,05	2,89	0,35350			
Spatial ability	Male	62	11,32	4,98	0,34195	0,619	0,023	0,660
	Female	70	10,98	3,68	0,34195			

In Table 2, the relationship between gender and spatial ability of students is examined. It is seen that there is no significant relationship between the gender of the students and the spatial ability and rotation in the sub-dimensions, revitalization in the mind (p> 0.05).

Table 3: The Relationship between School Achievement and Spatial Ability of Students

Dimension	Variables	N	Mean	Std. deviation	F	p
Rotation in space	0.99 and below	10	4,6000	1,17	4,421	0,005
	1.00-1.99	57	4,3158	2,02		
	2.00-2.99	48	5,4375	1,73		
	3.00 and over	17	5,7059	1,79		
Visualization in the mind	0.99 and below	10	5,0000	1,15	22,375	0,000
	1.00-1.99	57	4,3158	2,63		
	2.00-2.99	48	7,7500	2,94		
	3.00 and over	17	9,0000	2,23		
Spatial ability	0.99 and below	10	9,6000	9,60	20,699	0,000
	1.00-1.99	57	8,6316	8,63		
	2.00-2.99	48	13,1875	13,18		
	3.00 and over	17	14,7059	14,70		

In Table 3, students' spatial ability relationships with school achievements are examined. It is seen that there is a significant relationship between students' school achievements and spatial ability and rotation in the sub-dimensions of space and visualization in mind (p<0.05). The difference between grade point average and spatial ability was determined by post-hoc analysis.

Table 4: Difference between Groups Scheffe Test

Scholl achievement (I)	Scholl achievement (J)	Mean Difference (I-J)	Sth.Error	p
	1.00-1.99	0,212	0,2809	0,902
0.99 and below	2.00-2.99	-0,855*	0,2848	0,033
	3.00 and over	-1,244*	0,3265	0,003
1.00-1.99	0.99 and below	-0,212	0,2809	0,902
	2.00-2.99	-1,068*	0,1605	0,000
	3.00 and over	-1,457*	0,2264	0,000
2.00-2.99	0.99 and below	0,855*	0,2848	0,033
	1.00-1.99	1,068*	0,1605	0,000
	3.00 and over	-0,389	0,2312	0,422
3.00 and over	0.99 and below	1,244*	0,3265	0,003

	1.00-1.99	1,457*	0,2264	0,000
	2.00-2.99	0,389	0,2312	0,422

* The mean difference is significant at the 0.05 level.

Scheffe test was used for post-hoc analysis. It is possible to state that the higher the grade point average, the higher the ability to rotate in space, which has sub-dimensions, and the ability to visualize in the mind.

Table 5: The Relationship between Students' Class Levels and Spatial Ability

Dimension	Variables	N	Mean	Std. deviation	Mean difference	t	F	p
Rotation in space	1st class	65	4,57	1,88	-0,69697	-2,11	2,660	0,036
	2 nd class	67	5,27	1,89	-0,01154			
Visualization in	1st class	65	5,19	2,43	0,35350	-2,04	0,090	0,000
the mind	2 nd class	67	7,24	3,56	0,35350			
Spatial ability	1st class	65	9,77	3,47	0,34195	-2,74	0,023	0,000
	2 nd class	67	12,51	4,66	0,34195			

In Table 4, students' spatial ability relationships with class levels are examined. It is seen that there is a significant relationship between students' class levels and spatial ability and sub-dimensions ($p < 0.05$). It is possible to state that as the class levels of the students increase, their visualization, rotation and spatial abilities increase.

4. Discussion and Conclusion

In the study, the variables affecting the spatial ability performance of the students were examined; there was no significant relationship between gender and molecular model spatial ability and sub-dimensions. Turğut and Yenilmez (2012) found no relationship between gender and spatial ability in their studies. On the contrary, Stief et al. (2012) found that girls' spatial ability performances were lower than boys.

Turğut and Yılmaz (2012: 74-75) found that spatial visualization scores of seventh grade students, spatial visualization and spatial relations scores of eighth grade students did not differ according to gender, but spatial relations scores of seventh grade students were higher. In addition to these findings; found that spatial visualization and spatial relations scores of seventh and eighth grade students showed a moderate and correct relationship with mathematics achievement.

In this study, it was found that the higher the grade level, the higher the students' ability to revive and rotate in space, the molecular spatial ability and sub-dimensions. A similar finding was obtained by Bulut and Köroğlu (2000: 59). The researchers found that the differences in the spatial ability, orientation and vision test scores of the eleventh grade students in the mathematics teaching department were significant in favor of the students studying in the mathematics teaching department.

In this study, it is seen that there is a positive relationship between students' grade point averages and rotation of the molecular model in space with spatial ability and sub-dimensions and visualization in mind. The higher the grade point average, the more the ability to rotate and model the molecular model in space with its spatial ability and sub-dimensions. Turğut and Yılmaz (2012) found a correct relationship between students' mathematics achievement and spatial ability, and Ertekin (2017) found a correct relationship between spatial ability and science achievement.

Today, using computer technology, it is possible to develop alternative learning methods specific to the individual as an education and learning method. In order to use spatial ability, it is important to determine the spatial ability level.

The fact that there is not much research on the molecular model spatial ability test and that the sample of this research consists of associate degree chemistry students reveal the importance of the research. Molecular model spatial ability test for future research related to vocational high school chemistry department students, science high school students, science-literature faculty chemistry department students, chemical engineering students are recommended to apply.

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