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Investigation of Mathematics Teachers' Spatial Habits of Mind in the Context of Brain Dominance Status

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ABSTRACT

In this study, it is aimed to determine the spatial habits of the mind of mathematics teachers and to examine these habits in the context of teachers' brain dominance. The quantitative research method and the relational survey model were used within the scope of this method. The participants of the study consist of 124 mathematics teachers. The spatial habits of the mind scale and the brain dominance inventory were used as data collection tools. Since the data showed normal distribution, parametric tests were used. Descriptive statistics, independent samples t-test and one-way analysis of variance (ANOVA) were applied. It has been observed that the spatial habits of the mind of the mathematics teachers are at a high level and the majority of them tend to use the left brain. While the scores of spatial habits of mind, visualization and spatial concept usage sub-dimensions differed according to brain dominance levels, it was determined that they did not differ in terms of both sub-dimensions and total scores according to the brain dominance group. While the scores of mathematics teachers on spatial habits of mind differed according to the type of faculty graduated, years of study, taking geometry courses during undergraduate/graduate education, it did not differ according to gender and postgraduate education status.

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1. Introduction

Teaching thinking is one of the goals of education and the main purpose of teaching, especially in mathematics, which involves mental process skills and aims to improve the mental interaction between the learner and the lived experiences (Altakhyneh and Aburiash, 2017). The National Council of Teachers of Mathematics (NCTM, 2000) states that one of the remarkable outcomes of mathematics teaching is thinking. While the usual educational approach focuses on quantitatively evaluating the student's level of knowledge and how many problems they can solve, the educational approach that aims to teach thinking focuses on the behavior to be exhibited in problem situations with unknown answers and the mental process that leads to the answer. As a result of the teaching organized within the framework of this educational approach, the traces created in the mind by the experience, when and how the cognitive awareness gained is useful and the ability to decide on the reuse of these situations; brings to mind a number of mental processes and the habitualization of these processes. Habituation is very valuable in terms of controlling the behavior of the individual in problem situations, as it strengthens the individual in how knowledge is produced. In fact, it is stated that intelligent people not only have pure knowledge but also know how to use it (Altakhyneh and Aburiash, 2017). This situation is referred to in the literature as mental habits that improve the thinking process and provide functionality to the process (Yavuzsoy Köse and Tanışlı, 2014). Habits of mind are a set of skills that

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give the individual the flexibility to develop different solutions as a result of his/her own thinking process in solving a problem situation and to choose and apply the most appropriate solution to the situation (Altakhyneh and Aburiash, 2017; Cuoco, Goldenberg and Mark, 1996; Leikin, 2007). In classroom environments where habits of mind are valued, students are aware that they are responsible for their own thinking and find it valuable to find multiple solutions to problems rather than just responding impulsively (Altakhyneh and Aburiash, 2017). In this sense, learning environments nourished by habits of mind come to the forefront in terms of student gains.

Habits of mind have been addressed by researchers as a wide range of composite skills, specific thinking processes and automatic tendency behaviors in a broad perspective with different approaches (Kim, 2011; Kim and Bednarz, 2014). Cuoco, et al. (1996), by emphasizing specific ways of thinking, discusses habits of mind in two types: general in every discipline and specific to only one field. Mathematical habits of mind, which are considered within the scope of mental habits that are general in terms of application area and specific to a field in terms of meaning, mostly come to the fore as algebraic or geometric habits of mind (Gürbüz, et al., 2018; Yavuzsoy Köse and Tanışlı, 2014). Driscoll's definition of habits of mind as the ways in which algebra can be learned successfully if these habits are used as habits in a real sense is also evidence for this (Lim and Selden, 2009). In his study, Kim (2011) utilized Cuoco et al.'s (1996) definitions of general habits of mind and included spatial habits of mind with its sub-dimensions. Kim (2011) defines spatial habits of mind as internalized thinking processes directed towards spatial perspectives, based on the definition of internalized thinking processes directed towards a particular perspective regarding habits of mind. The sub-dimensions of spatial habits of mind are pattern recognition, spatial description, visualization, spatial concept use and spatial tool use by modifying the general habits of mind developed by Cuoco et al. The sub-dimensions and the features indicated by these sub-dimensions (Dokumacı Sütçü, 2021; Kim and Bednarz, 2014) are presented in Table 1.

Table 1. Sub dimensions and characteristics of spatial habits of mind

Sub Dimension	Behavior Observed in the Individual
Recognizing the pattern	Trying to reveal spatial patterns
Spatial identification	Using spatial vocabulary appropriately
Visualization	Understanding events through graphical representations
Spatial concept use	Utilize spatial concepts in performing tasks
Spatial tool use	Supporting spatial thinking with maps and various interactive visual tools

Pattern recognition is the dimension of identifying spatial patterns in a wide range of situations, such as discovering and recognizing patterns in daily life such as the distribution of cars in the parking lot and the layout of roads. Spatial identification is the dimension that emphasizes the importance of spatial literacy, i.e. the competent use of spatial words such as location, direction and span, and the adequate level of spatial vocabulary. Visualization is the process of gaining understanding with the help of graphic representations. It is the ability to imagine the situations that occur with the movement of objects in the mind (Bedir and Yılmaz, 2020; Olkun, 2003). Those who prioritize visualization use visualization strategies both in their own comprehension processes and in their expressions to the other party. Spatial concept is the dimension that involves the use of spatial concepts to perform various tasks. Spatial concepts such as distance and pattern form the basis of spatial perspective and those with spatial competence use these concepts to understand their environment. The spatial tool dimension symbolizes the use of spatial representations and tools, such as maps, to support spatial thinking and the development of spatial cognition. Spatial thinkers enjoy using spatial tools to solve problems (Kim and Bednarz, 2014). The results of Turgut and Yılmaz (2012b) that there is a positive relationship between spatial ability and academic achievement and the results of Kayhan (2005) that there is a strong and significant positive relationship between mathematics achievement and spatial ability support this situation.

In order to better understand an abstract field such as mathematics, it is important to teach it with concrete examples. Visualization is considered a sub-dimension of the spatial habits of the mind and is an effective method used in mathematics teaching. This approach enables students to better understand abstract concepts by associating them with real life situations. It also plays an effective role in increasing mathematics and geometry achievement. Research, especially according to sources such as Dreyfus (1991) and Karasar (2005), emphasizes that visualization is an important strategy that strengthens the spatial habits of the mind in the mathematics learning process and brings the reflections of abstract concepts in daily life into the learning environment. In addition, using visualization and encouraging students to visualize helps students to look at problems from different perspectives and develop different thinking styles for problem solving (Konyalioğlu, Aksu and Şenel, 2012). There are also studies indicating that students' spatial skills affect their problem solving performance (Haciomeroglu, 2016; Haciomeroglu, et al., 2014). On the other hand, spatial ability is an important concept in understanding students' geometric thinking and learning process (Karakuş and Peker, 2015).

Clements and Battista (1992), based on the strong link between success in geometry and spatial skills, stated that spatial skills should be integrated into the curriculum and various activities should be carried out in the classroom environment to improve students' spatial skills. In fact, increasing students' spatial ability is considered a necessity (NCTM, 2000) and is seen as the foundation of students' mathematical reasoning process (Wiles, 2013). The fact that interventions that improve spatial ability provide better learning of mathematics and that spatial ability can be developed through education and schooling (Huttenlocher, et al., 1998; Karakuş and Peker, 2015; Olkun and Altun, 2003; Uygan, 2011) also suggests the effectiveness of teachers on students' spatial ability. In fact, strategies for teacher practices and in-class geometry practices are recommended to help students with weak spatial ability strengthen their spatial learning abilities (Newcombe, 2010, 2013; Olkun, 2003; Olkun and Altun, 2003). It has been determined that teachers' use of visualization, which is one of the spatial habits of the mind, at the beginning of the lesson draws students' attention to the subject and transforms students' passive behavior at the beginning of the lesson into a tendency to be more active, increases students' participation and causes them to develop positive attitudes towards concepts (Konyalioğlu, et al., 2012). In their study, Newcombe and Stieff (2012) emphasized the effectiveness of using spatial language effectively in maximizing spatial learning and stated that preschool children whose parents use more spatial words are better at spatial thinking. In addition, it shows the importance of teachers who are guides in school life with the language skills they use in teaching spatial thinking (Newcombe, 2010).

Based on the information that the current geometry curriculum does not provide sufficient opportunities for the development of spatial ability and that in many schools, geometry topics are postponed until the end of the school year and sometimes not addressed at all, Gürbüz, et al. (2018), in his study, especially included the spatial habits of the mind. It is even stated that students give wrong answers to the questions as a result of not preferring visualization even to support the analytical process, which they see as a waste of time in the current exam system due to their desire to reach the result as quickly as possible (Konyalioğlu, et al., 2012). NCTM's (2000) geometry standards emphasize the need for students at all levels of education to understand spatial relationships in analytic geometry and other geometric systems, use visualization in problem solving processes, use spatial reasoning skills, and create mental images of geometric shapes using spatial memory and spatial visualization. These standards suggest that spatial habits of mind should find a place in teaching environments and programs. In addition, the importance of spatial ability in the realization of the productions that societies will need, especially in science and engineering, is mentioned, and spatial education has been found to improve educational outcomes such as helping university students complete their engineering degrees (Newcombe, 2010; Özyaprak, 2012; Sorby, 2005).

This situation again makes us think about the spatial ability levels of teachers, who are the architects of our future, and the factors affecting them. As a matter of fact, it is stated that the good level of spatial skills of prospective teachers will be effective in the acquisition of these skills by their students and the importance of conducting studies on spatial visualization in undergraduate education is mentioned (Şen, 2020). Again, determining how to use visualization, which is one of the sub-dimensions of spatial habits of mind, in which subject and in which part of the subject and how to gain spatial thinking requires the teacher to make preliminary preparations (Konyalioğlu, et al., 2012; Newcombe, 2010). Based on these considerations, in this study, spatial habits of the mind are discussed from the perspective of teachers who design the teaching environment. At this point, it is also important to know which hemisphere of the brain can be used more effectively with these habits, which are aimed to be gained by students through practices related to the spatial habits of mind in the designed teaching environments. In fact, it is thought that it is important to reveal the factors that feed the habits by knowing which mental activities take place in the background while the person is practicing the spatial habits of the mind, that is, which of the brain hemispheres is more dominant.

As a matter of fact, Herrman (1982) stated that one of the brain hemispheres is more active in people's learning processes. In addition, behavioral changes gained as a result of learning change in connection with the structural differences of the brain (İlkörücü and Arslan, 2017; Turan and Kurtuluş, 2021). In the teaching process, processes such as utilizing existing prior knowledge, sending the acquired information to permanent memory and activating it to be used from permanent memory when necessary affect various stages of education and training. Many studies (Battro, et al., 2013; Şenel Çoruhlu, et al., 2016) emphasized that instruction should be planned in line with the dominant hemisphere of the brain. Özden (2014) emphasized the importance of conducting educational programs by taking into account the functions of the brain hemispheres and that in this way, a learning environment suitable for everyone's learning needs can be provided.

The two hemispheres of the brain have different orientations: the left hemisphere is more involved in mathematical, logical, analytical processes, while the right hemisphere is more involved in spatial, intuitive, holistic processes (Herrmann, 1982). As a result of this distinction, it is seen that some people in society are more detailed, realistic, disciplined, competitive and time-oriented, while others are more creative, intuitive, emotional, like to live unplanned and event-oriented (Davis, et al., 1994). In solving a problem, people with left-brain dominance are interested in the details of the theory used, while people with right-brain dominance focus on other theories only after learning the solution (Akay and Kurtuluş, 2017). This distinction also creates differences in learning styles: left-brain dominant learners prefer to work individually and can apply new information more quickly, while right-brain dominant learners prefer to work collaboratively and focus on assimilating what they have learned (Davis, et al., 1994). Dominance status is individual-specific and there may be individuals in society in which one hemisphere is more dominant or both hemispheres are equally dominant. However, the fact that one hemisphere is more dominant should not be taken to mean that the other hemisphere becomes completely passive; dominance should only be considered as a whole distributed in different proportions between the two hemispheres. While both hemispheres work together, only one of them is worked with more and more effectively (Herrmann, 1982). According to Davis, et al. (1994), healthy individuals use some combinations of behaviors belonging to both brain hemispheres. In fact, instead of activating one of the hemispheres more, a more productive and talented state can be achieved by using both of them together in cooperation (Akay and Kurtuluş, 2017).

Researchers have classified individuals into two groups in mathematics education. While those with right brain dominance control their solutions in various ways and exhibit a guarantee attitude, those with left brain dominance do not control their solutions by solving problems with a single solution method with pencil and paper (Ornstein and Haden, 2001). In this sense, the need for education to be suitable for individual differences and the fact that learning becomes more qualified by determining the dominant brain hemisphere emphasizes the knowledge of the brain dominance status of individuals (İlkörücü and Arslan, 2017). In addition, the extent to which the spatial habits of mind used especially in geometric structures are related to which hemisphere of the brain is dominant also comes to mind. In this way, designing learning environments created by teachers according to brain dominance states can make geometry teaching and spatial thinking process more qualified. In line with individual differences, it is predicted that as a result of the experiences students have in learning environments suitable for their brain dominance states, efficiency will occur in spatial thinking processes and improvement will be experienced in activities requiring spatial skills. According to Van Hiele (1986, as cited in Akay and Kurtuluş, 2017), teachers' thinking habits in the geometry learning process are very effective on students' understanding of geometry. From this point of view, since the brain dominance status of teachers will be determined in this study and its relationship with their spatial thinking habits will be revealed, it is thought that the development of teachers' spatial thinking according to their brain dominance degrees and thus the development of students will be contributed. In addition, although there are studies in the literature (Çeker, 2018; Dokumacı Sütçü, 2021; Kim and Bednarz, 2014; Perugini and Bodzin, 2020; Newcombe and Stieff, 2012; Şen, 2020) that address the spatial habits of mind in various contexts such as visual literacy, age, academic grade point average, and duration of education, there is no study that associates these habits with brain dominance. In this sense, this study aims to contribute to the literature by including this association.

In this study, it is aimed to determine mathematics teachers' spatial habits of mind and to examine these habits in the context of teachers' brain dominance status. In this context, " Do mathematics teachers' spatial habits of mind differ according to the variables of brain dominance level, brain dominance group, gender, faculty of graduation, postgraduate education, year of study and taking geometry courses during undergraduate/graduate education?" answer to this question will be sought.

2. Method

2.1. Research Design

In the study, the spatial habits of mind and brain dominance states of secondary mathematics teachers were determined and the relationship between these two states was focused on. Within this framework, the study was designed in the quantitative research method and the relational survey model within the scope of this method. The survey model is defined as a research model that describes the current situation of the participants of an event or subject as it exists (Büyüköztürk at al. , 2018). The relational survey model is one of the general survey model approaches that aims to reveal the change and the degree of change between two or more variables (Karasar, 2005).

2.2. Sample of Study

In the process of conducting the study, easy accessibility and volunteerism were taken as a basis. Participants were informed about the content of the study and for what purpose the results obtained would be used, and volunteers were included in the study. In addition, the study owners were contacted regarding the use of the scales used in the study and their consent was obtained. Sampling was used to determine the study group. Using simple random sampling method, 124 teachers were included in the study. Teachers voluntarily participated in the study. Information about the participants is given in Table 2.

Table 2. Demographic characteristics of the participants

	Demographic Characteristics	n	%
Gender	Women	80	64,5
	Men	44	35,5
Working Year	1-10	41	33,1
	11-20	42	33,8
	Over 20	41	33,1
Type of School Worked	High School	100	80,7
	Secondary School	24	19,3
Type of Faculty Graduated from	Mathematics Teacher Education	44	35,5
	Elementary Mathematics Teacher Education	18	14,5
	Mathematics/Faculty of Arts and Sciences	62	50
Postgraduate Education Status	Yes	52	41,9
	No	72	58,1
Taking geometry-related courses during undergraduate/graduate education	Yes	63	50,8
	No	61	49,2

When Table 2 is examined, 64.5% (n=80) of the teachers participating in the study were female, 50% (n=62) were graduates of the Department of Mathematics, Faculty of Arts and Sciences, and 80.7% (n=100) were working in high schools. While 58.1% (n=72) of the teachers did not receive postgraduate education, 50.8% (n=63) of them took geometry-related courses during undergraduate/graduate education.

2.3. Data Collection Tools

The data of the study were collected using the personal information form, the spatial habits of the mind scale, and the brain dominance inventory.

2.3.1. Personal Information Form

It is the form that collects information about gender, working year, school type, graduated faculty type, graduate education status and the status of taking the geometry course in the education process.

2.3.2. Spatial Habits of Mind Scale

The Spatial Mind Habits Scale was developed by Kim (2011) within the scope of his doctoral thesis. It was adapted into Turkish by Çeker (2018). The scale designed to determine the spatial habituation level of the mind is in five-point Likert type and consists of 27 items. The items of the scale were graded as "strongly disagree=1", "disagree=2", "undecided=3", "agree=4" and "strongly agree=5". According to the determined rating, the highest score that can be obtained from the scale is 135. 19 of the items in the scale are positive and eight are negative. Negative items are 3, 7, 10, 13, 20, 22, 24 and 26. Negative items were scored from one to five, and positive items were scored from five to one.

There are five sub-dimensions in the scale and each sub-dimension consists of a different number of items. Details on this are given in Table 3.

Table 3. Sub dimensions and item numbers of spatial habits of the mind

Sub Dimension	Item Number
Recognizing the pattern	1, 2, 3, 4, 5, 6
Spatial identification	7, 8, 9, 10, 11
Visualization	12, 13, 14, 15, 16, 17, 18
Spatial concept use	19, 20, 21, 22
Spatial tool use	23, 24, 25, 26, 27

The Cronbach Alpha reliability coefficient of the scale was reported as .917 by Kim (2011). In this study, the Cronbach Alpha reliability coefficient of the scale was calculated as .922.

2.3.3. Brain Dominance Inventory

The Brain Dominance Inventory was used to determine the brain dominance status of the teachers participating in the study. The inventory was edited by Davis et al. (1994). The internal consistency coefficient of the scale was reported as .87 (Davis et al., 1994). The scale consists of 39 multiple-choice items with three options as A, B and C. The evaluation condition of the scale is that all items are answered. In the scoring stage, the B-A difference is found by subtracting the total number of B's from the total number of A's. If the total number of C's is 17 or more, the B-A score found is divided into three and the final score is obtained. If the total number of C's is between 10-16; The B-A score found is divided into two and the result score is obtained. If the total number of C's is less than 10, the B-A score is taken as the final score. Briefly, the result score calculation is given below.

$$P = \begin{cases} (B-A)/3 \ ; & C \geq 17 \\ (B-A)/2 \ ; & 10 \leq C \leq 16 \\ B-A \ ; & C < 10 \end{cases}$$

According to this formula, the brain dominance inventory is interpreted as follows (Akay and Kurtuluş, 2017).

$$P=\begin{cases}\text{right and left brain equal;} & P=0\\ \text{left brain mild ;} & -3\le P\le -1\\ \text{left brain moderate ;} & -6\le P\le -4\\ \text{left brain dominant ;} & -9\le P\le -7\\ \text{left brain strong ;} & -11\le P\le -10\\ \text{right brain mild ;} & 1\le P\le 3\\ \text{right brain moderate ;} & 4\le P\le 6\\ \text{right brain dominant ;} & 7\le P\le 9\\ \text{right brain strong ;} & 10\le P\le 11\end{cases}$$

2.4. Data Collection Process

First of all, scales were applied to two teachers who did not participate in the pilot study. It was seen that there were data overlapping with the aims of the study and it was decided to use these scales. Data were obtained by applying the personal information form and scales to the participants.

2.5. Analysis of Data

SPSS 23.0 program was used in the analysis of the data obtained in the research. Whether the data showed normal distribution or not was analyzed with the Kolmogorov-Smirnov test. The p value (p= .182) of the data obtained with the spatial habit of mind scale was greater than .05 and it was determined that the data showed a normal distribution. In the brain dominance inventory, it was seen that the data did not show normal distribution (p= .001<0.05). However, it is possible to observe whether the data show a normal distribution with the skewness and kurtosis measures (Kalaycı, 2009). Büyüköztürk et al. (2017), on the other hand, consider it sufficient for the skewness and kurtosis values to be between "∓ 1" for the normal distribution. The skewness coefficient of the data obtained with the brain dominance inventory was = .473 and the kurtosis coefficient = - .846, and it was determined that the data showed a normal distribution. Since the data showed a normal distribution, parametric tests were used in the analysis of the data (Pallant, 2001). In this context, descriptive statistics, independent samples t-test and one-way analysis of variance (ANOVA) were applied.

2.6. Validity and Reliability of the Research

Internal consistency was tried to be ensured for the reliability of the study and the reliability analysis of the data obtained from the teachers in line with the spatial habits of mind scale was made. According to the Cronbach Alpha reliability analysis applied for the answers given by the teachers to the questions in the scale, the Cronbach Alpha reliability coefficient was determined as .922. Since the Cronbach Alpha reliability coefficient is greater than .80 indicates that the scale is highly reliable (Can, 2020), it has been seen that the obtained scores are highly reliable.

3. Findings

3.1. Descriptive Analysis Findings on Spatial Habits of Mind and Brain Dominance States

The data obtained in line with the answers given by the teachers participating in the study to the data collection tools were analyzed with descriptive analysis methods in terms of the spatial habit levels of the mind and the brain dominance status. The scores obtained by the teachers from the scale were calculated and the descriptive statistical values of the scores were determined. The findings of the descriptive statistics are given in Table 4.

Table 4. Teachers' scores on the spatial habits of mind scale

	n	Min. Score	Max. Score	$\bar{X}$	SS
Recognizing the pattern	124	13	30	22.41	4.17
Spatial identification	124	11	25	18.31	3.15
Visualization	124	20	35	28.57	4.00
Spatial concept use	124	10	20	15.18	2.11
Spatial tool use	124	11	25	18.91	3.53
Total score	124	77	134	103.38	13.98

Upon examining Table 4, it is observed that teachers' average scores in the sub-dimensions of spatial habits are highest in visualization ($\bar{X}$= 28.57) and pattern recognition ($\bar{X}$= 22.41), while the average score in the sub-dimension of spatial concept usage ($\bar{X}$= 15.18) is the lowest. The sub-dimensions with the highest standard deviation are pattern recognition (SD= 4.17) and visualization (SD= 4.00). Based on the average and standard deviation data, it can be inferred that participants have high habits of pattern recognition and visualization, with greater individual variations in these sub-dimensions. The maximum total score that can be obtained from the scale is 135, and the highest score obtained by teachers is 134. The average total score of the participants is ($\bar{X}$= 103.38). It can be concluded that mathematics teachers have a high level of spatial habits. The descriptive statistics for the determined brain dominance states based on teachers' responses to the brain dominance inventory are presented in Table 5.

Table 5. Brain Dominance States of Teachers

Brain Dominance Group	Brain Dominance Level	n	%	Cumulative %
Left Brain	Left Brain Light	45	36.30	47.58
	Left Brain Moderate	9	7.25	
	Left Brain Dominant	5	4.03	
	Left Brain Strong	0	0.00	
Right Brain	Right Brain Light	40	32.25	41.92
	Right Brain Moderate	9	7.25	
	Right Brain Dominant	3	2.42	
	Right Brain Strong	0	0.00	
Equal Right Brain-Left Brain		13	10.50	10.50
Total		124	100	100

Upon reviewing Table 5, it is observed that the majority of mathematics teachers tend to use the left hemisphere of the brain (47.58%), compared to those who use the right hemisphere (41.92%). Both those inclined to use the left hemisphere and those inclined to use the right hemisphere are mostly at a light dominance level. Additionally, there are no mathematics teachers with a strong brain dominance.

3.2. Findings on the Analysis of Spatial Habits of the Mind According to Various Variables

Conducted for mathematics teachers, this research aims to examine various variables such as brain dominance level, brain dominance group, graduating faculty, graduating high school, postgraduate education status, years of experience, and participation in geometry courses during undergraduate/postgraduate education. Additionally, the study evaluates whether there are significant differences among variables based on the sub-dimensions and overall scores of the scale measuring spatial habits of the mind. For this purpose, if the number of groups in the variables is more than 2, the ANOVA method is applied, and if it is 2, an independent samples t-test is employed. In the analysis process of the ANOVA test, the homogeneity of variances is examined, and based on whether the homogeneity is equal ($p > .05$) or not ($p < .05$), the decision is made regarding which test to apply. ANOVA is used for homogeneous score distributions, while the Welch test is applied for non-homogeneous score distributions (Durmuş, Yurtkoru and Çinko, 2016, p. 133).

In the process of evaluating the significant differences in the spatial habits of the mind scale's sub-dimensions and the total scores for different brain dominance levels among mathematics teachers; it has been determined that the score distributions are homogeneous for the sub-dimensions of pattern recognition, spatial depiction, spatial concept usage, spatial tool usage, and for the overall scale. The non-homogeneous score distribution is identified in the visualization sub-dimension. The findings obtained from tests applied according to this situation are presented in Table 6 and Table 7.

Table 6. ANOVA Test Results for the Spatial Habits of the Mind Scale (According to the Brain Dominance Level Variable)

		Sum of Squares	Sd.	Mean Square	F	p
Pattern Recognition	Between Groups	128.357	6	21.393	1.218	.302
	Within Groups	2054.828	117	17.563		
	Total	2183.185	123			
Spatial Depiction	Between Groups	56.123	6	9.354	.941	.469
	Within Groups	1163.426	117	9.944		
	Total	1219.548	123			
Spatial Concept Usage	Between Groups	68.435	6	11.406	2.639	.019
	Within Groups	505.654	117	4.322		
	Total	574.089	123			
Spatial Tool Usage	Between Groups	94.142	6	15.690	1.248	.287
	Within Groups	1471.052	117	12.573		
	Total	1565.194	123			
Total Score	Between Groups	1606.738	6	267.790	1.352	.240
	Within Groups	23172.447	117	198.055		
	Total	24779.185	123			

Table 7. Welch Test Results for the Spatial Habits of the Mind Scale (According to the Brain Dominance Level Variable)

	Statistics	Sd.	p
Visualization	32.977	6	.000

Upon reviewing Table 6 and Table 7, it is observed that the scores of mathematics teachers in terms of spatial habits of the mind differ according to brain dominance levels, particularly in the sub-dimensions of spatial concept usage ($F=2.639$, $p=0.019<0.05$) and visualization ($p=0.00<0.05$). To examine whether differentiation exists based on brain dominance groups, the homogeneity of variances was again investigated, and a decision was made on which test to apply based on whether the homogeneity is equal. Since the homogeneity of the distribution variances for sub-dimensions and total scores is exactly the same as the findings for brain dominance levels; ANOVA was applied for pattern recognition, spatial depiction, spatial concept usage, spatial tool usage, and total score, while the Welch test was applied for visualization. The findings are presented in Table 8 and Table 9.

Table 8. ANOVA Test Results for the Spatial Habits of the Mind Scale (According to the Brain Dominance Group Variable)

		Sum of Squares	Sd.	Mean Square	F	p
Pattern Recognition	Between Groups	63.553	2	31.776	1.814	.167
	Within Groups	2119.633	121	17.518		
	Total	2183.185	123			
Spatial Depiction	Between Groups	11.191	2	5.595	.560	.573
	Within Groups	1208.358	121	9.986		
	Total	1219.548	123			
Spatial Concept Usage	Between Groups	8.666	2	4.333	.927	.398
	Within Groups	565.422	121	4.673		
	Total	574.089	123			
Spatial Tool Usage	Between Groups	33.628	2	16.814	1.328	.269
	Within Groups	1531.566	121	12.658		
	Total	1565.194	123			
Total Score	Between Groups	558.380	2	279.190	1.395	.252
	Within Groups	24220.806	121	200.172		
	Total	24779.185	123			

Table 9. Welch Test Results for the Spatial Habits of the Mind Scale (According to the Brain Dominance Group Variable)

	Statistics	Sd.	p
Visualization	1.747	2	.189

Upon reviewing Table 8 and Table 9, it is observed that there is no significant differentiation in the scores of mathematics teachers in terms of all sub-dimensions and total scores of the spatial habits of the mind based on the brain dominance group ($p>.05$).

In the process of examining the impact of the type of graduated faculty on the sub-dimensions and total scores of the spatial habits of the mind scale for mathematics teachers, homogeneous distribution variances were observed in the sub-dimensions of visualization, spatial concept usage, and spatial tool usage. On the other hand, non-homogeneous distribution variances were identified in the pattern recognition and spatial depiction sub-dimensions, as well as the overall scale score. The findings obtained from tests applied according to this situation are presented in Table 10 and Table 11.

Table 10. ANOVA Test Results for the Spatial Habits of the Mind Scale (According to the Graduated Faculty Variable)

		Sum of Squares	Sd.	Mean Square	F	p
Visualization	Between Groups	113.919	2	56.960	3,701	.028
	Within Groups	1862.427	121	15.392		
	Total	1976.347	123			
Spatial Concept Usage	Between Groups	10.280	2	5.140	1.148	.321
	Within Groups	541.817	121	4.478		
	Total	552.097	123			
Spatial Tool Usage	Between Groups	111.427	2	55.713	4.719	.011
	Within Groups	1428.597	121	11.807		
	Total	1540.024	123			
Total Score	Between Groups	113.919	2	56.960	3.701	.028
	Within Groups	1862.427	121	15.392		
	Total	1976.347	123			

Table 11. Welch Test Results for the Spatial Habits of the Mind Scale (According to the Graduated Faculty Variable)

	Statistics	Sd.	p
Pattern Recognition	9.211	2	.000
Spatial Depiction	21.206	2	.000
Total Score	10.616	2	.000

Upon examining Table 10 and Table 11, it is observed that there is differentiation in the scores of mathematics teachers in terms of all four sub-dimensions and total scores of the spatial habits of the mind scale, except for the spatial concept usage sub-dimension ($F=1.148$, $p>.05$), based on the type of graduated faculty. To determine which faculty types this differentiation is between, Scheffe and Tamhane tests were applied, with Scheffe relying on equality of variance homogeneity and Tamhane relying on the difference in variance homogeneity. The results of these tests are presented in Table 12. In this table, it will be expressed as Mathematics Teacher Education (MTE), Elementary Mathematics Teacher Education (EMTE) and Mathematics/Faculty of Arts and Sciences (MAT).

Table 12. Scheffe and Tamhane Test Results for the Sub-Dimensions and Total Scores of Mathematics Teachers' Spatial Habits of the Mind According to the Graduated Faculty

	Class (I)	Class (J)	Mean Difference (I-J)	p
Pattern Recognition	MTE	EMTE	-2.735*	.006
		MAT	-.165	.997
	EMTE	MTE	2.735*	.006
		MAT	2.570*	.001
	MAT	MTE	.165	.997
		EMTE	-2.570*	.001
Spatial Depiction	MTE	EMTE	-3.159*	.000
		MAT	-.014	1.000
	EMTE	MTE	3.159*	.000
		MAT	3.145*	.000
	MAT	MTE	.014	1.000
		EMTE	-3.145*	.000
Visualization	MTE	EMTE	-.525	.892
		MAT	1.735*	.027
	EMTE	MTE	.525	.892
		MAT	2.260*	.033
	MAT	MTE	-1.735*	.027
		EMTE	-2.260*	.033

Spatial Concept Usage	MTE	EMTE	-2.929*	.011
		MAT	-.609	.669
	EMTE	MTE	2.929*	.011
		MAT	2.321*	.045
	MAT	MTE	.609	.669
		EMTE	-2.321*	.045
Total Score	MTE	EMTE	-10.240*	.003
		MAT	.624	.995
	EMTE	MTE	10.240*	.003
		MAT	10.864*	.000
	MAT	MTE	-.624	.995
		EMTE	-10.864*	.000

When Table 12 is examined, it is observed that the levels of pattern recognition, spatial depiction, visualization, use of spatial tools and spatial habit are significantly higher in EMTE than in MTE and MAT graduates. In addition, the visualization habit levels of MTE were found to be significantly higher than the habit levels of MAT graduates. To examine the significant difference in the total scores obtained from the spatial habits of mind scale among mathematics teachers based on their status of receiving postgraduate education, an independent samples t-test was applied. The findings are presented in Table 13.

Table 13. Independent Samples t-Test Results for the Sub-Dimensions and Total Scores of Mathematics Teachers' Spatial Habits of the Mind According to the Status of Receiving Postgraduate Education

Status of Receiving Postgraduate Education		N	$\bar{X}$	Sd.	t	p
Pattern Recognition	Yes	52	21.71	4.09	1.595	.113
	No	72	22.92	4.19		
Spatial Depiction	Yes	52	17.90	3.23	1.210	.229
	No	72	18.60	3.08		
Visualization	Yes	52	28.12	4.41	1.080	.282
	No	72	28.90	3.68		
Spatial Concept Usage	Yes	52	15.19	1.88	-.066	.947
	No	72	15.17	2.28		
Spatial Tool Usage	Yes	52	18.58	3.82	.894	.373
	No	72	19.15	3.32		
Total Score	Yes	52	101.50	14.15	1.275	.205
	No	72	104.74	13.80		

According to the Independent Samples t-Test conducted based on the status of receiving postgraduate education, it is observed that the equality of variance homogeneity is met for all sub-dimensions and total scores (p>.05). When examining Table 13, it is observed that there is no differentiation in the spatial habit levels of mathematics teachers based on their status of receiving postgraduate education, both for all sub-dimensions and the total scores obtained from the scale (p>.05). In the process of examining the significant difference in the total scores obtained from the spatial habits of mind scale among teachers based on their years of experience, it was determined that the variance distributions were homogeneous for all sub-dimension scores as well as the total score. The findings obtained from the test applied according to this situation are presented in Table 14.

Upon examining Table 14, it is observed that the scores of mathematics teachers in terms of spatial habits of mind differ according to the years of experience only in the sub-dimension of spatial tool usage (F=4.675, p<.05). To determine between which ranges of years of experience this differentiation occurs, the Tukey test, relying on the equality of variance homogeneity, was applied. The results of this test are presented in Table 15.

Table 14. ANOVA Test Results for the Spatial Habits of the Mind Scale (According to the Years of Experience Variable)

		Sum of Squares	Sd.	Mean Square	F	p
Pattern Recognition	Between Groups	88.405	2	44.203	2.599	.078
	Within Groups	2057.619	121	17.005		
	Total	2146.024	123			
Spatial Depiction	Between Groups	55.247	2	27.623	2.859	.061
	Within Groups	1169.108	121	9.662		
	Total	1224.355	123			
Visualization	Between Groups	44.749	2	22.374	1.402	.250
	Within Groups	1931.598	121	15.964		
	Total	1976.347	123			
Spatial Concept Usage	Between Groups	26.482	2	13.241	3.048	.051
	Within Groups	521.967	121	4.386		
	Total	552.097	123			
Spatial Tool Usage	Between Groups	110.463	2	55.231	4.675	.011
	Within Groups	1429.562	121	11.815		
	Total	1540.024	123			
Total Score	Between Groups	113.919	2	56.960	3.701	.028
	Within Groups	1862.427	121	15.392		
	Total	1976.347	123			

Table 15. Tukey Test Results for the Sub-Dimensions and Total Scores of Mathematics Teachers' Spatial Habits of the Mind According to Years of Experience

	Years of Experience (I)	Years of Experience (J)	Mean Difference (I-J)	p
Spatial Tool Usage	1-10	11-20	1.407	.153
		20-	-.878	.481
	11-20	1-10	-1.407	.153
		20-	.755	.008
	20-	1-10	.878	.481
		11-20	2.285*	.008

When examining Table 15, it is observed that the spatial tool usage habit levels of mathematics teachers with over 20 years of experience are significantly higher than those of mathematics teachers with 11-20 years of experience. To examine the significant difference in the total scores obtained from the spatial habits of mind scale among mathematics teachers based on their experience of taking geometry courses during undergraduate/postgraduate education, an independent samples t-test was conducted. The findings are presented in Table 16.

Table 16. Independent Samples t-Test Results for the Sub-Dimensions and Total Scores of Mathematics Teachers' Spatial Habits of the Mind According to the Experience of Taking Geometry Courses

	Taking Geometry Courses	N	$\bar{X}$	Sd.	t	p
Pattern Recognition	Yes	63	23.29	4.03	2.415	.017
	No	61	21.51	4.16		
Spatial Depiction	Yes	63	18.79	2.90	1.762	.081
	No	61	17.80	3.34		
Visualization	Yes	63	29.13	4.17	1.575	.118
	No	61	28.00	3.78		
Spatial Concept Usage	Yes	63	15.43	2.30	1.346	.181
	No	61	14.92	1.891		
Spatial Tool Usage	Yes	63	19.84	3.20	3.075	.003
	No	61	17.95	3.63		
Total Score	Yes	63	106.48	13.91	2.562	.012
	No	61	100.18	13.43		

According to the Independent Samples t-Test conducted based on the experience of taking geometry courses, it was observed that the equality of variance homogeneity is met for all sub-dimensions and the total score (p>.05). When examining Table 16, it is observed that the spatial habit levels of mathematics teachers significantly differ based on their experience of taking geometry courses during undergraduate/postgraduate education in terms of pattern recognition (t=2.415, p=.017<.05), spatial tool usage (t=3.075, p=.003<.05) sub-dimensions, as well as the total score obtained from the scale (t=2.562, p=.012<.05).

Independent samples t-test was applied to examine whether gender created a significant difference on the sub-dimensions of the mathematics teachers' spatial habits of mind scale and the total scores they received from the overall scale. The findings obtained are presented in Table 17.

Table 17. Sub-dimensions of Mathematics Teachers' Spatial Habits of Mind and Scale Total Scores, Independent Samples t-Test Results According to Gender

	Gender	N	$\bar{X}$	Sd.	t	p
Pattern Recognition	Woman	80	22.71	4.19	1.084	.281
	Man	44	21.86	4.14		
Spatial Depiction	Woman	80	18.45	3.16	.682	.497
	Man	44	18.05	3.15		
Visualization	Woman	80	28.84	4.05	.992	.323
	Man	44	28.09	3.92		
Spatial Concept Usage	Woman	80	15.33	2.26	1.046	.297
	Man	44	14.91	1.82		
Spatial Tool Usage	Woman	80	18.99	3.38	.322	.748
	Man	44	18.77	3.83		
Total Score	Woman	80	104.31	14.03	1.002	.318
	Man	44	101.68	13.90		

According to the Independent Samples t-Test conducted based on the gender variable, it was observed that the equality of variances is met for all sub-dimensions and the total score (p>.05). When examining Table 17, it can be observed that there is no significant difference in the spatial habit levels of mathematics teachers based on gender, neither in any of the sub-dimensions nor in the total score (p > .05).

4. Conclusion and Discussion

This study investigated the distribution of spatial habits and brain dominance status among mathematics teachers, as well as whether the spatial habit levels of mathematics teachers vary according to variables such as brain dominance level, brain dominance group, faculty of graduation, postgraduate education status, years of teaching experience, and taking geometry courses during undergraduate/postgraduate education. Additionally, the relationship between the scores of mathematics teachers on the sub-dimensions of spatial habits has been examined.

When evaluating the spatial habits of mathematics teachers based on the total score that can be obtained from the scale within the scope of sub-dimensions, it has been determined that spatial habits are at a high level. It has been observed that in the scale, the sub-dimensions of visualization and pattern recognition have higher average scores compared to other sub-dimensions, while the spatial concept usage sub-dimension has a lower average score. Additionally, individual differences in the sub-dimensions of visualization and pattern recognition were found to be greater. Sen's (2018) study also supports this result. These findings regarding spatial habits parallel Çeker's (2018) study in terms of the high level of spatial habituation and the presence of significant individual differences, particularly in dimensions characterized by high averages. The studies indicating that prospective mathematics teachers have low or moderate levels of spatial visualization skills (Abay, Tertemiz and Gökbulut, 2018; Turgut, Cantürk Günhan and Yılmaz, 2009; Turgut and Yenilmez, 2012; Turgut and Yılmaz, 2012b; Turgut, Yenilmez and Balbağ, 2017; Yurt and Tünkler, 2016) do not support the findings of this study.

The distribution of mathematics teachers according to their brain dominance groups reveals that the majority tend to use the left hemisphere. This result contradicts the conclusion of İlkörücü and Arslan (2017) that the left-brain region was less preferred in their study whose participants were science and mathematics candidate teachers. The majority of prospective primary school mathematics teachers using both brain hemispheres equally, as found by Akay and Kurtuluş (2017), also does not support the findings of this study. The distribution based on brain dominance levels indicates that the number of teachers with a mild dominance level is higher compared to other levels, and there are no mathematics teachers with a strong dominance level. This majority at the mild dominance level is compatible with the result of the brain dominance level distribution of prospektife primary school mathematics teachers in Akay and Kurtuluş's (2017) study. These results regarding brain dominance group and level coincide with the results obtained by Turan and Kurtuluş (2021) in their study that the majority of mathematics teachers generally use the left brain and are at a slight left-brain dominance level.

The scores of mathematics teachers' spatial habits vary according to brain dominance levels in terms of visualization and spatial concept usage sub-dimensions, but they do not differ according to brain dominance groups in terms of both sub-dimensions and total scores. The lack of relationship between teachers' spatial habits and brain dominance states suggests that spatial habit is not a skill specific to any hemisphere of the brain. Thus, individuals using the same hemisphere of the brain may have different spatial habits, or individuals with the same spatial habits may tend to use different brain hemispheres.

Mathematics teachers' scores on spatial habits of mind differ according to the type of faculty they graduated from in terms of the four sub-dimensions and the total score, except for the spatial concept use sub-dimension. This differentiation is constituted by the levels of spatial habits of primary school mathematics teacher graduates, which are higher than those of secondary school mathematics teacher graduates and graduates of the faculty of arts and sciences, regarding pattern recognition, spatial representation, visualization, spatial tool usage and generally in terms of spatial habits. Additionally, it has been observed that the visualization habit levels of secondary school mathematics teacher graduates are higher than those of graduates from the faculty of arts and sciences. This situation can be attributed to the fact that the subjects of views of objects from different directions and transformation geometry are included in the primary school mathematics curriculum, whereas there are no similar subject contents in the secondary school mathematics curriculum (MEB, 2018a, 2018b). As a matter of fact, the preliminary preparation process of primary school mathematics teachers while transferring the subject contents to the teaching environment and the experience they gained in the classroom environment may have contributed to the development of spatial habit levels.

It was determined that the scores of mathematics teachers on spatial habits of mind differed according to the year of study in terms of the spatial tool use sub-dimension, and this differentiation was due to the fact that the scores of those whose working years were over 20, on the spatial tool use sub-dimension were significantly higher than those of those whose working years were between 11-20. This result does not coincide with the study of Abay, Tertemiz, and Gökbulut (2018), in which they stated that there was a low and negative relationship between the spatial abilities of prospective teachers and their ages.

It has been determined that mathematics teachers' levels of spatial habits of mind differ significantly in terms of pattern recognition, spatial tool use sub-dimensions and the total score obtained from the scale, depending on whether they took geometry courses during undergraduate/graduate education. This result contradicts studies such as Karakuş and Peker (2015) and Symser (1994), which suggest that there is no statistically significant relationship between Van Hiele geometric thinking levels and spatial abilities.

It was observed that mathematics teachers' levels of spatial habit of mind did not differ according to gender and postgraduate education in terms of all sub-dimensions of the scale and the total score obtained from the scale. The findings of Çeker's (2018) study, which investigated the level of spatial habits of candidate middle school mathematics teachers, did not differ significantly in most of the sub-dimensions and the overall score of the same scale. This is parallel to the results of Şen's (2020) study, which found no significant difference in the spatial habits of candidate primary school mathematics teachers based on gender. Similarly, there are different studies indicating that there is no statistically significant difference between gender and spatial ability (Abay, Tertemiz and Gökbulut, 2018; Newcombe, 2010; Turgut and Yılmaz, 2012b; Yurt and Tünkler, 2016). In support of the study, Prokýšek and Štípek (2016) concluded in their study with prospective teachers that gender did not have a significant effect on the mental rotation skill. Maccoby and Jacklin (1974) examined studies on spatial visualization and showed that no consistent gender differences emerged on spatial visualization. Newcombe (2013) and Sarı (2016) found that males generally outperformed females in spatial ability, while Hacıömeroğlu (2016) found that males performed better than females in mental rotation skills. Newcombe and Stieff (2012) showed that there is a gender-related difference in spatial thinking that is not dependent on biological factors, while Ben-Chaim, Lappan, and Houang (1988) showed that spatial visualization ability differs according to gender. These results contradict the study's conclusion that spatial habits of the mind do not differ by gender. Similarly, the study by Linn and Petersen (1985) found that gender differences in spatial ability created large differences for mental rotation, moderate differences for spatial perception, and small differences for spatial visualization, which does not align with the results of this study. The study of Aydın, Yılmaz and Şeker (2020) also does not support the study in terms of the effect of gender on spatial ability. The study conducted by Turgut, Yenilmez, and Balbağ (2017) with teacher candidates, which found no difference in spatial visualization based on gender, supports the study, while the result indicating differences in spatial orientation and spatial thinking does not support it.

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