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SPATIAL AND GEOSPATIAL THINKING OF SECONDARY EDUCATION STUDENTS IN GREECE

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Abstract
Internationally, curriculums emphasize the importance of spatial abilities development in school, and it has proven that teaching geography can help improve spatial thinking. The main goal of this study was to investigate spatial thinking of Secondary Education students. The research sample was 474 Junior High school students (246 students from the 7th grade and 248 students from the 8th grade), aged 13-14 years, coming from 49 different public schools all over Greece. A questionnaire was distributed to students that included questions based on the categories of spatial thinking of Gersmehl and Gersmehl (2011). The findings of the research have identified a weakness in the students' spatial perception, with satisfactory performances only in the floor plans. There is no statistical difference between boys and girls, but the total score in most questions was low.

1. Introduction

Geography involves the study of human activities and their interrelationships and interactions with environments at a local and global scale. It bridges natural and social sciences, and thus deals with spatial variability (Yli-Panula *et al.*, 2020). Spatial thinking is an important branch of geography, so one of the goals of learning geography is to provide students with spatial thinking skills (Putri, 2020). Spatial ability is the basis of cognitive mapping; it is important in the process of perception, encoding, conversion, and extraction of map information (Dong *et al.*, 2018). Goodchild (2006), argues that spatial thinking is one of the fundamental categories of intelligence required for modern society to function. New methods of studying the brain suggest that spatial thinking is not one simple kind of "intelligence"; instead, it appears to be a complex of parallel processes involving several specialized structures in different parts of the human brain (Dong *et al.*, 2018). Spatial ability is composed of several distinct but interrelated factors.

Fostering students' spatial thinking skills holds great promise for improving Science, Technology, Engineering, and Mathematics (STEM) education (Gagnier *et al.*, 2022). It is possible to develop spatial thinking, thus spatial thinking can and should be offered in the educational system at all levels (Dewi *et al.*, 2021). This is a basic and essential skill that development should be the goal in every field of education. Representation tools - such as: maps, graphs, sketches, diagrams, images, and models - allow and support spatial thinking (Metoyer and Bednarz,

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2017; Passadelli *et al.*, 2021). Using digital maps, 3D representations of the spatial image of a location are some ways to help students to improve their spatial ability (Koc and Topu, 2022). Avila-Garzon *et al.* (2021) have revealed that teachers' lack of knowledge of geospatial technologies makes it difficult to improve students' spatial ability. Therefore, if teachers apply appropriate methods and teaching materials, students will be able to develop their spatial skills (Passadelli *et al.*, 2020).

Internationally, spatial thinking has received some attention, but most studies have usually related it to spatial cognition and spatial knowledge. Recent efforts have focused on the development of classroom interventions to build students' spatial skills (Gagnier *et al.*, 2022). Overall, there is a lack of systematic research on spatial thinking in geography education (Lee *et al.*, 2018), and there are few studies about students' performances in spatial ability. Because spatial thinking has many categories, if it is researched in which categories students face more and less difficulties, it will be easier for teachers to find and use appropriate innovative material and activities to improve students' spatial thinking. Thus, it is an area that needs further investigation. Now, in Greece although the Secondary Education Curriculum includes the development of spatial skills, in pilot research in 2019 we found that most students face problems with spatial thinking and, especially, students with dyslexia (Klonari and Passadelli, 2019). So, this research aimed to investigate spatial abilities of a larger sample of students to draw more accurate conclusions that will help a wider educational community to better handle students' spatial weaknesses.

2. Methodology

2.1. Participants

The collection of questionnaires was based on random sampling in which we had a random sample rather than a convenience sample [36]. We used stratified random sampling. Out of 1677 junior high schools in Greece (2019), according to the official ministry records, we created 13 groups based on each school's region. A random selection of 10% of the schools of each region using the official registry records resulted in a total of 170 schools (Figure 1) across 32 prefectures of Greece. In that way, we secured that there would be geographical spread among the responses.

The students who participated in the research attended public Junior High schools of the country during the school year 2017-2018. A total of 474 students aged 13-14 (Mean = 13.52 Std. deviation = 0.50) came from 49 schools distributed throughout Greece. Of the total participants, 284 (59.9%) were boys and 190 (40.1%) were girls. All the students, who participated in the research, were studying in 7th grade (246 students, 51.9%) and 8th grade of high school (228 students, 48.1%), since in Greece Geography is taught in secondary education only in these grades.

Subsequently, the students' answers about their familiarity with computers were categorized. It was observed that most students stated high familiarity with computers (82.8%). It is worth noting that only six students stated that are little familiar with computers. In addition to students' preference for the subject of Geography, 78.6% of the students stated that they like Geography, whereas only 14 students stated that they like it little.

Figure-1. A map with schools that participated in research

2.2. Research Tools

That survey used one two-part questionnaire which was given to students. This questionnaire was based on Gersmehl and Gersmehl (2007) research, according to which spatial thinking is divided into 7 categories. A questionnaire consisting of 14 questions of these categories (2 questions for each category) was created, and most of the questions were open. More specifically, the questionnaire consisted of two parts:

- The first part referred to the students' demographics as well as to their familiarity with the use of the computer and their liking in the subject of Geography
- The second part consisted of 7 categories of questions, and each category contained 2 questions aiming to explore the students' spatial thinking. These categories are:

➢ Location (the first question consisted of four sub-questions, one of which was closed-ended);
➢ Spatial influence (Aura) (two open-ended questions);
➢ Spatial groups (Region) (two open-ended questions);
➢ Spatial hierarchy (two open-ended questions);
➢ Spatial analogies (two open-ended questions); Spatial patterns (two matching exercises); and
➢ Spatial associations (correlations) (two open-ended questions).

2.3. Procedure

After the research tools were made, the proposal was submitted to the Research Department of the University of the Aegean so that we would be permitted to carry out that kind of research at schools. The approval for carrying out our research was made on 17-01-2018 and concerned the academic year 2017-2018. So, in February 2018, we started the telephone communication with the school principals. Then, the first problem of the research appeared, since many of them did not accept their schools to participate in the research despite we had a research permit. Of 170 schools we approached, only 49 participated in the present research. Those principals who agreed to participate in that research were informed about the progress of the research (as it was advancing), and, eventually, informed the teachers of the subject of Geography. There were two different documents that were sent to schools whose principals had agreed to participate in that research: (1) Anonymous questionnaires printed in color only for students; and (2) statements for parents to approve or disapprove of their children's participation in the research. At this point, we should emphasize that in order for a student to participate in the research, there had to be parental consent in addition to the consent of the principal and the teachers. And that was one of the reasons why some students refused to participate in the research.

The anonymous questionnaires had to be answered on the school premises individually and without the help of the teacher. The duration required for its completion was about 30-40 minutes. After collecting all the questionnaires, the teacher forwarded them back to the researchers. The completion of the sample collection took place at the end of June 2018. Schools did not have any financial burden on printing and resending the questionnaires, since a prepaid envelope had been sent so that completed questionnaires could be returned to the researchers.

3. Data Analysis

3.1. Results

3.1.1. Descriptive Statistics

This section describes in detail the findings of the research, which came out with the aid of the statistical program SPSS 23. The questions whose asymmetry coefficient is in the range -1 to 1 have a normal distribution, whereas the other questions have no normal distribution (Table 1). An additional check was performed with histograms and Q-Q charts for all questions and groups questions. The findings of the present study are presented in the following subchapters using parametric controls for variables with normal distribution and non-parametric controls for non-normal allocation of variables.

Table-1. The distribution of the questions

Question	**Non-normal Distribution**
Q1: Notice the image on the next page and answer in a few words the following questions	Q8: Work as in the previous exercise. Observe the Amazon system (rivers tributaries), their relationship and size and formed two groups moving forward from smallest to largest
Q2: When we talk about North on a map, we mean that we are "moving" towards the North Pole of the earth. This is the address of most maps. If the address is different find out where the North is and note Greece in the following maps	Q11: Match the photos with a corresponding top view
Q3: How does this area affect the people's lives living around it in various fields?	Q12: Match the images of the first column with those of the second one
Q4: This house is in a northern country of Europe. How does the climate in this area affect the architecture of these houses?	Q13: Observe and relate the maps below. Then, explain the criteria by which Europe has been divided into three regions
Q5: A. What do the islands, such as: Corsica, Sardinia, Sicily, Crete, Cyprus, Balearic Islands, Malta have in common? B. Locate them and show them on the map	
Q6: Given the points on the horizon, observe the map and explain how religions are classified in it	

Q7: Select the areas in which Greece is included, to rank them from the smallest to the largest. Think about a larger region which Greece belongs to, which, in turn, belongs to another even greater etc.	
Q9: In the geophysical map below, note what the circled cities have in common	
Q10: The picture below shows the areas that have vines and olives. Explain what these areas have in common so to have the same vegetation	
Q14: The picture below shows the areas that have vines and olives. Explain what these areas have in common so to have the same vegetation	

Each question was rated by 3 points, so the maximum score that each student could have was 42 (3*14=42). Figure 2 below presents the means of the questions after being grouped into categories according to the kind of question. So, each category graded by six points, because it included 2 questions. After a brief overview and, according to the coefficient of asymmetry, it seems that in all groups of questions we have normal distribution apart from spatial patterns.

Figure-2. Means of the student's answers in categories of spatial thinking

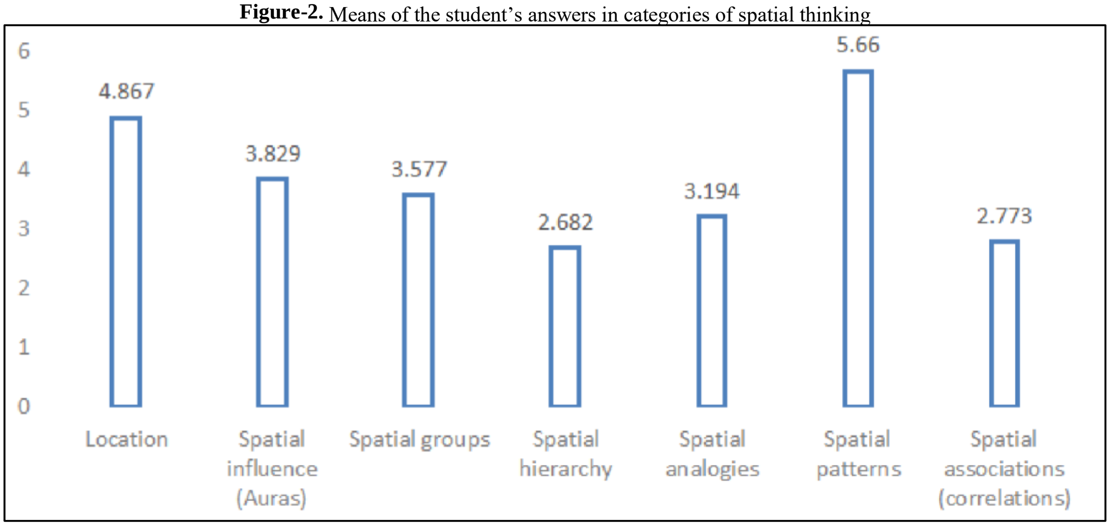
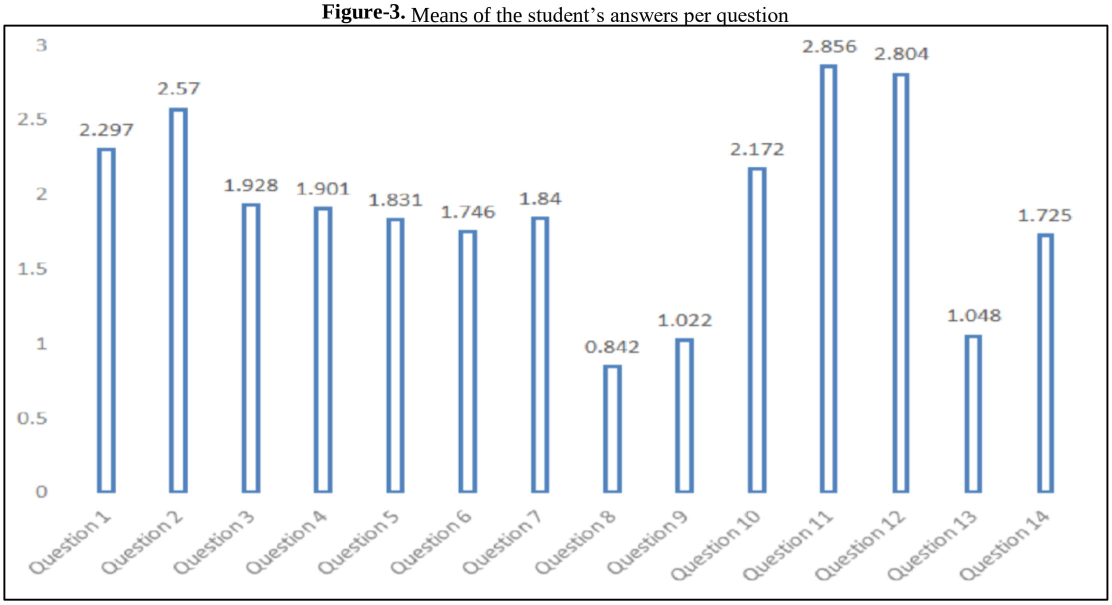


Figure 3 below shows the means of the students' answers per question. After a short review, we observed that students had very low score in many questions and the percentages of correct answers were very small.

Figure-3. Means of the student's answers per question



3.2. Inferential Statistics First, the comparisons of the students' average performance of demographic variables of the research are described, and the correlation between the dimensions of the variables is presented. For the control of the differences of the averages of the basic variables about the independent variables of the research, both parametric (for the variables that had a normal distribution) and non-parametric criteria (for the variables that did not have a normal distribution) were used. More specifically, the t-test parameter tests for independent variables and one-way ANOVA were used. The Mann-Whitney statistical criterion was used for the irregular distributions. In Table 2 it is observed that many variables are significant.

Table-2. The significance of variables

Variable	p	df
Student's familiarity with computers	0.43	6
Student's liking of geography	0.008**	233
Father's educational level	0.003**	233
Mother's educational level	0.000***	6
Area of residence	0.04*	233
Sex	0.13	214

4. Discussion

Because of the development of the mass media and the immediate information of the individual about what is happening in the world, the demand for geographical information has increased and geography is now a part of our daily lives; that means that Geography is not just about scientists (geologists, geographers, cartographers, etc.), but it also concerns every citizen who must have a fundamental level of geographical knowledge. That is why it is now necessary to teach Geography in such a way that is a tool and not an encyclopedic education. To do this, however, we, first, should detect and cover the geographical deficits that students of all levels of education have, and, second, we should give equal opportunities to all regardless of learning abilities.

In this study, we have made an initial attempt to identify spatial deficits and geospatial thinking focusing on the development of geographical education and spatial skills to junior high school students. The findings of the present study fully agree with a previous study by the same researchers with a small sample of participants (50 students) (Klonari and Passadelli, 2019b).

The highest performance was noted in the questions of spatial patterns (Question 11 and 12). The "perception of spatial patterns" is the ability of the individual to discern a drawing representing in horizontal structure a threedimensional body. The percentage of the students' answers was 88.2% and was the highest of all questions. Therefore, the results of the research are in line with the literature on the students' good performance in 3D representations (Eide and Eide, 2011). In the category of the position the students' performance were quite good, since 60.7% of students had correct answers. However, the students had very low performance in spatial hierarchies (Questions 7 and 8) and spatial associations (Questions 13 and 14) where the students' means were under the half points. Moreover, the students' performance in spatial influences (Auras), spatial groups and spatial analogies were not good either. Many researchers claim that students, due to incomplete spatial coding, may experience problems of distance and space, have difficulty with navigating, find it difficult to distinguish mainly between the right and the left (Klonari and Passadelli, 2019b; Orton, 1925;1937; Pollok and Waller, 1994; Thomson, 1996; Vernon, 1971). According to McGill-Franzen and Allington (2010), the right design and the appropriate implementation of the necessary teaching methodology in conjunction with the scientific competence of teachers may be the starting point of the solution to this serious problem. Spatial orientation ability and spatial visualization ability are two primary abilities that are widely included in the definition of spatial ability (Dong *et al.*, 2018).

At this point, we must mention that, making the correlation between the degree Preference of the subject of Geography and the students' performance of the student, it is clear that in all categories of exercises the correlations were statistically proven important. This means that the more the students like the subject of Geography, the higher is the average of performance gathered in the questions. So, the goal should be to make the subject of Geography more enjoyable and interesting. Nevertheless, the question is whether this goal can be achieved within two teaching hours in the weekly programme for teaching Geography.

Recommendations

Considering the findings of this research, which converge with the conclusions of the international literature, and aiming to improve the quality of teaching geography, we are recommending:

1. There should be further exploration of the knowledge of all kinds of students (students with learning disabilities are included) in other areas of Geography, such as: Human Geography and Physical Geography, to identify misunderstandings and lack of prior knowledge;
2. There should be further exploration of lack of geographical knowledge in groups of students with other types of learning disabilities (e.g., students with Asperger syndrome or ADHD) as well as investigation of their participation in and attitude towards the subject of Geography.
3. Similar educational studies in Primary Education should be carried out in the future, with a sample of students' mixed learning profiles, in order for the students' level of cognitive knowledge in Geography can be ascertained, with which the students will move on to the next level of education.

To sum up, in order for the quality of teaching the subject of Geography to be improved, it is crucial that the subject of Geography that is offered should be evaluated properly by both the state and the teachers. It is also crucial, as part of upgrading teaching Geography, that solutions that will help all kinds of students, including those with learning disabilities.

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