THE SPATIAL ABILITY OF SCHOOL STUDENTS WITH LEARNING DISABILITIES IN SAUDI ARABIA

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ABSTRACT*: This study aimed at investigating the development of the spatial ability of students with learning disabilities in Asir region and its relation to some variables. The study also aimed at identifying the statistical differences in performing the spatial ability test due to students' grades, the type of learning disability, and gender. The necessary data of this study were gathered from the Vandenberg's (1975) computerized version of spatial ability test. The sample of the study included 320 students with learning disabilities who study in the schools of the Department of Education, Asir Region. The findings of the present study revealed that there were no statistically significant differences in performing the spatial test ability attributed to grade. However, the findings showed statistically significant differences in performing the spatial ability test attributed to the type of learning difficulty and gender. In light of the findings of this study, the researcher recommends paying much attention to learning disabilities in terms of providing trained personnel, training programs, and the appropriate diagnostic tools to obtain the greatest benefit and improve the abilities of students with learning disabilities.*

Keywords: Learning disabilities, spatial ability, mental rotation, Asir region, Saudi Arabia.

INTRODUCTION

Spatial ability is considered one of the many cognitive skills that play a vital role in educational success and professional construction. Spatial ability involves understanding, creating, transforming, manipulating, and recalling visual images and mental models [1]. Several studies have concluded that spatial skills are strongly related to mathematics performance and solving mathematics problems [2]. The previous studies have revealed a significant correlation between spatial ability and achievement in science and physics [3]. There is great importance between spatial abilities and other cognitive abilities such as logical thinking [4]. In addition, psychologists had been vigilant of the importance of visualization; and how they tried to develop various tools and frames to test individuals [5]. Spatial ability has received much attention from researchers as it forms the major problem for educators and teachers a long time ago. This attention is attributed to the effective role of spatial ability in our daily life such as doing sport, using maps, and putting our things in order [6]. Spatial ability is felt strongly in our daily activities as it determines people's achievement and interprets the occurrence of their failures [7].

Problem Statement

As mentioned earlier, spatial ability plays an important role in many fields such as Arts, Engineering, and Mathematics. Students with learning disabilities are considered a heterogeneous class in terms of intelligence or achievement at the level of class subjects. Some of those students are intelligent and some are more intelligent than others. This implies that students with learning disabilities have mental abilities that could help them learn what their peers are learning, especially in the teaching methods used in their education [8]. The disability of perceiving spatial relations is one manifestation of the learning difficulties [9]. These difficulties include the disability of recognizing spatial relationships such as up and down, above and below, near and far, and front and back. These are the most faced difficulties among students with learning disabilities. These students may have difficulty in estimating the distance between numbers, the difficulty of writing in a straight line, and the difficulty of recognizing the sequence of numbers. Most of the previous studies have investigated the relationship between spatial ability and students' achievement or mathematical abilities among normal students. Based on the researchers' knowledge, there are very few studies conducted to investigate spatial abilities among students with learning disabilities. In addition, very few studies have been carried out to investigate spatial abilities among students with learning disabilities in the Kingdom of Saudi Arabia. Therefore, this study aims at identifying the spatial ability among students with learning disabilities and its relation to some variables (i.e. grade, type of learning difficulty, and gender).

Research Objectives

This study aims at achieving the following objectives:

1. To identify the level of spatial ability of students with learning disabilities in Asir region.
2. To investigate the differences between the spatial ability of students and some variables (i.e. grade, type of learning difficulty, and gender).

Research Questions

The present study seeks to give answers to the following research questions:

1. What is the level of spatial ability of students with learning disabilities in Asir region?
2. Are there statistically significant differences between students' spatial ability and their grade, type of learning difficulty, and gender?

Significance of the Study

The significance of this study stems from the fact that it is one of the very few studies to examine the spatial ability of students with learning disabilities in Saudi Arabia. The results obtained from this study would be useful for stakeholders by providing them with a theoretical background of the differences between students' demographic information and spatial ability. The findings would also provide teachers, students, and curriculum designers with the most effective instrument in measuring the spatial ability of students with learning disabilities. Providing teachers with an effective instrument of measuring spatial ability will help students to exercise their spatial skills and develop them.

Delimitations of the Study

The generalization of findings is highly related to the size of the study sample. The present study is limited to students with learning difficulties. The selected student's age ranges from (8-11) years and no other ages have been selected. The sample of this study is limited to students, who enrolled in the rooms of learning difficulties of schools that belong to the Department of Education in Assir Region. The data was collected using Vandenberg's (1975) test for measuring spatial ability, and no other instruments have been used to collect the necessary data.

Definition of Operational Terms

The present study included many terms, which can be defined as follows:

Spatial ability: The ability to recognize spatial and spatial relations between objects. The spatial ability was measured by the degree to which the student was able to respond to Vandenberg's (1975) computerized version of spatial ability, which has a total score of 43 points.

Mental rotation ability: a part of the spatial ability that requires a mental rotation of the three-dimensional stimuli. The student is required to rotate the objects in order to match them with the original form.

Students with learning disabilities: those who have disorders in one or more of the basic psychological processes, which include an understanding of written or spoken language and their use.

LITERATURE REVIEW

This section provides some literature concerning the topic of the present study. The literature includes the definition of spatial ability, the definition of spatial visualization and spatial orientation, spatial ability and its importance to education, and some previous studies regarding spatial ability.

Definitions of Spatial Ability

The prior studies on spatial ability revealed no rigorous definition of the concept. Thus, many researchers have defined spatial ability in different ways. Spatial ability is creating a mental image of objects and manipulate them. This ability is considered as spatial visualization [10]. Other definition stated that spatial ability as mental skills which involve understanding, manipulating, and interpreting relationships visually [11]. Moreover, the spatial ability was also defined as the ability to construct mental images and manipulate those images in the mind [12]. Some scholars defined it as the cognitive abilities that allow people to deal with spatial relationships [13]; while others defined as the mental manipulation of objects in two and three-dimensional spaces [14].

Definition of Spatial Visualization and Spatial Orientation

The definition of spatial ability also involves the definition of its ability sub-skills. Researchers have divided the spatial abilities into different sub-skills, such as, spatial thinking, which includes the creation of mental images and the manipulation of those images. Mental images are mental representations of mathematical concepts or property containing information based on diagrammatic or graphical components [15]. Other scholars divided spatial ability into two visual abilities: visual processing of the information, which involves the manipulation of visual imagery and the transformation of a visual image to another. The second ability involves the information interpretation of spatial vocabulary used in graphs, diagrams, and charts, which would be useful in getting the information necessary to solve a problem [16]. Another classification provided a more detailed classification of spatial ability. This classification included four processes of visualization and mental images: 1. Getting a mental image from the obtained information, 2. Inspecting a mental image to observe its position or the presence of parts or elements, 3. Transforming a mental image by rotating, translating, scaling or decomposing it and lastly, 4. Using a mental image to answer questions. The present study used a specific classification [18], which related to two main aspects of spatial ability, namely spatial orientation, and spatial visualization. Spatial orientation involves the capability of imagining how given objects appear from a spatial perspective different from that in which the objects are shown. On the other hand, spatial visualization implies the mental rotation of the visualized objects such as the rearrangement of object pieces from a whole object.

Spatial Ability and its Importance to Education

As mentioned earlier, the spatial ability is extremely important in teaching and learning, and it is also essential to living in a three-dimensional world. There is a great importance of spatial ability and skills in detecting objects; manipulate quantities, and understanding charts, drawings, and graphics [19]. Spatial ability includes a wide range of thinking processes such as motor, visual, behavioral, and analytical skills. It is also divided into three groups: mental rotation, spatial visualization, and spatial orientation [20]. The educational research concerning spatial ability started in the 1940s. These research works have emphasized the importance of spatial ability and spatial reasoning skills in improving the students' comprehension of Mathematics, and it also leads to improving the curriculum and pedagogy of Mathematics, and determines the students' achievement in Mathematics and other relevant fields [19]. The prior studies conducted on spatial ability have revealed that spatial skills are influenced by certain factors. These studies aimed at determining the role of those factors in spatial skills, and how these factors affect people's ability. Much of the research attempted to investigate the possible gender gap that exists in spatial ability. Some of these research indicate no gender difference in spatial ability [21, 22]. However, the majority of the research revealed male advantage in mental rotation test scores [23, 24, 25]. In addition, research showed that spatial ability is not only influenced by gender, but also by age, which may contribute to the gender difference for some age groups [24].

Previous Studies on Spatial Ability

A number of studies have been conducted to investigate the spatial ability among students, and these studies have come up with different results. In Turkey, a study investigated the spatial ability among middle school students in Istanbul. The sample of the study consisted of 704 middle school students from grades 6, 7, and 8 who were studying in different schools in Istanbul. The researchers used exploratory analysis and validity analysis to analyze the data of the study. Three factors emerged from the findings of the study: spatial imaging, mental rotation, and spatial relations. The results have also revealed that these factors constitute an appropriate model of measuring spatial ability. The 23 items that emerged from the scale show credibility and validity to measure spatial ability among those students [26].

In Spain, another study investigated the use of educational robots to develop the spatial abilities of 12-year-old students. It also aimed at preparing motivational and practical sessions to increase student participation in the actual learning process. For this purpose, a curriculum was designed to introduce sixth-grade students to robots. The teacher taught the students to deal with the problems and work in groups of 3 members. Students were randomly assigned to an experimental group with robot sessions, and a control group, which did not receive such sessions. The spatial abilities of the experimental and control groups were evaluated by a pre-test. The post-test results showed a positive change in the spatial abilities of the participants after the tutorial sessions in robots than the students who did not participate in the sessions, and the improvement was statistically significant [27].

In the US, one study designed questionnaires, spatial tasks, and rotation capabilities and gave them to a group of adults of 41 males aged 57-90, as well as other tests on rotation capabilities (mental rotation test, embedded image test) and visual-spatial working memory tests. The results showed that the new spatial tasks were true and interrelated with working memory and spatial capacity tests, and when compared to the latter, they showed a stronger correlation with self-assessment questionnaires with respect to rotation capabilities. The model was also tested so that it was assumed that new missions were related to spatial capabilities to predict rotation capabilities [28].

Another study conducted to identify gender differences in performing spatial capacity tests and their relationship to experience and attitudes towards achievement. The sample of the study encompassed 183 students who enrolled to Arts, Humanities, Mathematics, and Computer Science disciplines. The research instrument used was the Vandenberg's (1975) test of mental rotation. The results showed that the performance on the mental rotation test was influenced by academic specialization and gender. However, the impact of gender varies. The effect was greater among male students in the arts and humanities. The results showed that there was a statistically significant correlation between performance on the mental rotation test and computer experience for females only [29].

Finally, in Hong Kong, one study examined the gender differences in the spatial ability of gifted Chinese students. The sample of the study was 337 primary and secondary gifted students aged from 7 to 17 years in Hong Kong. The results showed that males outperformed females in the spatial ability test. The results also revealed that high school students outperformed primary school students, which means that spatial ability improves as school and age progress.

RESEARCH METHODOLOGY

This section provides information on the methodology of the present study, which includes population and sample, research instrument, and validity and reliability of the instrument.

Population and Sample

The population of the study consisted of (750) students with learning disabilities in Asir region. The sample consisted of 320 students aged 8-11 years and their percentage was (42.6%) from the overall study population. These students have been randomly chosen from four grades: the third, the fourth, the fifth, and the sixth grades. Table (1) shows the demographic information of the study sample.

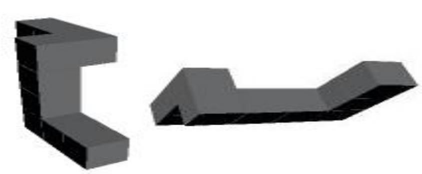
Table 1
Demographic Distribution of the Study Sample

Type of Difficulty	No.	Gender	No.	Grade	No.
Dictation	90	Males	160	Third	130
Written Expression	90			Fourth	80
Reading	65	Females	160	Fifth	60
Spelling	55			Sixth	50
Arithmetic	20				
Total	320	Total	320	Total	320

As shown in the table, the distribution of the sample according to the difficulty type was as follows: 90 students with dictation difficulty, 90 students with writing expression difficulty, 65 students with reading difficulty, 50 students with spelling difficulty, and 20 students with arithmetic difficulty. The gender of the sample was equal (160 male students, and 160 female students. Regarding the students' grade, the distribution was as follows: 130 students in the third grade, 80 students in the fourth grade, 60 students in the fifth grade, and 50 students in the sixth grade.

Research Instrument

The research instrument used in this study was the computerized version of Vandenberg's (1975) test of mental rotation. This test measures the spatial ability of people, and it contains 43 geometric shapes. This instrument is a non-verbal test and it does not need to be adapted to the Saudi environment. Each item of the instrument contains two contiguous shapes, and students will be asked to determine whether they are similar or different, after they mentally rotate the right shape. The following figure is one example of the instrument's items:



Different Same

(The correct answer is "same", meaning that the two shapes are the same)

Figure 1: Example of Vandenberg's test of mental rotation (Source: Vandenberg's test of mental rotation)

Data Collection

The researchers have made the necessary email correspondence in order to get the computerized version of Vandenberg's (1975) mental rotation test. The content of the test has been thoroughly revised to ensure its accuracy. The test has been uploaded to computers of learning disabilities rooms. The researchers provided the necessary instruction to the students in order to clarify things for students. In addition, the students have been informed that their identities will remain anonymous, and the results obtained from this study will be used for research purpose only. Then, the students were required to respond to the test items and they were informed that the duration to complete the test is one hour. After finishing the test, the students' responses have been marked by giving 1 mark for correct answer and 0 for the wrong answer.

Data Analysis

The returned test was recorded and tabulated with the assistance of Statistical Package for Social Sciences (SPSS) for windows 17.0 to identify the correlated relationships of variables concerning spatial abilities among students with learning disabilities. Different statistical methods were used to achieve the main objectives of the present investigation. These methods include descriptive statistics, independent sample T-Test, and analysis of variance (ANOVA). Descriptive statistics, including means, standard deviation, and frequencies, were computed to summarize the students 'responses to spatial abilities; descriptive statistics and frequencies were employed to calculate the demographic data of the students with regard to gender, type of difficulty, and grade. An independent sample T-test is a statistical method employed to demonstrate the variations among the means of two groups of a variable. In the current research, this statistical method was used in order to identify the significant differences between the students 'spatial ability and their gender. An analysis of variance (ANOVA) is a method of statistical analysis used to determine differences among the means of more than two groups of a variable. In the present study, this statistical method was used to determine the relationship between students' spatial ability and grade and type of difficulty.

Validity and Reliability of the Instrument

To ensure the validity of the instrument, the correlation coefficient was calculated. The correlation has been achieved as the test was not a verbal test but 3D geometric shapes. The correlation coefficients are shown in Table (2) below.

Table 2
Correlation Coefficients of the Test Items

Item No.	Correlation Coefficient	Item No.	Correlation Coefficient
1.	**0.637	23.	**0.661
2.	**0.736	24.	**0.633
3.	**0.725	25.	**0.730
4.	**0.648	26.	**0.790
5.	**0.832	27.	**0.825
6.	**0.694	28.	**0.763
7.	**0.816	29.	**0.779
8.	**0.836	30.	**0.852
9.	**0.820	31.	**0.899
10.	**0.747	32.	**0.865
11.	**0.887	33.	**0.798
12.	**0.754	34.	**0.919
13.	**0.814	35.	**0.749
14.	**0.811	36.	**0.573
15.	**0.542	37.	**0.763
16.	**0.887	38.	**0.710
17.	**0.908	39.	**0.795
18.	**0.824	40.	**0.725
19.	**0.899	41.	**0.702
20.	**0.876	42.	**0.875
21.	**0.617	43.	**0.733
22.	**0.705	**Overall**	**0.822

As illustrated in Table (2), the correlation coefficient for all the test items was above 0.40, and the overall correlation coefficient for the test was 0.822, which means that the test was valid to administer in the Saudi environment. To ensure the reliability of the test, the internal consistency was calculated using (Cronbach Alpha) statistical method to verify the consistency of the students' responses. The internal consistency results revealed that the Cronbach Alpha of the responses was (0.96.8), and this value is acceptable to accept the reliability of the test.

FINDINGS AND DISCUSSION

This section provides the findings obtained from the present study. These findings are presented based on the research questions that guide the present research.

The Level of Students' Spatial Ability

This section provides answers to the first research question: *What is the level of spatial ability of students with learning disabilities in Asir region?* In order to answer this question, descriptive statistics including means and standard deviation were employed to identify the level of spatial ability of students with learning disabilities. The findings have been classified and tabulated according to the variables of the present study. Table (3) shows the level of spatial ability of students according to their grades.

Table 3
Descriptive Statistics of Spatial Ability Level of Students According to their Grade

Grade	No. of Students	Mean	Std. Deviation
Third	130	23.68	4.245
Fourth	80	24.10	3.896
Fifth	60	25.17	3.542
Sixth	50	26.40	5.845
Total	320	24.80	4.349

As shown in Table (3), the overall mean of spatial ability reported by students was (M= 24.80). The sixth-grade students came in the first rank regarding spatial ability (M= 26.40), followed by fifth-graders (M= 25.17), fourth graders (M= 24.10), and third graders (M= 23.68). The following table shows the descriptive statistics of the level of spatial ability according to the type of learning difficulty.

Table 4
Descriptive Statistics of Spatial Ability Level of Students According to the Type of Learning Difficulty

Type of Difficulty	No. of Students	Mean	Std. Deviation
Written Expression	90	24.32	4.250
Reading	65	23.99	4.833
Dictation	90	23.78	3.832
Spelling	55	24.00	5.138
Arithmetic	20	24.78	2.920
Total	320	24.80	4.349

As illustrated in Table (4), students with arithmetic difficulty reported the highest level of spatial ability (M= 24.78), followed by written expression difficulty (M= 24.32), spelling difficulty (M= 24.00), reading difficulty (M= 23.99), and dictation difficulty (M= 23.78). The next table illustrates the descriptive statistics of the level of spatial ability according to gender.

Table 5
Descriptive Statistics of Spatial Ability Level of Students According to Their Gender

Gender	No. of Students	Mean	Std. Deviation
Males	160	24.53	3.98
Females	160	23.83	4.67
Total	320	24.80	4.32

As shown in Table (5), male students showed higher spatial ability (M= 24.53) compared to their female student's counterparts (M= 23.83).

Variation in Students' Level of Spatial Ability

This section tends to explore the variations in the students' overall spatial ability according to three variables: grade, type of learning difficulty, and gender. This will be done to give answers to the second research question: *Are there statistically significant differences between students' spatial ability and their grade, type of learning difficulty, and gender?* The researchers used several statistical methods to present the results of data analysis. The statistical methods include the T-test which has been used in order for the researchers to determine the significant differences between the overall students' level of spatial ability and their gender. An analysis of variance (ANOVA) was employed to determine the significant variations of the overall students' level of spatial ability and their grade and type of learning difficulty.

Variation in Students' Overall Spatial Ability According to Grade

Table (6) shows the differences in the students' overall spatial ability according to their grade.

Table 6
ANOVA Test of Students' Overall Spatial Ability According to their Grade

Grade	No. of Students	Mean	Std. Deviation	F -Value	Significance Level
Third	130	23.68	4.245		
Fourth	80	24.10	3.896		
Fifth	60	25.17	3.542	1.680	.171
Sixth	50	26.40	5.845		
Total	320	24.80	4.349		

As revealed in Table (6), the students showed a moderate level of spatial ability across all grades (i.e. third, fourth, fifth, and sixth. The results of the ANOVA test reveal no significant differences between students' overall spatial ability and their grades ($F= 1.680$, $p > .005$). These findings are in accord with other studies [26] and [30], which found that spatial ability evolves as school years progress. In this study, fifth grade students showed a higher level of spatial ability than sixth-grade students. The possible explanation for this finding is that the education system in the learning difficulties rooms in the Asir region provides suitable programs for people with learning disabilities. Table (7) illustrates the differences in the students' overall spatial ability according to the type of learning difficulty.

Table 7
ANOVA Test of Students' Overall Spatial Ability According to their type of learning difficulty

Type of Difficulty	No. of Students	Mean	Std. Deviation	F -Value	Significance Level
Written Expression	90	24.32	4.250	.471	.757
Reading	65	23.99	4.833		
Dictation	90	23.78	3.832		
Spelling	55	24.00	5.138		
Arithmetic	20	24.78	2.920		
Total	320	24.80	4.349		

The above table showed no significant differences between students' overall spatial ability and the type of learning difficulty (F= .471, p > .005). These findings are consistent with other studies [29] and [30], which found that spatial ability does not differ due to the type of learning difficulty. This result might be attributed to the consistent academic level of students as they are all students with learning disabilities. The following table shows the differences in the students' overall spatial ability according to their gender.

Table 8
T-Test Results of Students' Overall Spatial Ability According to their Gender

Gender	No. of Students	Mean	Std. Deviation	T-Value	F-Value	Significance Level
Males	160	24.53	3.98	1.429	.318	.154
Females	160	23.83	4.67			
Total	320	24.80	4.32			

According to Table (8), there was no significant difference between students' overall spatial ability and their gender. This result contradicts the findings of other studies [29] and [30], which reported that males were better than females in performance on spatial capacity tests. This result explains that the curricula do not differentiate between genders in terms of preparation. It also implies that teachers treat their students equally regardless of their gender in which this treatment is reflected in their performance in examinations and general tests.

CONCLUSION AND RECOMMENDATIONS

The present study aimed at investigating the level of spatial ability of students with learning disabilities in Asir region, Saudi Arabia. The study also aimed at examining the statistically significant differences between the level of spatial ability of students and three variables (i.e. students' grade, type of learning difficulty, and the students; gender. The results revealed that the students reported a moderate level of spatial ability, and this is considered normal as they are students with learning disabilities. In addition, there were no statistically significant differences between the students' spatial ability and the variables of this study (i.e. students' grades, type of learning difficulty, and the students' gender. In light of the findings of the study, the researcher recommends paying much attention to the rooms of learning difficulties, in terms of providing trained personnel and training programs to achieve the greatest benefit and to improve the abilities of people with learning disabilities. There is also a need to reviewing the study plans offered in line with technological and scientific development. Future research is highly recommended to further studying spatial ability dealing with other variables, and the psychometric characteristics of the spatial intelligence scale.

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