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Exploring middle school students' spatial skills self-efficacy*[1]

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Abstract

The purpose of this study was to explore middle school students' spatial skills self-efficacy in relation to some variables. The sample consisted of 582 fifth-, sixth-, seventh-, and eighth-grade students in the spring term of the 2021-2022 academic year. The data was collected using the Spatial Skills Self-Efficacy Scale developed by the researchers. The study found that the middle school students had a moderate level of spatial skills self-efficacy on the overall scale and the intrinsic dynamic and extrinsic static subscales, while their level was high, although close to moderate, on the intrinsic static and extrinsic dynamic subscales. Additionally, middle school students' spatial skills self-efficacy differed significantly according to gender, receiving preschool education, grade levels, the amount of time spent out of home, the frequency of going out of town, and the type of game that they most often playing. However, grade levels did not consistently lead to a significant increase in middle students' spatial skills self-efficacy. Accordingly, it is proposed to provide intensive technology-supported training that goes beyond classical methods and practices, and to provide continuous spatial skills training throughout the entire learning cycle of students, starting from preschool education. This study is significant because it examined different dimensions of spatial skills in the same sample group and it explored, for the first time, the affective dimension of middle school students' spatial skills using a valid and reliable scale.

Keywords: Spatial skills, spatial skill self-efficacy, secondary school, intrinsic-extrinsic, static-dynamic.

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INTRODUCTION

Spatial skills are important, to varying degrees, in all human actions, whether simple or complex (Plumert & Spencer, 2007). Approximately 80% of jobs depend on spatial skills rather than verbal skills (Bannatyne, 2003, p. 3). For example, surgeons, orthodontists, geologists, astronomers, and biologists often use spatial skills in their jobs (Rule, 2016, p. 2). People need to use spatial skills in numerous actions, from simple to complex, for example, when searching for an address or packing a suitcase (Hegarty & Waller, 2005), guessing whether a piece of clothing will fit or not, parking a car, playing computer games, or taking selfies.

Spatial skills, as many researchers have noted, are among the basic and vital skills for individuals (Aladağ, Arıkan & Özenoğlu, 2021). Therefore, spatial skills should be acquired in school life (Şanlı, 2020). The National Research Council (2006) stated that spatial skills education should be provided in schools, and students should acquire these skills. Schools are convenient and strategic environments for developing spatial skills. The process of developing spatial skills can be adapted to any learning activity (Arıkan & Aladağ, 2019; Septia, Prahmana, Pebrianto & Wahyu, 2018). Evidence confirms that spatial skills training programs in early childhood (including disadvantaged children) can improve learning and ensure better success (Verdine, Golinkoff, Hirsh-Pasek, Newcombe, Filipowicz & Chang, 2014).

Spatial skills begin to develop in infancy and develop further in childhood (Frick & Wang, 2014). Most of the studies so far have reported that spatial skills training is effective in developing spatial skills (Fesliyen, Şanlı & Pınar, 2019; Mulligan, Woolcott, Mitchelmore & Davis, 2018; Uttal, Meadow, Tipton, Hand, Alden, Warren & Newcombe, 2013). However, despite their importance, spatial skills are not incorporated into curricula as equally as verbal and numerical skills (Coxon, 2012; Ertekin 2017; Kara, Sezer & Şanlı, 2018). Spatial skills are neglected and not encouraged in learning environments (Borzekowski, Chale & Cole, 2022; Mulligan et al., 2018). Spatial skills are among the skills that teachers have the most difficulty developing in students, while students have the most difficulty comprehending spatial skills and feel inadequate to improve spatial skills (Akengin, Bengiç, Çolak & Taş, 2011; Ayvaz, 2019; Çelikkaya, 2015; Değirmenci, Bulut & Kuzey, 2021; Erol, 2017; Karakuş & Karaman, 2019; Kuzey & Değirmenci, 2020).

Little is still known about what spatial skills affect, how they affect, and what they are affected by (Morris, 2018). One of the most important variables affecting an individual's spatial skills may be self-efficacy. Self-efficacy beliefs affect individuals' behaviors, cognitive, motivational, emotional, and choice-making processes (Bandura, 1997), achievements (Yurt, 2014), strategy development (Maddux, 1995), and the effort they will show when faced with difficulties (Bandura, 1991). Although the literature includes studies that investigated middle school students' spatial skills performance, no study has explored spatial skills self-efficacy in middle school students using a valid and reliable scale. However, the age of 9 and 12 years is critical for spatial skills development. Spatial skills should be measured during this age range, and deficiencies, if any, should be remedied (Soluki, Yazdani, Arjmandnia, Fathabadi, Hassanzadeh & Nejati, 2021).

Literature Review

Spatial skill self-efficacy refers to an individual's belief in their ability to utilize their spatial skills and cope with spatial situations or problems they encounter. To better understand this concept, it is useful to examine the concept of spatial skills.

The concept of spatial ability was first mentioned by Sir Francis Galton (1883) in his book *Inquiries into Human Faculty and its Development*. Galton used the concept of spatial ability when studying problem-solving skills as part of systematic psychological research (Bishop, 1980, p. 1). The birth of modern studies on spatial ability is also based on a study conducted by Galton in 1918 (Tekin, 2007).

Looking at the history of research on spatial ability, it is seen that early research from 1883 to 1940 was mostly psychometric studies that investigated the factor structure of spatial ability and whether spatial ability differs from intelligence. During this period, the studies conducted by Thorndike (1921), Spearman (1927), Kelley (1928), and Thurstone (1938) steered the literature. The results of the research conducted during this period revealed that spatial ability consists of multiple factors, and accordingly, various tests were developed to measure spatial ability (Mohler, 2008). Researchers concentrated their work on the components of spatial ability between 1940 and 1960. During this period, several spatial ability tests were administered, and the names, numbers, and definitions of the factors were determined using factor analysis (Cooper & Mumaw, 1985). Psychometric studies on spatial ability were undertaken between 1960 and 1980; however, a greater emphasis was on developing and differentiating this ability. The focus of these studies was to explore the development of spatial skills in children and adults. Piaget and Inhelder (1956) were the first to conduct such studies. Since the 1980s, there has been a growing research interest in the relationship between technology and spatial skills, the development of spatial skills, and the definition of process models to make a theoretical explanation of spatial skills (Mohler, 2008).

Apart from these three periods, studies have today focused more on the development of spatial skills using different methods and technological aids such as computers and telephones (Yıldız, 2009). Additionally, there has recently been a growing interest in variables affecting spatial skills (e.g., gender, technology use, etc.) and variables affected by spatial skills (e.g., STEM, academic achievement, etc.) to better understand the nature of spatial skills.

The Factor Structure of Spatial Skills

The factor structure of spatial skills has been an object of study since the mid-1940s (Yılmaz, 2009, p. 84). Researchers have differing views on spatial skills; thus, they have divided spatial skills into different factor categories. Looking at the studies that investigated the factor structure of spatial skills, it can be stated that spatial skills do not consist of a single dimension but multiple interrelated factors. McGee (1979) divided spatial skills into two components: spatial visualization and spatial orientation. According to Lohman (1979-1988), spatial skills consist of three factors: spatial visualization, spatial relations (speeded rotation), and spatial orientation. Likewise, Linn and Petersen (1985) divided spatial skill into three components: spatial perception, mental rotation, and spatial visualization. Building on the Cattell-Horn-Carroll theory of fluid and crystallized intelligence, Carroll (1993) divided spatial skills into eleven components. Hegarty, Montello, Richardson, Ishikawa, and Lovelace (2006) divided spatial skills into small-scale and large-scale spatial skills. Uttal and colleagues (2013) examined previous studies on spatial skills from a linguistic, cognitive, and neuroscientific point of view. They proposed a 2X2 classification of spatial skills. The first distinction is between intrinsic and extrinsic information and the second is between static and dynamic information. In recent years, this classification has been widely accepted in the literature, and studies have been conducted on this classification (Geer, 2019; Jung et al., 2020; McLaughlin & Bailey, 2022). In addition, the factor structure of the data collection tool used in this study was created by taking into account self-efficacy, which is one of the most important concepts in the Social Learning Theory, and this classification was proposed by Uttal and colleagues (2013). Therefore, it seems useful to explain this classification in detail.

2x2 Classification of Spatial Skills

In their meta-analysis study, Uttal and colleagues (2013) divided spatial skills into four groups in a 2X2 formation. They are intrinsic static, intrinsic dynamic, extrinsic static, and extrinsic dynamic. Spatial information is expressed intrinsically or extrinsically depending on whether a task is based on the object itself or based on the object's surroundings (Tüker, 2017; Uttal et al., 2013). The focus of intrinsic information is on a specific feature of an object or the relations between its parts (Garcia, Dick & Pruden, 2021). These skills can be measured through embedded figure tasks, paper folding tasks, and mental rotation tests. The focus of extrinsic information is on the identification of the relations between multiple items or objects in relation to one another or a general framework. Extrinsic skills, on the other hand, can be measured through water-level tasks and Piaget's three mountains task. To better illustrate, distinguishing rakes from hoes and shovels in the garden shed relates to intrinsic information while discerning that the hoe stands between the rake and the shovel or determining the direction of the rake, anchor, and shovel in relation to the garden shed relates to extrinsic information (Uttal et al. 2013).

It is possible to distinguish between static and dynamic spatial skills. Spatial activities in which the main object is not moved are static. For example, in embedded figures and water-level tasks, the object in hand does not change in direction, location, or size. The main object or frame of reference remains constant to the respondent throughout the task. On the other hand, the main object moves physically or in the mind of the respondent in dynamic spatial activities (Uttal et al., 2013; Okamoto, Kotsopoulos, McGarvey & Hallowell, 2015).

Intrinsic static refers to skills needed for tasks that are performed without transforming objects, such as embedded figures and pattern completion tasks (Xie, Zhang, Chen & Xin, 2020). Intrinsic dynamic refers to skills needed for tasks that involve physically or mentally transforming or manipulating objects or shapes, such as block design, mental rotation, and paper folding tasks (Xie et al., 2020). Studies have shown that successful intrinsic dynamic activities can be observed since infancy (Hodgkiss, Gilligan-Lee, Thomas, Tolmie & Farran, 2021).

Extrinsic static skills are needed when there are numerous alternative routes to get from point A to point B. Extrinsic static skills mainly involve mapping or other perceptual tasks, such as choosing and planning a route (Okamoto et al., 2015). These skills are needed for tasks that require processing relations among objects or shapes without transformation, such as water-level and static map reading tasks (Xie et al., 2020). It is more likely to learn extrinsic static skills through education and training compared to the other three skills (Uttal et al., 2013). Frick and Newcombe (2012) stated that these skills begin to develop between the ages of 3 and 6.

Extrinsic dynamic skills are needed for tasks such as perspective-taking tasks that involve determining exactly how objects are perceived from different perspectives (Hodgkiss et al., 2021), and spatial navigation and dynamic map reading tasks that involve processing relations among objects or shapes through physical or mental transformation (Xie et al., 2020). For example, in Piaget's three mountains task, respondents are expected to rotate objects from their points of view. These processes require dynamic interaction with the stimulus (Uttal et al., 2013).

It is assumed that intrinsic development precedes extrinsic development (Newcombe & Huttenlocher, 2006), and static development precedes dynamic development (Okamoto et al., 2015). In summary, the hierarchical development of spatial skills is as follows: intrinsic static > intrinsic dynamic > extrinsic static > extrinsic dynamic (Jung et al., 2020). Besides, static spatial skills may be an essential prerequisite for dynamic spatial skills (Gilligan-Lee, Hodgkiss, Thomas, Patel & Farran, 2021). Table 1 summarizes the factors of spatial skills proposed by Uttal and colleagues (2013).

Looking at Table 1, it is understood that spatial skills consist of four subsequent and cumulative processes. This developmental process is comparable to the stages of a baby learning to walk, i.e., creeping, crawling, walking while holding onto objects, walking without help, and running. Individuals learn new things and cumulatively develop their skills by layering experiences on top of each other. During everyday routine activities (e.g., going to a destination, wandering, driving, playing games, putting things in the closet, etc.), individuals need to use one of these spatial skills only, but most often multiple spatial skills at one time. Although this intertwining situation makes spatial skills complicated, it creates a strong need to work on spatial skills. The fact that spatial skills are often needed and used in everyday life is an indication that these skills are vital.

Table 1. Factors of Spatial Skills Proposed by Uttal and colleagues (2013)

Spatial Skills	
Intrinsic Static	**Intrinsic Dynamic**
It involves distinguishing objects and shapes in a distracting and complex background or sorting objects according to their specific characteristics, such as size, and color. It is similar to spatial visualization. It refers to skills needed for tasks that do not require object transformation, such as embedded figures and pattern completion tasks.	It involves mentally transforming objects from 2D to 3D or from 3D to 2D, rotating 2D and 3D objects, putting together objects into more complicated configurations, understanding part-whole relationships, and spatial visualization. It is similar to mental rotation and spatial visualization. These skills are needed for tasks such as that involve transforming or manipulating objects or shapes, mental rotations, and paper folding tests.
Extrinsic Static	**Extrinsic Dynamic**
These skills are needed for tasks that require processing relations among objects or shapes without transformation, such as map reading, spatial scaling, and water-level tasks.	These skills are needed for tasks such as perspective-taking which involves determining how objects are perceived from different points of view, navigation, and direction-finding.

Current Study

Research shows that spatial skills exist and begin to develop at a very young age (Frick & Wang, 2010; Lauer & Lourenco, 2016). Despite the importance of spatial skills, little is known about why differences in spatial skills occur or what factors may affect their development (Garcia et al., 2021; Ramirez, Gunderson, Levine & Beilock, 2012). There is limited information about the development of spatial skills after the age of 8 due to the lack of research (Hodgkiss et al., 2021). However, the age range from 9 to 12 is a critical period for these skills (Soluki et al., 2021). Spatial skills are considered vital for an individual's life and thus need to be determined at an early age. Moreover, the identification of spatial skills enables the discovery of one's potential in other areas and the elimination of any deficiency (Özyaprak, 2012). Effective spatial skills training can unlock the potential of children, especially in low- and middle-income countries, and promote their creativity (Borzekowski et al., 2022). It is noted that deficiencies in spatial skills at an early age are associated with difficulties in learning mathematics at a later age (Zhang, Rasanen, Koponen, Aunola, Lerkkanen & Nurmi, 2020). Middle school years, in particular, are the most critical period in the development of spatial skills. Thus, it is of key importance to determine students' levels of spatial skills during the middle school period, to help students acquire spatial skills in the teaching and learning process, and to remedy deficiencies, if any.

Thus, it is of critical importance to investigate the factors affecting spatial skills (Garcia et al., 2021). The general view in the literature is that spatial skills are influenced by biological, cultural, and evolutionary factors (Iachini, Ruggiero, Conson & Trojano, 2009; Silverman & Eals, 1992; Yılmaz, 2009). Given these factors, the present study investigated the following factors that may have an impact on spatial skills as shown in the literature: gender (İrioğlu & Ertekin, 2012; Joh, 2016), receiving preschool education (Adak Özdemir, 2011), grade levels (Mulligan et al., 2018), the amount of time spent in out-of-home settings other than school, (Baenninger & Newcombe, 1989), the frequency of getting out of town in the past year (Ecuyer Dab & Robert, 2004), the type of most-played games at present (Ginn & Pickens, 2005). However, the direction and extent of this effect, i.e., when the effect occurs and which dimensions of spatial skills are affected, are important matters of discussion. In particular, little is known about the variables that lead to individual differences in the developmental trajectory of spatial skills (Xiao & Zhang, 2021). Very few studies have examined different dimensions of spatial skills within the same sample group (Hodgkiss et al., 2021). Besides, the taxonomy that was proposed by Uttal and colleagues (2013) and formed a basis for the scale used in the present study is predominantly based on psychological tests. Thus, this taxonomy should be supported by different scientific research methods (Mix, Hambrick, Satyam, Burgoyne & Levine, 2018).

Against this background, the purpose of this study was to explore middle school students' level of spatial skills self-efficacy in relation to some variables. To this end, answers were sought to the following research problems:

1. What is middle school students' level of spatial skills self-efficacy?
2. Does middle school students' spatial skills self-efficacy differ significantly according to gender?
3. Does middle school students' spatial skills self-efficacy differ significantly according to the experience of receiving preschool education?
4. Does middle school students' spatial skills self-efficacy differ significantly according to their grade level?
5. Does middle school students' spatial skills self-efficacy differ significantly according to the amount of time spent in out-of-home settings other than school?
6. Does middle school students' spatial skills self-efficacy differ significantly according to the frequency of going out of town in the past year?
7. Does middle school students' spatial skills self-efficacy differ significantly according to the type of game that they most often play?

METHOD

This study used a relational survey design, which is a form of quantitative research method. First, ethical approval was obtained from the Ethics Commission of Gazi University at session No. 12 held on August 3, 2021.

Sample

The study population consisted of middle school students studying in the Efeler district of Aydn province in the Aegean Region of Turkey in the 2021–2022 academic year. The sample consisted of students who were attending four public middle schools selected using simple random sampling from the population.

A multistage sampling method was adopted in the sample selection. Stratified sampling was used in the first stage to determine the socioeconomic status of schools in the relevant province. In this stage, seven experts (three academicians, one administrator, and three teachers) who were living in the Efeler district and well-informed about the conditions of the middle schools there were consulted for expert opinion about the socioeconomic status and success level of the schools. Maximum variation sampling, which is a type of purposive sampling, was used in the second stage. Accordingly, schools from three socioeconomic levels (i.e., low, middle, and high) were randomly included in the study in proportion to their distribution across the accessible population so that maximum variation could be achieved. Table 2 shows the demographics of the students from whom the data were collected.

Table 2. Demographics of the Participating Students

Grade Levels		5	6	7	8	Total
Number of Students in Grade Levels		199	122	145	116	582
Gender	Female	87	59	75	70	291
	Male	112	63	70	46	291
Age	10	17	-	-	-	17
	11	141	16	-	-	157
	12	39	94	17	-	150
	13	2	12	119	35	168
	14	-	-	7	76	83
	15	-	-	2	5	7

According to the data reported by the Aydın Provincial Directorate of National Education (2022) for the Efeler district of Aydın the number of middle school students was 15,197 in the 2021-2022 academic year. It is stated that a sample size of 370 to 377 students is sufficient for such a population at a reliability level of 95% (Cohen, Manion, & Morrison, 2000). Looking at Table 2, it is seen that an adequate number of students was reached in line with the literature.

Data Collection Instrument

The Spatial Skills Self-Efficacy Scale developed by the researcher was used as the data collection instrument. The scale was developed to determine middle school students' spatial skill self-efficacy. It is rated on a 4-point Likert-type scale as follows: I certainly cannot (1), I cannot (2), I can (3), and I certainly can (4). The scale consists of four subscales in keeping with the taxonomy proposed by Uttal and colleagues (2013). The subscales are intrinsic static, intrinsic dynamic, extrinsic static, and extrinsic dynamic. The data were collected from 1369 students for the pilot study and the validity and reliability analysis to investigate the psychometric properties of the scale. Twenty-five subject matter experts were asked for opinions, and Lawshe's content validity ratio (1975) was used to measure the content validity of the scale. The construct validity of the scale was tested using the exploratory factor analysis (EFA). The analysis results yielded a four-factor structure consisting of 17 items, which accounted for 41.37% of the total variance. According to the results of the confirmatory factor analysis (CFA), the goodness-of-fit indices of the spatial skills self-efficacy scale were within the range of perfect or acceptable fit. The results of the correlation analysis run to test the criterion-related validity of the scale showed that the factors have a significant moderate positive correlation with other frequently used tests and scales that have proven valid and reliable. The Cronbach's alpha coefficient was found to be .77 for the total scale. The results of the independent samples t-test for the upper and lower 27% groups showed a significant difference between the groups for all scale items. The correlation coefficients of the subscales with one another and with the total scale showed significant positive moderate and high correlations. The test-retest reliability coefficients also showed significant positive moderate and high correlations.

Data Analysis

Statistical analysis was performed using SPSS software version 26.0. First, the normality of the data was tested. It is recommended that for a normal distribution, skewness and kurtosis values should be within the range of +1.0 to -1.0 (Hair, Black, Babin, Anderson & Tatham, 2013), +1.5 to -1.5 (Tabachnick & Fidell, 2013), or +2.0 to -2.0 (George & Mallery, 2010). In the present study, the normality of data was assessed using histograms and the range of skewness and kurtosis between -2 and +2 (George & Mallery, 2010). Normality was also tested using the Kolmogorov–Smirnov and Shapiro –Wilk tests and Q-Q plots. All the data were normally distributed based on the skewness and kurtosis values and histograms; thus, parametric tests were used in the data analysis.

Additionally, effect size (Cohen's d, eta squared, and Pearson's r) was computed and reported in this study. Cohen's d values were interpreted as follows: $1.45 < d$ as perfect, $1.10 < d < 1.45$ as very large, $0.75 < d < 1.10$ as large, $0.40 < d < 0.75$ as moderate, $0.15 < d < 0.40$ as small, and $-0.15 < d < 0.15$ as trivial (Thalheimer & Cook, 2002). Considering eta squared values, $\eta 2 = .01$ was interpreted as a small effect size, $\eta 2 = .06$ was interpreted as a medium effect size, and $\eta 2 = .14$ was interpreted as a large effect size (Büyüköztürk, 2020).

FINDINGS

Findings of the First Research Problem

The first research problem was "What is middle school students' level of spatial skills self-efficacy?". Table 3 shows the descriptive statistics regarding middle school students' mean scores on the overall spatial skills self-efficacy scale and its subscales.

Table 3. The Results of Descriptive Statistics on Middle School Students' Mean Scores on the Spatial Skills Self-Efficacy Scale

Subscales	N	SD	Se	X̄	Level
Intrinsic Static	582	2.00	.08	13.34	High
Intrinsic Dynamic	582	2.68	.11	14.02	Moderate
Extrinsic Static	582	2.25	.09	9.42	Moderate
Extrinsic Dynamic	582	2.27	.09	12.24	High
Overall Scale	582	6.56	.27	49.02	Moderate

As seen in Table 3, middle school students' mean score was $\bar{X} = 49.02$ on the overall scale, $\bar{X} = 13.34$ on the intrinsic static subscale, $\bar{X} = 14.02$ on the intrinsic dynamic subscale, $\bar{X} = 9.42$ on the extrinsic static subscale, and $\bar{X} = 12.24$ on the extrinsic dynamic subscale. Based on these results, it can be said that the middle school students had a moderate level of spatial skills self-efficacy on the overall scale and the intrinsic dynamic and extrinsic static subscales, while they have a high level of spatial skills self-efficacy on the intrinsic static and extrinsic dynamic subscales.

Findings of the Second Research Problem

The second research problem was "Does middle school students' spatial skills self-efficacy differ significantly according to gender?". The data were normally distributed. Thus, an independent samples t-test was performed to answer the research problem. Table 4 shows the test results.

Table 4. Independent Samples T-Test Results for Middle School Students' Spatial Skills Self-Efficacy according to Gender

Subscales	Gender	N	X̄	SD	df	t	p	Cohen's d
Intrinsic Static	Female	291	13.36	1.92	580	.23	.82	.02
	Male	291	13.32	2.07				
Intrinsic Dynamic	Female	291	13.74	2.67	580	-2.58	.01*	.21
	Male	291	14.31	2.67				
Extrinsic Static	Female	291	9.01	2.18	580	-4.48	.00*	.37
	Male	291	9.83	2.24				
Extrinsic Dynamic	Female	291	11.93	2.27	580	-3.35	.00*	.28
	Male	291	12.55	2.24				
Overall Scale	Female	291	48.03	6.11	572.54	-3.68	.00*	.31
	Male	291	50.01	6.85				

*p < .05

Based on the t-test results, middle school students' spatial skills self-efficacy differed significantly according to gender for the overall scale [$t(572.54) = -3.68$; $p < .05$; Cohen's $d = .31$], for the intrinsic dynamic subscale [$t(580) = -2.58$; $p < .05$; Cohen's $d = .21$], for the extrinsic static subscale [$t(580) = -4.48$; $p < .05$; Cohen's $d = .37$], and for the extrinsic dynamic subscale [$t(580) = -3.35$; $p < .05$; Cohen's $d = .28$]; however, there was no significant difference for the intrinsic static subscale [$t(580) = .23$; $p>.05$; Cohen's $d = .02$]. Looking at these results, it seems that this difference was in favour of male students and had a small effect size.

Findings on the Third Research Problem

The third research problem was "Does middle school students' spatial skills self-efficacy differ significantly according to the experience of receiving preschool education?". Because the data were normally distributed, an independent samples t-test was performed to answer the research problem. Table 5 shows the test results.

Table 5. Independent Samples T-Test Results for Middle School Students' Spatial Skills Self-Efficacy according to Receiving Preschool Education

Subscales	Received Preschool Education	N	X̄	SD	df	t	p	Cohen's d
Intrinsic Static	Yes	383	13.54	1.96	580	3.40	.00*	.30
	No	199	12.95	2.01				
Intrinsic Dynamic	Yes	383	14.25	2.76	580	2.89	.00*	.25
	No	199	13.58	2.48				
Extrinsic Static	Yes	383	9.67	2.28	580	3.78	.00*	.33
	No	199	8.93	2.11				
Extrinsic Dynamic	Yes	383	12.52	2.25	580	4.20	.00*	.37
	No	199	11.70	2.22				
Overall Scale	Yes	383	49.98	6.65	439.89	5.19	.00*	.44
	No	199	47.17	5.98				

*p < .05

Based on the t-test results, middle school students' spatial skills self-efficacy differed significantly according to the experience of receiving preschool education for the overall scale [t(439.89) = 5.19; p < .05; Cohen's d = .44], for the intrinsic static subscale [t(580) = 3.40; p < .05; Cohen's d = .30], for the intrinsic dynamic subscale [t(580) = 2.89; p < .05; Cohen's d =.25], for the extrinsic static subscale [t(580) = 3.78; p < .05; Cohen's d =.33], and for the extrinsic dynamic subscale [t(580) = 4.20; p < .05; Cohen's d = .37]. Given these results, this difference was in favour of those students who received preschool education and the effect size of the difference was moderate for the overall scale and small for the subscales.

Findings on the Fourth Research Problem

The fourth research problem was "Does middle school students' spatial skills self-efficacy differ significantly according to their grade level?". A one-way analysis of variance (ANOVA) was performed to answer the research problem. Table 6 shows the analysis results.

Based on the one-way ANOVA results, middle school students' spatial skills self-efficacy differed significantly according to their grade level for the overall scale [F(3, 578) = 10.91; p < .05; η2 =.05], for the intrinsic static subscale [F(3, 578) = 11.67; p < .05; η2 = .06], for the intrinsic dynamic subscale [F(3, 578) = 7.05; p < .05; η2 = .04], for the extrinsic static subscale [F(3, 578) = 4.30; p < .05; η2 = .02], and for the extrinsic dynamic subscale [F(3, 578) = 4.96; p < .05; η2 = .03]. Tukey's test was used to determine the direction of the difference because the assumption of homogeneity of variance was met. Accordingly, there was a statistically significant difference in students' mean scores on the overall scale. The differences were between 5th-grade and 7th-grade students in favour of the latter, between 5th-grade and 8th-grade students in favour of the latter, and between 6th-grade and 7th-grade students in favour of the latter. The effect size of the differences was small. There was also a statistically significant difference in students' mean scores on the intrinsic static subscale between 5th-grade and 6th-grade students in favour of the latter, between 5th-grade and 7th-grade students in favour of the latter, and between 5th-grade and 8th-grade students in favour of the latter. The effect size of the differences was moderate. There was also a statistically significant difference in students' mean scores on the intrinsic dynamic subscale between 5th-grade and 7th-grade students in favour of the latter, and between 5th-grade and 8th-grade students in favour of the latter. The effect size of the differences was small. There was also a statistically significant in students' mean scores on the extrinsic static subscale difference between 5th-grade and 7th-grade students in favour of the latter. The difference had a small effect size. There was also a statistically significant difference in students' mean scores on the extrinsic dynamic subscale between 5th-grade and 7th-grade students in favour of the latter, and between 6th-grade and 7th-grade students in favour of the latter. The effect size of the differences was small.

Table 6. One-Way ANOVA Results for Middle School Students' Spatial Skills Self-Efficacy according to Grade Levels

Subscales	Grade Levels	N	X̄	SD	F	p	Significant Difference	η2
Intrinsic Static	5	199	12.70	1.95	11.67	.00*	5-6 5-7 5-8	.06
	6	122	13.45	1.90				
	7	145	13.77	1.99				
	8	116	13.79	1.92				
	Total	582	13.34	2.00				
Intrinsic Dynamic	5	199	13.38	2.55	7.05	.00*	5-7 5-8	.04
	6	122	14.01	2.69				
	7	145	14.56	2.75				
	8	116	14.47	2.61				
	Total	582	14.02	2.68				
Extrinsic Static	5	199	9.13	2.18	4.30	.01*	5-7	.02
	6	122	9.10	2.26				
	7	145	9.79	2.23				
	8	116	9.78	2.27				
	Total	582	9.42	2.25				
Extrinsic Dynamic	5	199	12.01	2.05	4.96	.00*	5-7 6-7	.03
	6	122	12.11	2.37				
	7	145	12.86	2.26				
	8	116	12.01	2.44				
	Total	582	12.24	2.27				
Overall Scale	5	199	47.22	5.67	10.91	.00*	5-7 5-8 6-7	.05
	6	122	48.66	6.56				
	7	145	50.97	6.97				
	8	116	50.05	6.65				
	Total	582	49.02	6.56				

*p < .05

Findings on the Fifth Research Problem

The fifth research problem was "Does middle school students' spatial skills self-efficacy differ significantly according to the amount of time spent in out-of-home settings other than school?". A one-way ANOVA was performed to answer the research problem. Table 7 shows the analysis results.

Based on the one-way ANOVA results, middle school students' spatial skills self-efficacy differed significantly according to the amount of time spent out of home for the overall scale [F(2, 579) = 18.09; p < .05; η2 = .06], for the intrinsic static subscale [F(2, 579) = 3.20; p < .05; η2 = .01], for the intrinsic dynamic subscale [F(2, 579) = 11.10; p < .05; η2 = .04], for the extrinsic static subscale [F(2, 579) = 8.10; p < .05; η2 = .03], and for the extrinsic dynamic subscale [F(2, 579) = 14.96; p < .05; η2 = .05]. Tukey's test was used to determine the direction of the difference because the assumption of homogeneity of variance was met. Considering the mean scores on the overall spatial skills self-efficacy scale, there was a significant difference between students who do not spend time in out-of-home settings other than school and those who spend 1 to 2 hours in favour of the latter, between those who do not spend time and those who spend 3 to 4 hours in favour of the latter, and between those who spend 1 to 2 hours and those who spend 3 to 4 hours in favour of the latter. The effect size of the differences was moderate. Considering the mean scores on the intrinsic static subscale, a significant difference was observed between students who do not spend time in out-of-home settings other than school and those who spend 3 to 4 hours in favour of the latter. The effect size of the difference was small. Considering the mean scores on the intrinsic dynamic subscale, there was a significant difference between students who do not spend time in out-of-home settings other than school and those who spend 3 to 4 hours in favour of the latter, and between those who spend 1 to 2 hours and those who spend 3 to 4 hours in favour of the latter. The effect size of the differences was small. Considering the mean scores on the extrinsic static subscale, there was a significant difference between students who do not spend time in out-of-home settings other than school and those who spend 1 to 2 hours in favour of the latter, between those who do not spend time and those who spend 3 to 4 hours in favour of the latter, and between those who spend 1 to 2 hours and those who spend 3 to 4 hours in favour of the latter. The effect size of the differences was small. Considering the mean scores on the extrinsic dynamic subscale, there was a significant difference between students who do not spend time in out-of-home settings other than school and those who spend 1 to 2 hours in favour of the latter, between those who do not spend time and those who spend 3 to 4 hours in favour of the latter, and between those who spend 1 to 2 hours and those who spend 3 to 4 hours in favour of the latter. The effect size of the differences was small.

Table 7. One-Way ANOVA Results for Middle School Students' Spatial Skills Self-Efficacy according to the Amount of Time Spent Out of Home

Subscales	Time	N	X̄	SD	F	p	Significant Difference	η2
Intrinsic Static	Never	45	12.71	2.21	3.20	.04*	Never – 3-4 hrs.	.01
	1-2 hrs.	323	13.31	1.95				
	3-4 hrs.	214	13.52	1.99				
	Total	582	13.34	2.00				
Intrinsic Dynamic	Never	45	12.82	3.14	11.10	.00*	Never – 3-4 hrs. 1-2 hrs. – 3-4 hrs.	.04
	1-2 hrs.	323	13.80	2.54				
	3-4 hrs.	214	14.61	2.67				
	Total	582	14.02	2.68				
Extrinsic Static	Never	45	8.42	2.33	8.10	.00*	Never – 1-2 hrs. Never – 3-4 hrs. 1-2 hrs. – 3-4 hrs.	.03
	1-2 hrs.	323	9.30	2.21				
	3-4 hrs.	214	9.80	2.21				
	Total	582	9.42	2.25				
Extrinsic Dynamic	Never	45	10.98	2.21	14.96	.00*	Never – 1-2 hrs. Never – 3-4 hrs. 1-2 hrs. – 3-4 hrs.	.05
	1-2 hrs.	323	12.05	2.31				
	3-4 hrs.	214	12.79	2.08				
	Total	582	12.24	2.27				
Overall Scale	Never	45	44.93	6.65	18.09	.00*	Never – 1-2 hrs. Never – 3-4 hrs. 1-2 hrs. – 3-4 hrs.	.06
	1-2 hrs.	323	48.46	6.39				
	3-4 hrs.	214	50.72	6.29				
	Total	582	49.02	6.56				

*p < .05

Findings on the Sixth Research Problem

The sixth research problem was "Does middle school students' spatial skills self-efficacy differ significantly according to the frequency of going out of town in the past year?". A one-way ANOVA was performed to answer the research problem. Table 8 shows the analysis results.

Table 8. One-Way ANOVA Results for Middle School Students' Spatial Skills Self-Efficacy according to the Frequency of Going Out of Town

Subscales	Freq.	N	X̄	SD	F	p	Significant Difference	η2
Intrinsic Static	Never	118	12.98	2.06	10.21	.00*	Never – 3-4 1-2 – 3-4	.03
	1-2	290	13.16	1.94				
	3-4	174	13.90	1.94				
	Total	582	13.34	2.00				
Intrinsic Dynamic	Never	118	13.67	2.76	12.71	.00*	Never – 3-4 1-2 – 3-4	.04
	1-2	290	13.66	2.51				
	3-4	174	14.86	2.73				
	Total	582	14.02	2.68				
Extrinsic Static	Never	118	8.70	2.07	16.09	.00*	Never – 1-2. Never – 3-4 1-2 – 3-4	.05
	1-2	290	9.28	2.16				
	3-4	174	10.13	2.31				
	Total	582	9.42	2.25				
Extrinsic Dynamic	Never	118	11.86	2.39	10.13	.00*	Never – 3-4 1-2 – 3-4	.03
	1-2	290	12.02	2.29				
	3-4	174	12.87	2.05				
	Total	582	12.24	2.27				
Overall Scale	Never	118	47.21	6.24	24.31	.00*	Never – 3-4 1-2 – 3-4	.08
	1-2	290	48.11	6.30				
	3-4	174	51.76	6.37				
	Total	582	49.02	6.56				

*p < .05

Based on the one-way ANOVA results, middle school students' spatial skills self-efficacy differed significantly according to the frequency of going out of town for the overall scale [F(2, 579) = 24.31; p < .05; η2 = .08], for the intrinsic static subscale [F(2, 579) = 10.21; p < .05; η2 = .03], for the intrinsic dynamic subscale [F(2, 579) = 12.71; p < .05; η2 = .04], for the extrinsic static subscale [F(2, 579) = 16.09; p < .05; η2 = .05], and for the extrinsic dynamic subscale [F(2, 579) = 10.13; p < .05; η2 = .03]. Tukey's test was used to determine the direction of the difference because the assumption of homogeneity of variance was met. Considering the mean scores on the overall scale, there was a significant difference between students who never went out of town in the past year and those who went out of town 3 to 4 times in favour of the latter, and between those who went out of town once to twice and those went out of town 3 to 4 times in favour of the latter. The effect size of the differences was moderate. Considering the mean scores on the intrinsic static subscale, there was a significant difference between students who never went out of town in the past year and those who went out of town 3 to 4 times in favour of the latter, and between those who went out of town once to twice and those went out of town 3 to 4 times in favour of the latter. The effect size of the differences was small. Considering the mean scores on the intrinsic dynamic subscale, there was a significant difference between students who never went out of town in the past year and those who went out of town 3 to 4 times in favour of the latter, and between those who went out of town once to twice and those went out of town 3 to 4 times in favour of the latter. The effect size of the differences was small. Considering the mean scores on the extrinsic static subscale, there was a significant difference between students who never went out of town in the past year and those who went out of town once to twice in favour of the latter, between those who never went out of town and those who went out of town 3 to 4 times in favour of the latter, and between those who went out of town once to twice and those went out of town 3 to 4 times in favour of the latter. The effect size of the differences was small. Considering the mean scores on the extrinsic dynamic subscale, there was a significant difference between students who never went out of town in the past year and those who went out of town 3 to 4 times in favour of the latter, and between those who went out of town once to twice and those went out of town 3 to 4 times in favour of the latter. The effect size of the differences was small.

Findings on the Seventh Research Problem

The seventh research problem was "Does middle school students' spatial skills self-efficacy differ significantly according to the type of game that they most often play?". A one-way ANOVA was performed to answer the research problem. Table 9 shows the analysis results.

Table 9. One-Way ANOVA Results for Middle School Students' Spatial Skills Self-Efficacy according to the Type of the Game They Play the Most

Subscales	Game Types	N	X̄	SD	F	p	Significant Difference	η2
Intrinsic Static	Computer games	265	13.66	1.89	11.76	.00*	1-2, 1-3, 2-3	.04
	Street/outdoor games	293	13.17	2.05				
	Games played with toys at home	24	11.83	1.58				
	Total	582	13.34	2.00				
Intrinsic Dynamic	Computer games	265	14.38	2.69	6.86	.00*	1-2, 1-3	.02
	Street/outdoor games	293	13.81	2.66				
	Games played with toys at home	24	12.58	2.15				
	Total	582	14.02	2.68				
Extrinsic Static	Computer games	265	9.67	2.26	3.18	.04*	1-2	.01
	Street/outdoor games	293	9.19	2.25				
	Games played with toys at home	24	9.33	1.76				
	Total	582	9.42	2.25				
Extrinsic Dynamic	Computer games	265	12.46	2.24	10.08	.00*	1-3, 2-3	.03
	Street/outdoor games	293	12.19	2.28				
	Games played with toys at home	24	10.33	1.63				
	Total	582	12.24	2.27				
Overall Scale	Computer games	265	50.18	6.55	12.87	.00*	1-2, 1-3, 2-3	.04
	Street/outdoor games	293	48.38	6.46				
	Games played with toys at home	24	44.08	4.32				
	Total	582	49.02	6.56				

*p < .05

Based on the one-way ANOVA results, middle school students' spatial skills self-efficacy differed significantly according to the type of the most-played game for the overall scale [F(2, 579) = 12.87; p < .05; η2 = .04], for the intrinsic static subscale [F(2, 579) = 11.76; p < .05; η2 = .04], for the intrinsic dynamic subscale [F(2, 579) = 6.86; p < .05; η2 = .02], for the extrinsic static subscale [F(2, 579) = 3.18; p < .05; η2 = .01], and for the extrinsic dynamic subscale [F(2, 579) = 10.08; p < .05; η2 = .03]. Tukey's test was used to determine the direction of the difference because the assumption of homogeneity of variance was met. Looking at the mean scores on the overall spatial skills self-efficacy scale, a significant difference was observed between students who most often play computer games and those who most often play outdoor games in the street in favour of the former, between those who most often play computer games and those who most often play with toys at home in favour of the former, and between those who most often play outdoor games in the street and those who most often play with toys at home in favour of the former. The effect size of the differences was small. Looking at the mean scores on the intrinsic static subscale, a significant difference was also observed between students who most often play computer games and those who most often play outdoor games in the street in favour of the former, between those who most often play computer games and those who most often play with toys at home in favour of the former, and between those who most often play outdoor games in the street and those who most often play with toys at home in favour of the former. The effect size of the differences was small. Looking at the mean scores on the intrinsic dynamic subscale, a significant difference was also observed between students who most often play computer games and those who most often play outdoor games in the street in favour of the former, and between those who most often play computer games and those who most often play with toys at home in favour of the former. The effect size of the differences was small. Looking at the mean scores on the extrinsic static subscale, there was a significant difference between students who most often play computer games and those who most often play outdoor games in the street in favour of the former. The effect size of the difference was small. Looking at the mean scores on the extrinsic dynamic subscale, a significant difference was also observed between students who most often play computer games and those who most often play with toys at home in favour of the former, and between those who most often play outdoor games in the street and those who most often play with toys at home in favour of the former. The effect size of the differences was small.

DISCUSSION AND CONCLUSION

The purpose of this study was to explore middle school students' spatial skills self-efficacy in relation to some variables. To this end, the study first determined middle school students' levels of spatial skills self-efficacy and then examined whether their levels of spatial skills self-efficacy differ according to gender, grade levels, the experience of receiving preschool education, the amount of time spent out of home, the frequency of going out of town, the type of game that they most often play.

Middle school students' mean scores on the spatial skills self-efficacy scale were analysed to answer the first research problem. It was found that the middle school students had a moderate level of spatial skills self-efficacy on the overall scale and the intrinsic dynamic and extrinsic static subscales, while their level was high, although close to moderate, in the intrinsic static and extrinsic dynamic subscales. Earlier studies reported that students' levels of spatial skills were low (Ertuğrul, 2008; Gönülaçar & Öztürk, 2019; Turğut, 2007; Üzümcü, 2007), moderate (Ada, 2016; Erol, 2017; Kösa & Kalay, 2018), and high (Uzun, 2019). Spatial skills begin to develop in infancy and develop further in childhood (Frick & Wang, 2014). Most of the studies so far have reported that spatial skills training is effective in developing spatial skills (Fesliyen et al., 2019; Mulligan et al., 2018; Uttal et al., 2013). However, spatial skills are not incorporated into curricula as equally as verbal and numerical skills (Coxon, 2012; Ertekin 2017; Kara et al., 2018). To improve spatial skills, educators may usefully equip learning environments with tools and materials that increase students' spatial awareness and help students realize spatial relations in their interactions with the world (Harris, 2021). Thus, it is believed that intensive technology-supported training that goes beyond traditional teaching methods and approaches and makes use of, for example, drones, virtual reality glasses, and video clips recorded with 360-degree action cameras will help remedy deficiencies in spatial skills and, by extension, improve spatial skills.

Whether middle school students' mean scores on the spatial skills self-efficacy scale differ according to gender was examined to answer the second research problem. There was a statistically significant difference between male and female students in favour of male students in the overall scale and the intrinsic dynamic, extrinsic static, and extrinsic dynamic subscales, while no significant difference was found in the intrinsic static subscale. It is assumed that intrinsic development precedes extrinsic development (Newcombe & Huttenlocher, 2006), and static development precedes dynamic development (Okamoto et al., 2015). In summary, the hierarchical development of spatial skills is as follows: intrinsic static > intrinsic dynamic > extrinsic static > extrinsic dynamic (Jung et al., 2020). Thus, intrinsic static spatial skills are the most basic skills and are based on recognizing and distinguishing objects. This might be a possible reason that intrinsic static spatial skills did not differ according to gender. Similarly, some earlier studies reported gender-related differences in spatial skills (Ben Chaim, Lappan & Houang, 1988; Ehrlich, Levine & Goldin Meadow, 2006; Ferrini-Mundy, 1987; Guay & McDaniel, 1977; Joh, 2016) Linn & Petersen, 1985; Mazman & Altun, 2013; McCoun, 1993; Phunlapthawee, 2000; Walker, Krasnoff & Peaco, 1981). On the other hand, there are also studies that reported no gender-related differences (İrioğlu & Ertekin, 2012; Olkun & Altun, 2003; Seng & Chan, 2000; Shavalier, 1999). The general opinion in the literature is that gender causes a difference in spatial skills in favour of boys. This difference may result from biological factors (Annett, 1992; Iachini et al., 2009), cultural factors (Dearing, Casey, Ganley, Tillinger, Laski & Montecillo, 2012; Yılmaz, 2009), evolutionary factors (Silverman, Choi, Mackewn, Fisher, Moro & Olshansky, 2000; Silverman & Eals, 1992), and the use of different strategies by boys and girls to answer questions (Janssen & Geiser, 2010). Dearing and colleagues (2012) found that the visual-spatial skills of girls were linked to the visual-spatial skills of their mothers, especially the mental rotation skills of their mothers. The findings of the present study seem to be consistent with the literature. Thus, female students can be encouraged to gain adequate spatial experience and use their spatial skills in various tasks in low anxiety environments (Okamoto et al., 2015). Encouraging female students to gain spatial experience can help bridge the gender gap in spatial skills (Chan, 2007).

Middle school students' mean scores on the spatial skills self-efficacy scale were also analysed in relation to the experience of receiving preschool education to answer the third research problem. A statistically significant difference was found in terms of receiving preschool education in the overall scale and all subscales. It is emphasized that preschool education makes a difference in terms of mental rotation skills in the subsequent years, and this difference is associated with activities and gaming experiences in the preschool period (Adak Özdemir, 2011).

Whether middle school students' mean scores on the spatial skills self-efficacy scale differ according to their grade level was examined to answer the fourth research problem. A statistically significant difference was found in terms of grade levels in the overall scale and all subscales. The difference in the mean scores on the overall scale was in favour of 7th- and 8th-grade students compared to 5th-grade students and in favour of 7th-grade students compared to 6th-grade students. The difference in the mean scores on the intrinsic static subscale was in favour of 6th-, 7th-, and 8th-grade students compared to 5th-grade students. The difference in the mean scores on the intrinsic dynamic subscale was in favour of 7th- and 8th-grade students compared to 5th-grade students. The difference in the mean scores on the extrinsic static subscale was in favour of 7th-grade students compared to 5th-grade students. The difference in the mean scores on the extrinsic static subscale was in favour of 7th-grade students compared to 5th- and 6th-grade students. Looking at these findings, it is clear that grade levels did not consistently lead to a significant increase in middle students' spatial skills self-efficacy. Teachers' beliefs and perceptions about spatial skills directly affect the success of spatial skills activities conducted in the classroom (Gagnier, Holochwost & Fisher, 2021). However, it is argued that spatial skills are often neglected, given little attention, and are not encouraged adequately in classroom practices (Black, 2005; Borzekowski et al., 2022; Mathewson, 1999; McLaughlin & Bailey, 2022; Mulligan et al., 2018). In the present study, the highest scores on the overall scale and subscales were attained by 7th-grade students. A possible reason for this result might be that the 8th-grade curriculum does not involve social studies which is one of the critical lessons for spatial skills. Additionally, looking at the middle school curriculum, it is seen that some of the learning outcomes related to spatial skills (spatial visualization and rotation) are incorporated in mathematics and science courses. However, looking at the textbooks, it is surprising that these learning outcomes are treated contrary to the essence of the curriculum and are not handled in an interdisciplinary manner. The fact that spatial skills are treated in a disconnected manner in different lessons and at different times may have a negative impact on students' acquisition of spatial skills. Thus, a major conclusion of the present study is that the development of spatial skills does not receive due care and attention in the curriculum and practice. Many studies support this finding (Coxon, 2012; Borzekowski et al., 2022; McLaughlin & Bailey, 2022; Mulligan, et al., 2018).

Another finding of the study is that there was a statistically significant difference in middle school students' mean scores on the overall scale and all subscales in terms of the amount of time spent out of home. It should be noted that this difference is more pronounced in the extrinsic dynamic and extrinsic static subscales. Earlier research found a statistically significant positive relationship between spatial performance and participation in spatial activities (Baenninger & Newcombe 1989). A possible explanation for this result might be that outdoor activities require students to use spatial skills more often. Due to the different amounts of time allocated for spatial activities, some students could have improved their spatial skills and, by extension, their self-efficacy.

Whether middle school students' mean scores on the spatial skills self-efficacy scale differ according to the frequency of going out of town was examined to answer the sixth research problem. Exploring the effect of experiences on spatial skills or participation in activities that require spatial skills and determining the extent of such an effect could help improve students' spatial skills and bridge the gap between students (Terlecki & Newcombe, 2005). The present study found a statistically significant difference in students' mean scores on the overall scale and all subscales in terms of the frequency of going out of town. Students' spatial skills self-efficacy differed when the frequency of going out of town in the past year was 3 to 4 times, and the difference was more pronounced in the extrinsic dynamic and extrinsic static subscales. It would be reasonable to assume that children of middle school age go out of town with their parents. A possible explanation for the significant difference in spatial skills self-efficacy according to the frequency of going out of town might be that students search for information about their destinations using maps or geographic information system (GIS) applications before or after going out of town. Regarding spatial experiences, Webley (1981) noted that boys are allowed to explore new environments more often than girls. Baenninger and Newcombe (1995) also argued that girls have spatial experiences outside of school less often than boys. Having said that, spatial experiences have a more noticeable effect on girls (Chan, 2007). According to Silverman and colleagues (2000), women in hunter-gatherer societies usually foraged for food in familiar places, while men went to larger places to chase and hunt for prey and discovered new areas; thus, this may cause gender-related differences in spatial skills. Today, it is also expected that regardless of gender, people who more often go to different and new places have a higher level of spatial skills, especially extrinsic dynamic spatial skills.

The finding regarding the seventh research problem is that there was a statistically significant difference in students' mean scores on the overall scale and all subscales in terms of the type of the most-played game. The difference was in favour of computer games compared to outdoor games played in the street and indoor games played at home, and in favour of outdoor games compared to indoor games. It is thought that computer games have a positive effect on the development of geometric and spatial skills. Using computers involves switching between 2D and 3D spaces and rotating, enlarging, cutting, copying, pasting, overlapping, and transforming objects or content; thus, the use of computers is valuable for the development of spatial skills (Pollman, 2010; Turğut, 2007). In parallel with the development of mobile technologies today, mobile games played on smartphones and tablets as well as computer games may also be useful in spatial skills training. Uysal and Değirmenci (2021), for example, found a direct relationship between location-based mobile games and students' map skills and topography knowledge. In a meta-analysis study, Di and Zheng (2022) found that virtual technologies have a moderate effect on the development of spatial skills with a total effect size of 0.617. Computer games provide children with important opportunities for developing mental rotation, spatial visualization (Okagaki & Frensch, 1994), and spatial orientation skills (Chen, Lin & Lou, 2014). Considering outdoor games, men are more willing to play sports such as football and ice hockey, which especially require targeting skills (Kimura, 1999; Voyer, Nolan & Voyer, 2000). It may be useful to refer to Sherman's (1978) theory suggesting that there is an innate predisposition to certain abilities. The choice of activities might also be informed by this innate predisposition to the ability required by a specific activity. According to this theory, men may tend to do activities that involve more spatial skills due to their innate predisposition to spatial activities. Earlier studies have shown that boys are more often engaged in various spatial activities from an early age compared to girls (Schug, 2016). It can thus be said that men who engage in activities that require more spatial skills have an advantage in terms of spatial skills (Lawton & Morrin, 1999; Yılmaz, 2009). It is also argued that experiences gained through spatial activities (e.g., basketball, volleyball, musical performances in artistic activities, etc.) result in an increase in mental rotation performance (Ginn & Pickens, 2005). One way to develop spatial skills in children is to give them opportunities to participate in spatial activities (Gilligan-Lee et al., 2022, p. 4). In their 6-week experimental study, Denier and Serbin (1978) gave 3-year-old children male-preferred toys. The children in the experimental group were given blocks, dominoes, cube blocks, drawing papers, and materials. They observed an increase in the visual-spatial performance of the experimental group at the end of the experiment. Cockburn (1995) suggested that children's spatial skills are influenced by toys that they play with. In Grossman and Grossman (1994), 12- and 18-month-old girls preferred stuffed toys, dolls, toy kitchen items, and toy animals, while male peers preferred trucks, toy tools, and robots. It is known that boys get more opportunities to have spatial experiences compared to girls because boys play or prefer playing exploration games, team sports, block/brick construction games, and video games from early childhood. It is thought that boys' performance in spatial skills and girls' performance in verbal skills are based on these early experiences (Cockburn, 1995).

This study set out to examine middle school students' spatial skills self-efficacy in relation to a set of variables. This study is important because it is the first study that obtained findings on how middle school students' spatial skills self-efficacy differed according to some widely discussed variables using a valid and reliable scale. It is also believed that this study will contribute to the growing body of literature as it examined different dimensions of spatial skills with the same sample group and explored the affective dimension of spatial skills.

Recommendations

The data collected in this study were cross-sectional. Thus, longitudinal studies could offer further insights. This research found that female students had lower levels of spatial skill self-efficacy compared to male students. Female students' spatial skills self-efficacy can be improved by guiding them towards appropriate sports activities such as orienteering and plogging, by reinforcing these skills using computer games and similar applications in learning environments, and by raising parents' awareness of the importance of these skills. A major finding of this study was that spatial skills self-efficacy significantly differed between students who received preschool education and those who did not in favour of the former. In this regard, preschool education institutions could be expanded to promote the development of spatial skills in children. It may be useful to provide continuous spatial skills training throughout the entire learning cycle of individuals, starting from preschool education. For example, a module or course focused on spatial skills could be incorporated into the 8th-grade curriculum. This study examined some of the variables affecting spatial skills. Thus, further research could usefully explore other variables that were not explored in this study (e.g., grade point average, socioeconomic status, etc.) using structural equation modelling or hierarchical linear modelling. Another major finding of this study was that spatial skills self-efficacy significantly differed in favour of students who more often go out of town and play outdoor games compared to their peers. In this sense, it may be helpful to use outdoor learning/nature education activities or in-town and out-of-town sightseeing/observation activities to promote the development of spatial skills. Last but not least, the development of spatial skills could be supported through intensive technology-supported training that goes beyond traditional teaching approaches and makes use of, for example, drones, virtual reality glasses, and video clips recorded with 360-degree action cameras.

Statement of Researchers

Researchers contribution rate statement: The researchers contributed equally to the study
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