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An Empirical Study to Investigate Visual Discrimination in Geometry

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Abstract
Spatial abilities are considered as essential for solving complicated mathematical problems. The present study is aimed at investigating visual discrimination in geometry. The major objectives of the study were; (i) to investigate visual discrimination of students in geometry, (ii) to compare visual discrimination of public and private schools' students, (iii) to compare visual discrimination of rural and urban schools' students. On the basis of the above objectives, null hypotheses were developed and tested. A sample of 200 students studying Mathematics-9 in science group from sixteen schools were randomly selected to conduct the study. An empirical research design was used in the study. For data collection, five test items were developed and administered. Statistical techniques such as Mean, Standard Deviation, Welch's t-test (Two-tailed) for unequal variances and ANOVA were applied to analyze the collected data. The study is significant for students, teachers, researchers and curriculum developers. The study concluded that; urban private schools' students performed better than the other sampled students. It was recommended that the existing curriculum should be revised to enhance the visual discrimination of the students in geometry.

Keywords: Visual Discrimination, Geometry, Students, Urban, Rural

1. Introduction

Mathematics is one of the most important subjects, which is not only necessary for academic achievement but also for everyday life. Therefore, the students must learn mathematics. Because of the importance of mathematics, how to develop students' basic mathematical skills has been a crucial issue for the educators and teachers for years. One of the desired suggestions to develop mathematical skills is to suitably emphasize and develop primary abilities such as spatial ability instead of just teaching mathematics. Spatial ability was considered to be one of the primary abilities that seem especially important in learning and doing mathematics. Spatial ability is a good predictor for mathematics performance. Further at age 13 this ability is highly associated with science subject selection at age-18. (Young, Levine, & Mix, 2018; Tosto et al., 2014). Many studies found spatial skills were positively correlated with measures of mathematics performance. Spatial abilities are claimed to be powerful tools for understanding and solving mathematics problems. It is also reported that spatial ability not only influence mathematics achievement but also it was strongly linked to achievement in science. And further, there increase in spatial ability also affects their greater achievement in science subject. The consensus among mathematics educators and researchers that visualization, or spatial ability is important because it enhances a global and intuitive view and understanding in many areas of mathematics. Research studies show that there are relationships between spatial ability and geometrical achievement. Rouadi and Husni (2014) described that to learn geometry the spatial thinking is very essential and in this regards shape recognition or visualization is the pre-requisite for this wonderful subject. Different rotations of the object should be conserved by the learner in the initial stage of the geometry.

Spatial ability is absolutely essential to living in a three-dimensional world. According to Patkin and Dayan (2012), spatial reasoning skills affect our ability to "navigate from place to place, detect an object moving towards us, estimate quantities, understand drawings and charts, and compose various items" (p. 179-180). Spatial ability is listed as one of Howard Gardner's multiple intelligences, focusing on non-verbal cognitive abilities (Gardner, 2006). Spatial intelligence covers a wide variety of right-brain thinking and processes including visual, motor, analytic, and behavioral skills (Meadmore, Dror, & Bucks, 2009; Patkin & Dayan, 2012).

Generally, spatial ability can be divided into three categories. These categories are mental rotation (MR), spatial visualization (SV), and spatial orientation (SO).

The three categories of spatial ability play a major role in geometric thinking and understanding (Unal, Jakubowski, & Corey, 2009). Educational research regarding spatial ability dates back to the 1940s, but behavioral analysis of spatial ability has been

noted earlier by research conducted in the field of psychology. Spatial reasoning skills are absolutely essential for improving mathematical comprehension and mathematical pedagogy for mathematics educators. In fact, the National Council of Teachers of Mathematics (NCTM) identified spatial ability as a central goal in high school mathematics, specifically in geometry courses (The National Council of Teachers of Mathematics, 2013). The role of spatial ability is recognized in various other subjects including chemistry, geosciences, physics, and engineering. Patkin and Dayan (2012) suggest that one's spatial ability influences and can determine one's level of achievement in mathematics and other related fields.

Objectives of the Study

Objectives of the study were,

(i) to investigate visual discrimination of students in geometry,
(ii) to compare the visual discrimination of public and private schools' students, and
(iii) to compare visual discrimination of rural and urban schools' students.

Hypotheses of the Study

To achieve objectives of the study, the following null hypotheses were tested;
H01: There is no significant difference between visual discrimination of students in geometry,
H02: There is no significant difference between visual discrimination of rural and urban participants.
H03: There is no significant difference between visual discrimination of public and private participants.

Significance of the Study

The study was equally significant for all secondary school students, teachers teaching Mathematics as well as researchers and curriculum developers.

Literature Review

Generally, mathematics is considered as a subject boring and hard in teaching learning process. The nature of this subject demand logical thinking and high perception in understanding its width and breadth. This subject is the study of patterns and systems in organized form. Resultantly, the learner gains abstract thinking behaviour with creative and aesthetic development. High ability in this subject marked as knowledgeable man and society. No doubt, the concept in this subject is to learn through concrete activities or through realistic model approaches. Subsequently, the individuals must use mathematics in their lives, in solving real problems, discuss its multiple solutions, and believe in cooperation, confidence in doing so and their attitudes should be positive towards this subject (Gürlen, 2015).

Geometry is important and pre-requisite for learning and understanding mathematics. It is the part of every curriculum across the country. In Geometry we analyze multiple dimensions. Geometry is not just memorizing and sorting the shape. It is specifically need the dynamic, spatial and imaginative character of mind for its learning. This subject has got attention in research for its improvement for learning because students are still behind in its level as proposed by NCTM (Kinnear, Lai & Muir, 2017).

To learn geometry, the spatial thinking is very essential and in this regards shape recognition or visualization is the pre-requisite for this wonderful subject. Different rotations of the object should be conserved by the learner in the initial stage of the geometry (Ruadi & Husna, 2014).

In simple words, visualization is the cognitive process of presenting the object or event in real way. Closer investigation uncover, however, that for many visualization realistic depiction is neither their function nor intention. Visualization object is any object that a student observes to assist in the learning or understanding of some topic of educational importance. A visualization object could be a picture, a schematic diagram, a computer simulation, or a video. Using visualization for object is said to be visualization. The students who use visual imagery in the absence of visualization objects is said to be introspectory. Visualization makes learning easier and concrete (Phillips, Norris, & Macnab, 2010).

Visual discrimination is the ability to look at similarities and differences among different objects. Visual discrimination is the ability to recognize details in visual objects. It allows students to identify, and recognize the similarities and differences of different shapes/ forms, colours and position of objects, people, and printed material (Gutierrez, 1996).

The development of the Haptic Visual Discrimination Test (HVDT), according to McCarron and Horn (1979), this test investigates, —the relationship between tactual-visual discrimination and intelligence from a neuropsychological perspective. According to Study (2003), the HVDT test focuses on the tactile abilities of test subjects to visualize 3D objects through one handed manipulation, without using their sight. The test subject then determines a correct figure that is visible to the test subject. The test is composed of four components (shape, size, texture, and configuration) and is administered individually. The HVDT was not listed in either Eliot (2000) or Eliot and Smith (1983).

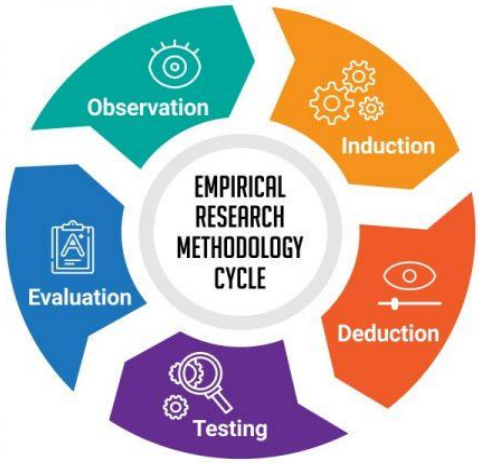
Research Methodology

Sample of the Study

Eight secondary/higher secondary schools were chosen (four urban, and four rural). From each sample school, twenty five students studying in 9th class were randomly (SRS) selected. In this way, 200 students as subjects were tested to investigate the visual discrimination in geometry (Muhammad, 2023; Crawford, 2008).

Research Design

To conduct the study, an empirical research design was used.



Source: (Muhammad, 2023)

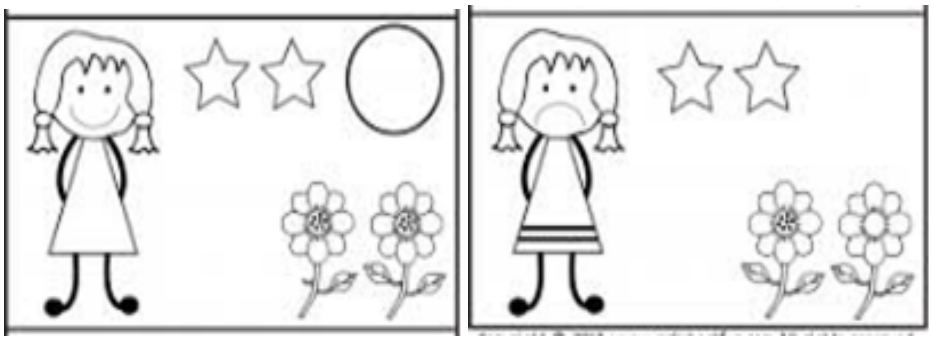
Research Instruments Material

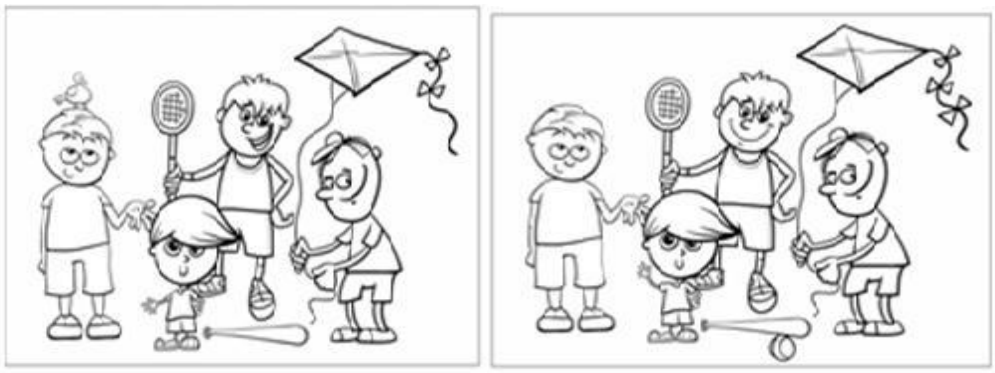
Five items test for visual discrimination were administered to collect the data.

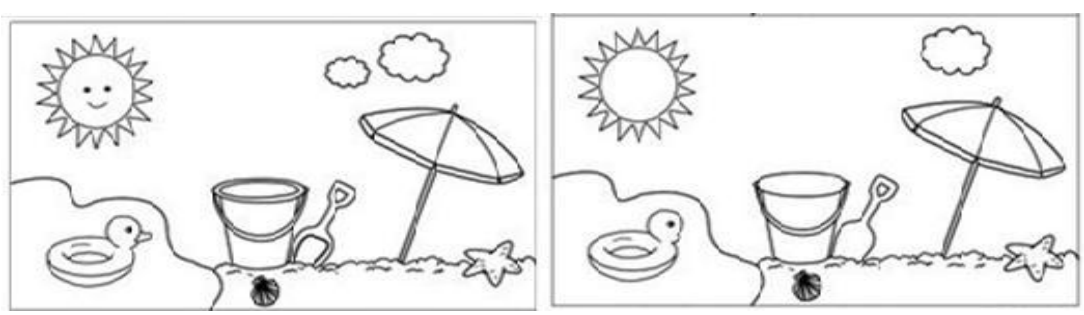
Procedure of the Study

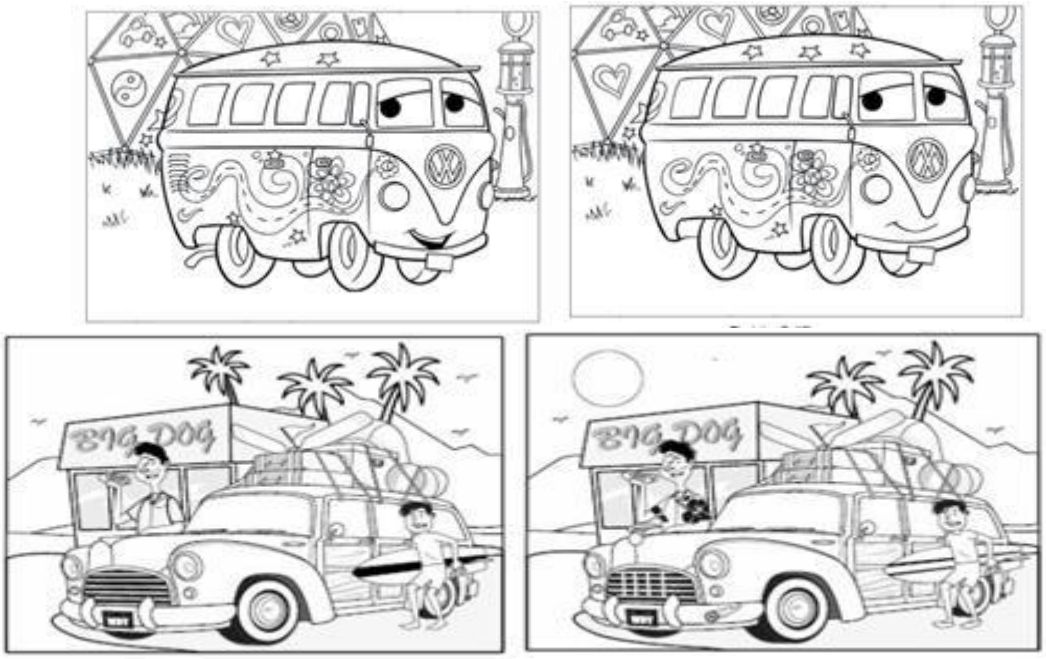
The researcher conducted the experiment in the following way; all sampled schools were visited personally by the researcher. Five items test was administered to 25 randomly selected students in each visited schools through test/observation. (Hubert Maier and other mathematicians have suggested five aspects of spatial ability, one of them is visual discrimination).

Visual discrimination.









Data Collection

Primary data were collected through test/ observation in a way that five items related to visual discrimination from the sample. Curriculum document was consisted of secondary data.

Analyses of the Data

Collected data were analyzed in the following way;

i) Mean and standard Deviation of the marks/ observation sheet were calculated.
ii) In order to find out the significant difference between the rural and urban secondary schools' students, Welch's t-test was applied.
iii) To find out the significant difference between the public and private secondary schools' students, Welch's t-test was applied.
iv) To find out significant difference among the rural, urban, public and private schools' students, ANOVA was applied.

H03: There is no significant difference between visual discrimination of public and private participants.

School Sector	N	Mean	SD	t-vale	P-value
Public	50	1.06	1.357669		
Private	50	1.44	1.150155	1.51	0.134

Table depicts that the calculated Welch's t-test is 1.51 for unequal variances of 50 each public and private secondary school students regarding visual discrimination in geometry at 0.05 level and df = 95. Since the p-value (0.134) for a two-tailed test is greater than the typical significance level (0.05), we fail to reject the null hypothesis, there is no significant difference between visual discrimination of public and private participants. Therefore, Private school students' performance regarding visual discrimination in geometry was better than the public school students.

H02: There is no significant difference between visual discrimination of rural and urban participants.

School Sector	N	Mean	SD	t-vale	P-value
Urban	50	1.36	1.138563		
Rural	50	1.00	1.195229	1.54	0.127

Table shows that the calculated Welch's t-test is 1.54 for unequal variances of 50 each urban and rural secondary school students regarding visual discrimination in geometry at 0.05 level and df = 98. Since the p-value (0.127) for a two-tailed test is greater than the typical significance level (0.05), which suggests that the difference between the means of rural and urban secondary schools' students may not be statistically significant at 0.05 level.

		SS	df	MS	F	P-value
VISUAL	Between Group	7.09	3	2.363	1.604	0.19
	Within Group	288.69	196	1.473		
DISCRIMINATION	Total	295.78	199			

Table shows that F-ratio is approximately 1.604 with df = (3, 196), the p-value suggests that the difference between the means of all four groups may not be statistically significant at the level of 0.05 and comparatively the performance of private schools regarding visual discrimination was better than the public secondary schools students.

Discussion

The study was carried out at observing the visual discrimination of students in geometry. The study was conducted in urban and rural areas of Khyber Pakhtunkhwa. The result of the study reveals that the performance of students regarding visual discrimination was determined. Overall discussion of the study is as under:

The results of the study concluded that the visual discrimination of urban students was greater (1.36) than mean value of rural students (1.00).

Similarly, the visual discrimination of private school students was greater (1.44) than mean value of public school students (1.06).

Recommendations

On the basis of conclusions, following recommendations were made; the study explored that there was a significance difference among all schools students' scores regarding visual discrimination of the students. Comparably the visual discrimination of private schools students with reference to the visual discrimination was much better than the public schools students. National Council of Teachers in Mathematics (NCTM) standards can be helpful to revise the curriculum. After the revision of the curriculum the students will be able to use visual discrimination tools while learning mathematics to increase their academic performance. It is recommended that in pre-service and in-service training of the teachers the teachers may be trained to use visual discrimination in their teaching. Due to this, the teachers will be able to use these visual discrimination while teaching geometry in real classes of their schools. In this way, the students' academic performance in the subject of mathematics will increase.

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