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Research Article

Investigating Greek kindergartners' spatial abilities. Are they the best they can be?

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Abstract
The development of spatial abilities in young children leads to better achievement in STEAM education and in their daily lives. Early interventions have been shown to be highly effective in developing spatial abilities. In this study, the spatial abilities curriculum of the Greek kindergarten is described, and the use of maps is recommended for inclusion in the curriculum. This study examines kindergarten pupils' spatial abilities at the end of two consecutive preschool years and determines whether attending kindergarten for one or two years succeeded in developing the participating pupils' spatial abilities and achieving the goals set by the curriculum. Furthermore, it investigates which spatial abilities can be developed to the greatest and lowest degree and whether there is a statistical difference in achievement between age (1 or 2 years of study) and gender. The research sample consisted of 90 pupils from 5 different kindergarten classes; these pupils had attended kindergarten for 1 year (younger children called pronipia in Greek) or for 2 years (older children called nipia in Greek). A questionnaire survey was used to collect data for analysis. It was found that the goals set by the curriculum were not satisfactorily met. Older children, as expected, performed better and there was no statistical difference between boys and girls for the total performance. This paper is part of a wider study that aims to investigate pupils' spatial abilities. It proposes an effective teaching intervention with the use of two large-scale giant maps and appropriate teaching material to develop kindergarteners' spatial abilities.

Highlights:

- *'Proper teaching interventions are required for kindergartners' spatial abilities*
- *There is significant room for improvement in kindergartners' spatial abilities*
- *Spatial abilities are strongly related to geographic science and education*

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1. INTRODUCTION

Spatial abilities are vital for humans' everyday life, assisting in activities such as driving a car or moving furniture (Lajoie, 2003); additionally, many professionals, including scientists, heavily rely on their spatial abilities (Newcombe, 2010). Spatial thinking is fundamental for developing abilities related to technology, science, engineering, and mathematics (Young et al, 2018). Psychological science insists that without spatial abilities, the psychological construction that supports creativity, innovation, and theoretical activities is not optimal (Kell & Lubinski, 2013).

Spatial ability is malleable—in other words, it can be improved with appropriately designed interventions (Yang et al., 2020; Sorby et al., 2018) regardless of age (Uttal et al., 2013). Individual differences in spatial abilities appear at preschool age; thus preschool years are vital to improve kindergarten pupils' performance in spatial tasks (Garcia et al., 2021). The development of spatial skills from the kindergarten level leads to greater performance in future (Heckman, 2006) for all genders (Wai et al., 2010). The kindergarten environment provides opportunities for children to become familiarized with the discovery of space and to acquire spatial skills (Özdemir et al., 2014). Consequently, the need of appropriate teaching interventions for effective learning outcomes has been pointed out in existing literature (Özdemir & Güven, 2014; Klonari, 2012).

The curriculum of Greek kindergarten describes the spatial abilities that children must acquire. However, this description is not accompanied by appropriate teaching interventions or teaching materials; instead, spatial abilities are presented as part of other cognitive skills without presenting detailed activities for enhancing the same. This lack of teaching interventions and material raises questions about whether the objectives of the curriculum are ultimately achieved.

This study investigates whether pupils who completed the kindergarten school year after studying for one or two consecutive years acquired the desired spatial abilities according to the guidelines of the Greek kindergarten curriculum. Additionally, it surveys which spatial abilities were developed to the greatest and lowest degree, and whether there is statistical difference in achievement between age (1 or 2 years of study) and gender. This study is part of a wider study that aims to provide kindergarten teachers with an appropriate teaching intervention to improve pupils' spatial skills.

2. SPATIAL ABILITY

Spatial thinking is defined as a combination of abilities and processes (Metoyer et al., 2017), and as a mixture of abilities related to concepts of space, using representation tools and processes of reasoning (Committee on Support for Thinking Spatially, National Research Council 2006, 12). Spatial thinking is strongly related to geographic science and education (Wakabayashi, 2015), and superior spatial thinking is related to high levels of geographic thinking ((Metoyer et al., 2017). Moreover, Juliasz (2018) argued that spatial thinking can be systematized through geography. Increased interaction with maps and spatial activities improves pupils' spatial thinking regardless of the activity type (Flynn, 2018; Collins, 2018)

Spatial ability includes spatial visualization (i.e., the ability to represent spatial elements mentally and operate with visual stimuli) and spatial orientation (i.e., the ability to picture spatial elements from different perspectives) (Uttal et al., 2013). Apart from these abilities, some geographers include spatial relations as a third dimension in spatial thinking. Spatial relations are abilities that include recognizing spatial patterns; connecting locations; using spatial hierarchies; regionalizing, sketching, comparing, and dissolving maps; and associating spatially distributed phenomena (Bednarz et al, 2011). Another approach divides spatial ability into spatial perception, mental rotation, and spatial visualization (Linn & Petersen, 1985) and refers to spatial ability as a skill that enables one to represent, generate, transform, and recall symbolic non-verbal information. Sorby (1999), clarifying previous studies, divided spatial skills into spatial visualization and spatial orientation, further dividing spatial visualization into mental rotation and mental transformation.

Practice in symbolic representation, proportions, and movements are reinforcing factors for spatial thinking (Newcombe, 2010), whereas spatial understanding of scale is developed especially between 3 to 5 years of age (preschool age) with significant differentiation between individuals (Frick & Newcombe, 2012).

There is a debate among spatial thinking researchers about spatial mapping abilities of young children between 3 to 6 years of age which represents two different beliefs. According to Blaut and colleagues (2003: 165), spatial mapping abilities are a universal acquisition made at a very young age and preschool children demonstrate spatial abilities even though they have never been taught these abilities formally. Other researchers (Kastens & Liben, 2010; Liben, 2009) have argued that young children's spatial mapping abilities are highly limited, and it cannot be taken for granted that children will develop and acquire these abilities from their life experiences or primary education. Skilled map use is an ability that needs to be practiced and taught, and it is not an ability that a child will develop inevitably (e.g., walking) (Kastens et al., 2001). It has been previously shown that spatial mapping abilities, even if they are little developed, can be improved in kindergarten with the appropriate teaching intervention.

Gender spatial abilities studies with young children show controversial results. According to some of these studies, boys outperform girls in activities that require spatial ability and perception (Rafi et al., 2008), including skills such as orientation ability (Coluccia & Louse, 2004), navigation in a straight and inclined plane (Holmes et al., 2015), and skills requiring spatial-visual talent (Yarmohammadian, 2014). Some studies have found no gender differences in visual-spatial skills (Kotsopoulos et al., 2019), mental rotation ability (Bruce and Hawes, 2014), and young children's spatial ability (Rutherford et al., 2018; Likouri et al., 2017). On the one hand, Coluccia and Louse (2004) have argued that when orientation activities do not require a high degree of spatial-visual memory, gender differences are eliminated; on the other hand, Samsudin et al. (2011) have insisted that spatial ability is higher among young girls and favors boys as they become older. Early interventions can have a significant effect on both genders' spatial performance (Wai et al., 2010). Gersmehl and Gersmehl (2006) have showed that the brain areas involved in different types of spatial thinking appear to develop in early childhood. They stated that pupils will get significantly benefited if spatial thinking abilities were given more significance in school curricula and if spatial abilities' assessment programs were started in kindergarten (Gersmehl and Gersmehl 2006).

2.1 The role of maps in kindergarten teaching

Maps are not only a representation of the surrounding world (Hus & Hojnik, 2013); they offer more than just showing the way and are tools of thinking as they present a wide variety of other variables (financial data, population, etc.) (Newcombe & Frick, 2010). Maps can be a powerful tool for teachers to teach children how to learn spatially and to help them develop their spatial abilities (Newcombe, 2013). As early as in 1988, it was found that kindergarten children should be encouraged to visualize spatial information by constructing and using maps and should be taught how to read maps and other map-related skills, with appropriate activities that vary in difficulty (Downs et al., 1988) to develop spatial abilities and skills needed in geographic education. Additionally, paper maps are considered powerful teaching materials to teach spatial skills despite their simplicity (Bidney & Piekielek, 2018).

Children aged 2–6 years can gradually mentally represent the surrounding space; however, they find it difficult to understand the geographical space. It should be noted that knowledge of space is improved over time (Kavouras et al., 2016). Maps can be used as a teaching tool to improve spatial thinking (Newcombe & Frick, 2010). As they are considered to be likeable by preschool children (Anderson, 1996), they prove to be useful tools to develop children's spatial abilities. Pupils with less developed spatial abilities create "poor" mapping projects, make fewer moves, and have poorer vocabulary when they come in contact with large-scale maps (Kotsopoulos et al., 2015).

There is a critical debate about the knowledge that maps provide pupils and about maps not just merely representing elements of the world. Whereas Wood and Fels have described maps as "field of concepts" (2008:2), other researchers have insisted that conscious and unconscious decisions of cartographers affect the creation of the map (Kitchin et al., 2007). In kindergarten, maps representing a small amount of carefully selected information can be used effectively as there is reduced possibility of confusing the children. Based on the study of interactive maps, researchers (Vincent et al., 2019) have found that a simpler map helps people to make correct decisions, and maps made for a specific reason and purpose are much more effective as compared to maps representing a wide variety of information.

2.2 Large-scale giant maps in kindergarten teaching

Large-scale giant maps are an effective and fun way for children to interact with maps and learn map reading in a playful manner. Large-scale maps allow children aged 3–6 years to explore them with their whole body; to engage in learning that requires movement, manipulation, or touch; and use hands-on activities. National Geographic suggests that kindergartners should work with and on giant maps that depict familiar places that are easy to interpret and which represent varied spatial information associated with symbols on the map surface (2016). Children can identify places, use landmarks, compare distances, orient the map, and identify symbols that represent an object or place in the real world (Mohan & Mohan, 2013:4) using such maps. The existing studies have shown that while children are more aware of their surrounding environment (neighborhood), they are also able to recognize important sights in the city (Özgece et al., 2015). It has been shown that 3-year-old children have a "basic" understanding of maps' symbolic relations; however, in order for children to become able to use maps efficiently, they should understand the following: a) the relationship between the symbols on the map and what they represent; b) the orientation of the map and how to align it in the correct orientation, if necessary; c) viewing angle; d) how a three-dimensional space is projected into a two-dimensional space; and, e) the scale (Frick & Newcombe, 2012).

3. KINDERGARTEN CURRICULUM

In the education system in Greece, learning of spatial thinking and geographical concepts in kindergarten does not exist as an autonomous subject or is not assigned a separate set of activities, but is instead integrated in different units in a Cross Thematic Curriculum Framework for Nursery School (DIATHEMATIKON PROGRAMMA, 2003). In the unit "Child and environment," children learn about their neighborhood, their city or village, compare the differences between cities and villages, use maps and symbols, use geographical terms, and observe how places look like in different scales. The unit "Child and language" states that kindergarten pupils should learn that maps are means of conveying messages, and the unit "Child and mathematics" claims that children should observe and describe the position of objects in space. It is clear that spatial thinking is not yet a highly developed subject in Greek kindergarten curriculum. Despite this, the curriculum states that students at the end of their study year (learning outcomes) in Greek kindergarten should:

- be able to "read" maps and interpret simple map symbols;
- be able to use maps, orient to a specific location, and describe the locations of objects;
- describe the place in which they live, and move in it following instructions; and,
- be encouraged to depict the space and the routes they take, as well as to use images and symbols for the same.

Although the Greek kindergarten curriculum describes spatial activities, there is lack of both proper teaching interventions for this purpose and appropriate teaching materials. Moreover, geography and spatial skills are neglected not only in Greek kindergarten, but also worldwide, and the number of studies on the teaching of spatial concepts to kindergarten students are insufficient. Additionally, a lack of educational policies that can provide teachers with specific geographical education and proper teaching interventions to develop pupils' spatial abilities is observed (Dönmez, 2021; Yang et al., 2020; Becker, 2016).

4. METHOD

The reference to the improvement of spatial abilities in the Greek kindergarten curriculum without providing appropriate teaching interventions has raised questions about the success of the curriculum in improving spatial skills.

In every class in the Greek kindergarten, nipia [or first age; children, who, on December 31 of this school year, reach the age of 5, completed the 2^{nd} year of study in kindergarten] and pronipia [or second age; children, who, on December 31 of this school year, reach the age of 4, completed the 1st year of study in kindergarten] coexist. All kindergartners learn the same curriculum. The pupils are distributed in classes in such a way that they have a similar number of students of each age group.

The purpose of this study was to investigate whether Greek kindergartners' spatial abilities meet the standards declared in the Greek Curriculum for Kindergarten at the end of the school year. Additionally, this study aimed to investigate two subquestions: whether there is a significant difference between boys and girls and between nipia and pronipia regarding spatial ability acquisition.

A survey was conducted in the last month of the school year (2019) among children that had attended kindergarten for 1 (younger children- pronipia) or 2 years (older children- nipia). The questionnaire used in this study addressed the Greek curriculum requirements for kindergarten and built on Goria's unpublished doctoral thesis (2014). Before initiating the study, it had been explained to the participating kindergartners that they would fill in some "secret worksheets" (similar to the worksheets students did in the classroom), but that until all the kids had completed the questionnaire, they would not reveal the questions and answers to other students. Completion of the questionnaires was voluntary since the students were asked to fill them in during their "free play" time. All the pupils were asked to fill in the questionnaire, and it was observed that they were impatient for their turn to come to complete the questionnaire. Either the kindergarten teacher or researcher went with a child to a quiet place in the classroom during mornings, read the questions to the child, and recorded the answers, while the other children were playing in the classroom; this process was repeated for every participant. As children of this age cannot read or write, they needed the help of a kindergarten teacher or researcher to complete the questionnaire. In some questions, the children marked the answers on their own. Serious care was taken during the completion of the questionnaire to ensure that the other children did not approach and listen to the answers given to avoid imitation. Some questions on how to create a map, how to draw a road, or how to put point out symbols on the map were completed by the children themselves. The completion of the questionnaire took 25–40 minutes, depending on the time each child needed to complete their map.

Data were analyzed by using SPSS. The data were checked for their normality by using the Kolmogorov-Smirnov test; it was observed that they do not follow normal distribution; consequently, the kindergarten pupils' performances were checked using the Mann-Whitney test.

4.1 The sample

The study sample included 90 participants from four Mytilene kindergartens (5 different classes) on Lesvos Island, Greece. Of the 90 pupils, there were 40 boys (nipia=22; pronipia=18) and 50 girls (nipia=28; pronipia= 22). In total, there were 50 nipia and 40 pronipia.

The four kindergartens were attended by pupils with a similar socioeconomic background (in this case, middle class).

Kindergarten teachers study either in the Department of Early Childhood Education or in the Department of Preschool Education in universities in Greece; the name of the department changes depending on the university. Kindergarten teachers often use old school maps to develop pupils' spatial abilities following old teaching methods, without emphasizing spatial competence and its improvement.

Here, it should be noted that Greek kindergarten teachers completed their studies at the university with little or no geographic education. After their graduation, they are neither provided any training on geographical education or spatial abilities development, nor are they provided with properly designed teaching interventions for teaching spatial abilities or appropriate teaching materials. Since there are no specialty teachers, there are no geography teachers in kindergartens. Kindergarten teachers who participated in this study had not completed a postgraduate program in geography. Kindergartners participated in activities that were based on the same curriculum and had been selected and organized by kindergarten teachers with similar studies. The sample is small, refers to children in the same area, and to a similar school reality—including similar school curriculum and teachers with no geographic education. However, despite its small size, the sample is representative of the school reality in terms of spatial abilities.

4.2 Limitations of this study

The small size of the sample does not allow generalizations for all the children in Greece; however, it is representative of the limitations that exist in the improvement of children's spatial abilities in the kindergarten.

5. ANALYSIS

The performance of the population was investigated in terms of their gender (male, female). It was observed that boys performed better than girls (mean=17.8 as compared to mean=16.9; max. score=60); however, no statistical difference was observed between boys and girls for the total performance ($z=-0.654$, $p=0.513$). Subsequently, the pupils' performance was investigated in terms of their class (pronipia vs nipia). The nipia showed statistically significant better performance (mean 20.1) as compared to the pronipia (mean=13.8; $z=-4.054$, $p<0.001$).

Total scores of boys and girls and the pronipia and nipia with the mean and max score are presented in Table 1.

Table 1. Total score in all groups (boys and girls, and pronipia and nipia) with mean and max score

	Boys		**Girls**		**Total achieved scores**	
	Mean	Max	Mean	Max	Mean	Max
Pronipia	14.05	24.50	13.59	22.50	13.80	24.50
Nipia	20.86	33.50	19.50	35.50	20.10	35.50

Source: Author's elaboration

All kindergarten pupils showed significantly low performance. For all, girls and boys in the nipia and the pronipia group, the mean scores were less than one third of the maximum score.Only the mean scores boys of nipia group boys and the mean of nipia group were just over one third of the maximum score.

It can be seen that the best performance of a pupil had a score of 35.5, slightly more than half of the maximum desired score (60). This best score (35.5) was achieved by a girl, while the maximum score among boys was 33.5; these are scores of the older pupils (nipia). Within the group of younger children, the maximum score was less than half of the maximum desired score (60) in both genders.

The performance of each categorized and grouped question was evaluated in each class (pronipia, nipia), and the results are presented in Table 2.

Table 2. Mean scores in each class (note: Significance level: ** p<0.01)

Questions	**Pronipia**	**Nipia**	**Max score (if all the questions were answered correctly)**
Which of these maps represent the same place? (1 question)	.225	.340	1
Draw the path from one colored spot (blue, red, yellow) to another. Three routes to be drawn.	.613	1.89	3
Where did the photographer stand when s/he took the photo?	1.125	1.440	3
If you invite us to your house and the starting point is the school, which route should we follow?	1.775	1.880	3
Map recognition	2.138	3.1	8
Map usefulness	.35	.48	3
Title of the map	.1	.24	3
Map symbols	1.5	2.88	10
Elements of a map	.10	0.00	4
Problem-solving (grouped question; for example, if you are in the red spot and you want to go somewhere nearby, to the nearest place to fish, which of the colored spots will you go to?)	1.488	1.78	5
Knowledge of the map (grouped question; for example, show me the way to go from the brown spot to the yellow one).	1.313	2.23	6
Map scale	1.55	2.08	3
Legend (Questions about why and how to use the legend).	.35	.44	4
Orientation (Four questions to choose the map with the right orientation and to justify the choice).	1.175	1.32	4
Total	**13.8**	**20.1**	**60**

Source: Author's elaboration

In Table 2, it can be observed that the best performance is in the map recognition task with a mean performance of 2.138 and 3.1, respectively, while the worst is in the map details task (on Lesvos Island map), with a mean performance of 0.1 and 0.0, respectively.

The performance of each categorized question was evaluated in two genders (boys and girls), and the results with total scores are presented in Table 3.

Table 3. Mean scores of two genders and total scores (note: Significance level: ** $p<0.01$)

	Boys	**Girls**	**Total**	**Max (if all the questions were answered correctly)**
Which of these maps represent the same place?	.30	.28	.289	1
Draw the path from one colored spot (blue, red, yellow, and red) to another.	1.175	1.44	1.322	3
Where did the photographer stand when s/he took the photo?	1.325	1.28	1.3	3
If you invite us to your house and start from school, which route should we follow?	1.65	1.98	1.833	3
Map recognition	2.638	2.7	2.672	8
Map usefulness	.25	.56	.422	3
Title of the map	.3	.08	.1778	3
Map symbols	2.975	1.7	2.267	10
Basic elements of a map	.05	.04	.044	4
Problem-solving	1.737	1.58	1.65	5
Knowledge of the map	1.825	1.82	1.82	6
Map scale	1.8	1.88	1.84	3
Legend	.525	.3	.4	4
Orientation	1.25	1.26	1.256	4
Total	**17.8**	**16.9**	**17.3**	**60**

Source: Author's elaboration

In Table 3, it can be observed that the three best performances by boys are in identifying map symbols (2.975), map recognition (2.638), and knowledge of the map (1.825); additionally, the three best performances by girls are in map recognition (2.7), drawing the route from school to their house (1.833), and map scale (1.88). In contrast, the worst performance can be observed regarding identifying the basic elements of a map by boys (0.05) and girls (0.04).

Boys performed better considering their mean scores of some questions; however, by using the Mann-Whitney test, statistically significant difference was observed only in the question of the map legend ($p=0.002<0.05$) between the two genders (females, males). These results are presented in Table 4.

Table 4. Statistically significant differences between boys and girls (note: Significance level: ** p<0.01)

Categorized questions	**Z**	**Asymp. Sig. (2-tailed)**
Legend	-3.044	0,002**
Which of these maps represent the same place?	-.905	.365
Draw the path from one colored spot (blue, yellow, and red) to another.	-1.012	.312
Where did the photographer stand when he took the photo?	-.062	.951
If you invite us to your house and start from school, which route should we follow?	-1.940	.052
Map recognition	-.595	.552
Map usefulness	-.496	.620
Title of the map	-1.871	.061
Map symbols	-1.731	.083
Elements of a map	.000	1.000
Problem solving	-.415	.678
Knowledge of the map	-.238	.812
Map scale	-.377	.706
Orientation	-.727	.467
Total	**-.684**	**.494**

Source: Author's elaboration

The performance of each question was assessed between the two classes (pronipia–nipia) using the Mann-Whitney test. The results are shown in Table 5.

Table 5. Statistically significant differences between the two classes (* indicates the statistically significant difference) (note: Significance level: *p<0.05, ** p<0.01, ***p<0.001).

Categorized questions	**z**	**Asymp. Sig. (2-tailed)**
Which of these maps represent the same place?	-1.189	.234
Draw the path from one colored spot (blue, red, yellow, and red) to another.	-4.453	.000***
Where did the photographer stand when he took the photo?	-.983	.325
If you invite me to your house and start from school, which route should we follow?	-.942	.346
Map recognition	-2.773	.006**
Map usefulness	-.536	.592
Title of the map	-1.318	.187
Map symbols	-2.668	.008**
Elements of a map	-1.590	.112
Problem solving	-.749	.454
Knowledge of the map	-3.208	.001**
Map scale	-2.617	.009**
Legend	-.549	.583
Orientation	-.809	.418
Total	-4.054	.000***

Source: Author's elaboration

It can be observed that there is statistically significant difference only regarding the total performance (p=0.000), "Draw the path from one colored spot (blue, yellow, and red) to another" task (p=0.000), map knowledge (p=0.001), map recognition (p=0.006), map symbols (p=0.008), and map legend (p=0.009).

The best performance was observed in tasks where the students had to draw the following:

- Draw the path from one colored spot to another colored spot (from blue to yellow or red): nipia (1.89), pronipia (1.11), boys (1.65), girls (1.98) (maximum desired score (3) achieved by a boy;
- Map scale (prefer large-scale maps to see details or not): boys (1.8), girls (1.88) (3 max);

- Draw the route to your home: nipia (1.88), pronipia (1.775), boys (1.175), girls (1.11) (max 3);
- Total: nipia (20.1) (max 35.5), pronipia (13. 8) (max 24.5). Total Max score: 60.

The worst performance was observed regarding identifying the elements of the map. It was also found that there were statistically significant differences between the pupils of the two different classes, with nipia performing better than pronipia, while a statistically significant difference between boys and girls was found only regarding the questions about the legend of the map.

6. CONCLUSIONS

The geographic knowledge that the pupils had acquired and the development of their spatial skills at the end of the school year in kindergarten were low regardless of the expectations of the Greek kindergarten curriculum.

Despite the fact that the acquisition of spatial abilities is mentioned in the curriculum, neither specific instructions of how to teach these concepts, nor appropriate teaching material, proper teacher training, or targeted spatial abilities activities are specified in the curriculum. Additionally, this issue is not restricted to only the Greek kindergarten curriculum; spatial ability is usually described as "neglected" in kindergarten curriculum worldwide (Webb, et al., 2007; Kell & Lubinski,2013). This study found that neither boys nor girls, and neither pronipia nor nipia managed to achieve more than 2/3 of the desired maximum score—in most answers, the result was much lower than half of the maximum score.

At the end of the school year, the participants' performance was not satisfactory, a result that is in line with other studies (Özdemir & Güven, 2014; Klonari, 2012). These studies have stated that there is a need of designing appropriate teaching interventions for effective learning outcomes. It is conspicuous that children with no appropriate teaching interventions have limited mapping abilities and that these skills need to be taught (Kastens et al, 2010).

Elder children perform better in total scores and in tasks and questions such as: "Draw the path from one colored spot (blue, yellow, and red) to another," map recognition, map symbols, map knowledge, map legend, and tasks that need knowledge and understanding of maps. It has been observed that 6-year-old children are more capable in mapping tasks than younger children, and spatial performance is improved when the children are approximately 4–5 years old (Vasilyeva & Lourenco, 2012); the spatial performance of children improves as they grow older (Sigurjónsson et al., 2020).

In this study, boys showed a better performance (mean=17.8) as compared to girls (mean=16.9). However, it was observed that there was no statistical difference between boys and girls regarding the total performance (Kotsopoulos et al., 2019; Rutherford et al., 2018). Boys performed better in identifying map symbols, whereas there was a statistically significant difference between boys and girls only in the grouped question of the map legend. Map legend and map symbols are about representations and demand strong visuospatial working memory (VSWM)—boys performed better in this regard (Coluccia & Louse, 2004). The worst performance by both boys and girls was observed in identifying the elements of a map.

The kindergartners in this study showed relatively higher results in route planning, recognizing where a photo was taken (bird view), plotting the route from home to school, and asking questions about scale. They faced great difficulties in recognizing villages, rivers, or roads on the map (map symbols), the title, and how to use the legend. They also found it difficult to solve problems that would require them to use spatial abilities, such as finding the nearest sea point or thinking about a fishing spot. They did not understand why and for what purpose they should use the map, and their ability to orient themselves was poor. It was observed that both boys and girls performed the worst in identifying the elements of a map.

This study's results have shown that there is significant room for improvement in the learning process of kindergarten students to enable them to develop their spatial abilities. It is noticeable that neither boys nor girls, and neither pronipia nor nipia managed to achieve more than 2/3 of the desired maximum score—in most answers, the achievement was far lower than half of the maximum score. As was expected (Kavouras et al., 2016), in this study, elder pupils performed better, with the total mean score being 35.5 for the older pupils and 24.5 for younger pupils (the maximum score was 60 in this instance).

Therefore, this study concludes that kindergarten pupils' spatial abilities are not the best they could be, and they are not as developed as the curriculum hopes them to be. Although the small sample of this study does not allow generalizations, it points to a necessity of future research that focuses on developing and evaluating specific teaching interventions and teaching material that improve kindergartners' spatial abilities.

This study shows that teaching interventions that aim at fostering kindergartners' spatial abilities need to focus on activities that: 1) promote map orientation skills, 2) engage pupils to solve spatial problems, and 3) teach them to use a map effectively.

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Appendix

The questionnaire

To create the questionnaire, the researchers relied on the instructions of the Greek Kindergarten Curriculum and the spatial abilities that the pupils must possess to use a map effectively.

- The questionnaire comprised three parts:
- **First part** – Demographic data: seven questions investigating the pupils' personal data.

— **Second part** - questions to be completed with the researcher's or kindergarten teacher's help who wrote the pupils' answers.

- Map recognition: focuses on the children recognizing the map of Lesvos and Mytilene (8 questions/8 points) (as the curriculum mentions that pupils should learn about their neighborhood, their city, and their villages using maps) (e.g., what does this picture show? - the map of Lesvos island; have you ever seen this picture? -the map of Lesvos island; the map of the island is presented to the kindergarteners when the liberation of the island is celebrated [i.e., on 8 November]);
- Map usefulness: questions about the map's usefulness and help provided by a map (3 questions/3 points), (as the curriculum mentions that pupils should learn what a map is and why it is used) (e.g., have you seen anyone using it? If so, how did s/he use it and why? How did it help him/her?)
- Map title: focuses on the children recognizing the title of the map and their looking for it (3 questions/3 points) (e.g., if a foreigner sees this map, how will s/he know which island it is? What does s/he have to look for on the map to find which place it is?);

- Map symbols: questions about map symbols (5 questions/10 points) (e.g., in the next picture, what do you think the red and orange lines are? Roads. What are the blue lines? Rivers. Show the sea on the map; the same task is mentioned in the curriculum);
- Map legend: focuses on the children describing the usefulness, the name and the need that it satisfies (4 questions/4 points) (e.g., In the picture below, you see the map of Lesvos and next to it, a rectangle with various symbols. Do you know what it is called? Legend. What is it useful for?).
- Orientation: focuses on the children recognizing the correct orientation of the map, and how to correct it (mental rotation) (4 questions/4 points) (e.g., The four images on the map do not "see" at the same point. What should I watch out for to make sure the map "looks" right? In which image does the map "look" correct?);
- Elements of a Map: focus on the children observing missing map elements (e.g., title, legend, or symbol of orientation) (2 questions/4 points). (Map title, Map symbols, Map legend, Orientation, Elements of a Map. The curriculum suggests that children in kindergarten should learn about maps, how to use them, and how to map symbols, and how to use geographical terms. In order for children to become able to use a map, they need to know where the name of the city/neighborhood is, where to find the meaning of the symbols, and how to realize that a map is not an image, but a means of conveying messages as claimed by the curriculum);
- Map scale: focuses on the children observing and subsequently selecting a map from different scale maps; after that, they are asked to explain their choice (3 questions/3 points). The curriculum mentions that pupils should learn how places seem on different scales;
- Bird view (viewing angle): Where did the photographer stand when s/he took the photo? (3 questions/3 points);
- Problem-solving: focuses on the children solving spatial problems (e.g., if you are in the red spot and you want to go to the nearest spot to go fishing, which colored spot will you go to? why did you choose this place? if you are in the black spot and you want to travel by boat, which point will you go to? why did you choose this point? ;) (5 questions with 5 sub questions/5 points) (the curriculum mentions that pupils should learn about their city, compare differences between places, use maps, describe the position of a place in a wider area. The underlying suggestion in the curriculum is that teaching interventions should give pupils opportunities to use their knowledge, practice their skills, learn through reasoning, develop critical thinking, and conduct problem-solving).

— **Third part** – focuses on the pupils drawing or sketching the answers themselves. The curriculum suggests that children should be given opportunities to develop and express ideas in many ways, such as play, writing, and painting. Pupils should be able to recognize and point landmarks, follow a path with their finger and locate the place where they live, indicate a route or draw it.

- Knowledge of the map: focuses on the children drawing, painting, or joining points on the map (6 questions/6 points), (e.g., show me the way to go from the brown spot to the yellow spot. Join in a line three parts that are by the sea. Why did you prefer these places?);
- Place identification: Which of these four maps represent the same place? (1 questions/1 points);
- Knowledge of the map, place identification, and their connection to curriculum presented above.

- Draw the path: focuses on children drawing the path from one colored spot (blue, yellow, and red) to the next (3 routes/3 points). (The task “to follow a path” is suggested in the curriculum in the unit “read simple symbols, blueprints and maps”);
- Creation of a simple map: focuses on the pupils drawing the road from school to their house without forgetting landmarks (1–3 points: only a line has been painted (0 point), a road and the school or house have been painted (1 point), the house, the school, and the road have been painted (2 points), and the home, school, road, and landmarks that will help people orient themselves and not take the wrong road (3 points)). (Creating a simple map, demonstrating their knowledge of maps, symbols, and their neighborhood. The curriculum suggests that they should present their ideas in many ways; for example, —by painting and/or making a neighborhood model).

The questions were categorized and scored. The maximum score (with all the answers correctly completed) was 60 points.