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An Investigation into Spatial Ability in Geometry among Secondary School Students

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Abstract

Spatial ability is reflected to be one of the major abilities that appear especially essential in learning and doing mathematics. The present study is aimed at observing the spatial ability in geometry among secondary school students and teachers teaching mathematics. Objective of the study was to compare the spatial ability of the students of urban and rural secondary schools. To achieve the above objective, following null hypothesis was tested; there is no significant difference between urban and rural secondary schools' students on spatial abilities. A total of 400 students studying in 9th class from sixteen schools were randomly selected as the sample of the study. The study was conducted with the help of an empirical research design. Different Spatial Ability Tests were developed to measure spatial ability. For the purpose of data collection, observation sheets and test items were developed to investigate the performance of the students. Different statistical techniques like Mean, Standard Deviation, and t-test were applied to analyze the collected data. The study is equally significant for all secondary school students as well as for researchers and curriculum developers. Major conclusions of the study were; urban private secondary school students performed better than the others (government urban, government rural and private rural). Main recommendation was; curriculum was relevant hence it was retained.

Keywords: Spatial Ability, Secondary School Students, Geometry

Introduction

Mathematics is the science of measurement, quantity and magnitude (Sidhu, 1992). It deal with the quantities, numbers, their characteristics and different shapes and the inter relations between them. For this various concepts like algebra, calculus, ratios, and geometry are utilized. Various processes o calculations, supposition, and reaching a conclusion are brought in use (Chamers Essential English dictionary, 2005). It is regarded as a subject of reasoning and logic which affects the overall thinking capabilities of an individual.

This is why the development of spatial skills is a critical task for the educators. Besides the researches proves that the impact of these activities varies in improving spatial (Robihaux, 2003). Similarly, many researchers are of the view that the involvement of learner's in learning specific spatial skills are of key importance which ultimately leads to learn visual manipulation skills (Bernie & Smith, 1999). Additionally, Dean (1976) is of the view that mastering visual skills allows one to acquire the skills of spatial ability

Moreover, these skills are considered as the important skills in professional career. For instance, spatial ability skills were evaluated in order to gauge the aptitude and performance level of candidates in the field of science and technology. This gave a better idea about how the candidates can adapt and learn organizational skills. Olkun (2003) expressed that with the help of applications of spatial ability the learning abilities of student's can be enhanced. Furthermore, he concluded by removing the key rules from the specified rules, the remaining visualization skills that were very similar to what were being used in spatial ability measures.

The five distinct attributes of the spatial ability skills are:

(i) Perceptual Constancy

It is the ability to comprehend and visualize the objects same even when their relative positions are changing. This include the variation in shape, size, and color.

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(ii) Mental Rotation

It is the ability to rotate mentally 2D and 3D objects visually in the human mind.

(iii) Perception of spatial position

It is the skill which can perceive the object with the change in its relative position and still the visual rotation can adjust to the changes.

(iv) Perception of spatial relationships

It is the skill which can gauge the inter relationship between various objects and its parts.

(v) Visual Discrimination

It is the skill that enables one to observe details and formation from the visual images .It is an important skill as it makes it possible to reach the details from simply observing the visual formation of various objects (Gutierrez, 1996).

Objective of the Study

Objective of the study was to compare the spatial ability of the students of urban and rural secondary schools in geometry.

Hypothesis of the Study

To achieve objective of the study, the following null hypothesis was tested;

H_{01}: There is no significant difference between urban and rural secondary schools' students on spatial abilities.

Significance of the Study

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

Literature Review

The subject of mathematics is the study of understanding and evaluating structures and patterns that help preparing skilled persons required for knowledge based society. (Baykul, 2005). The main concept is called as it is declared in National Curriculum (2006) that in 1975-76, our National Curriculum was developed and further revisited in 1984-1985. The focus of the curriculum was on content standards and to accelerate the students' capacity according to set the standard. The five standards have elaborated for different gradual stages. For secondary education (grade-9 to grade-10) the fourth stage is marked in this National Curriculum. The students' development stage about each and every topic is clearly mentioned in all those five standards along with expected outcomes.

Geometry is important and pre-requisite for learning and understanding mathematics and it is the part of every curriculum across the country. In Geometry we analyze multiple dimensions; the relationship that is three dimension in which we are at the moment and besides we consider other two dimensional reference in this three dimensional space. Geometry is not just memorizing and sorting the shape but 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 and for learning because students are still behind in its level that has been knocked by NCTM (Kinnear, Lai & Muir, 2017).

To survive in 3-Dimensional world it is pertinent to have knowledge and posses spatial ability. Spatial ability is essential for living in a world of three-dimensional objects. According to Patkin & Dayan (2013) believes that this ability is vital for our normal routine. For instance, while moving from one place to another, finding the speed of objects and gauging various places accurately, it is the ability of spatial knowledge that makes it possible.,). Howard Gardner's mentions the traits of intelligence based on non verbal skills (Gardner, 2006). Besides this skill encapsulates a broader framework of mental processes like thinking, and perception (Meadmore, Dror, & Bucks, 2009; Patkin& Dayan, 2013).

Spatial Ability is the general overall term relating the ability to mentally orient, visualize and understand spatial elements by manipulating objects in a 2D and 3D environment (Eliot & Smith, 1983; Sorby, 1999a).

In simple word visualization is the process of presenting the object or event in real way. Earlier investigation revealed that for many visualization, accurate depiction is neither their function nor intention. Visualization object is the any object which a student observes to assist in the learning or understanding of some topic of educational importance. A visualization object might be a picture, a schematic diagram, a computer simulation, or a video. Using visualization for object is said to be visualization. The student who uses visual images in the absence of visualization objects is said to be introspectory. Visualization makes learning easier and concrete (Phillips, Norris, & Macnab, 2010).

Visualization can be categorized into three different categories: i) one joint usage involves the clue that visualization is somewhat that people do which they visualize. Visualization processes are usually seen as mental processes in which certain thoughts have content that are related to- perhaps is identical to- the content of something that is seen with the eye; ii) a second sense of the term visualization, refers simply to imagining that is key to the success; iii) the last is computer generated animations, which are referred to as visualization (Phillips, Macnab, & Norris, 2010).

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).

At what point do you become aware of seeing, hearing, smelling, tasting, or feeling some stimulus, objects, or event? Become aware of stimulus: If you are blind or deaf than you are unable to see and hear the people around you.

The ability to see a different object as appearing the same even under different lighting condition, or at different distance, and angle is called perceptual constancy. For example, color and brightness constancy, and shape and size constancy. Perceptual constancy is the ability to recognize object despite variations in their representation. It entails recognizing the sameness of an object even though the object might in actuality vary in appearance, size, colour, texture, brightness, shape etc. The development of this aspect involve seeing, feeling, manipulating, smelling, tasting, hearing, naming, classifying and analyzing objects. Inadequate perceptual constancy affects the recognition of letters, numbers, shapes and other symbols in various contexts (Winnick & Porretta 2018).

Mental rotation is that ability, in which one imagine how an object appears when it is rotated from its first representation. Mental rotation is the ability of an individual to mentally rotate two or three dimensional objects in space. All those images are vivid along with multiples details (Guillot, et. Al, 2007). It is one of the important aspects of spatial ability and it highly correlated with exam performance. Students who perform well in the spatial rotation task they also perform well in their exam. In mental rotation problem, complex cognitive process is involved in mental representation and in spatial thinking as well. Significantly, mental rotation researches provide insight into inter-individual difference in cognitive strategy selection. Research revealed that the mental rotation ability can be improved with training and instruction (IRMA, 2018).

Mental rotation always varies among individual, and individual always struggle to manipulate the mental images by using cognitive processes and spatial transformation. This skill is useful in problem solving and spatial reasoning tasks (Guillot ,Champely, Batier, Thiriet, & Collet, 2007). It is one of the important aspects of spatial ability and it highly correlated with mental rotation ability was also acknowledged by cognitive psychologists, that's why they tried to construct strategies and investigating factors that are necessary in developing this ability. To assess this ability, that include internal mental processes, always scientific method should be used rather than introspection (Safaa, 2015).

Visual perception is a process in which the perception becomes aware of a specific knowledge in a specific setting. In modern psychology, perception is an dynamic process which consists numerous steps to be understood. Visual perception is a key aspect in the learning process, and from the age of 3½ to 7 years, change and growth in most visual perception, particularly with school assignments, reading, and communication. Because it requires the detection, recognition and understanding of each word. In a study conducted, it has been concluded that the reasons of defects in visual perception through visual recognition of letters and numbers is low, resulting in decreased reading vocabulary (Safaei, Bafrooee & Yarmohammadianc, 2014)

Research Methodology

Population of the study

All the 650,569 boys' secondary school students at secondary level were constituted the population of the study (Govt. of Khyber Pakhtunkhwa, 2017).

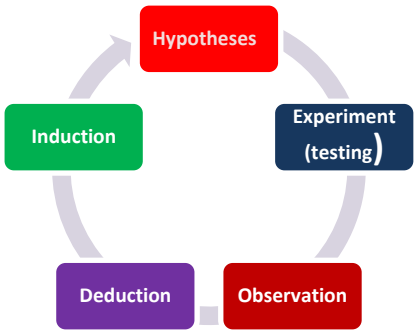
Sample of the study

Sixteen secondary/higher secondary schools were chosen (eight urban, and eight rural). From each sample school, twenty five students studying in 9^{th} class were randomly (SRS) selected. In this way, 400 students as subjects were tested to investigate the spatial abilities (Farooq, R. A. & Tabassum, R., 2018; Crawford, 2008).

According to Gay, Mills, & Airasian (2012) if the population size is in thousands or in millions, then a sample size of 400 will be adequate.

Research Design

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



Source: (Ahmad, 2017)

Research Instruments

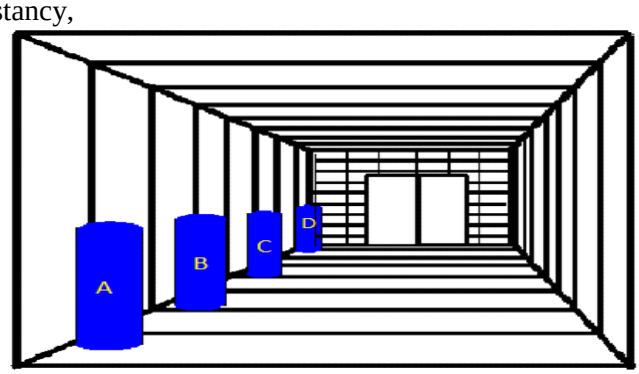
Material

Different cubes labeled geometric figures were used to observe spatial ability (five items of Mental Rotation), two glasses and a toy/body were used to observe spatial ability (five items of Perception of Spatial Position). Apart from the aforesaid ten items, fifteen items test (five items for each remaining three aspects of spatial ability i.e. perceptual constancy, perception of spatial relationships, and visual discrimination) were administered to collect data.

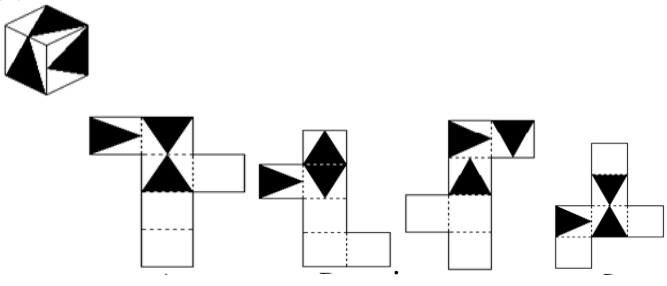
Procedure of the Study

The experiment was based on exploring spatial ability in geometry. The researcher conducted the experiment in the following way; all sampled schools were visited personally by the researcher. Twenty-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). Following five aspects of spatial ability were tested;

(i). Perceptual constancy,



(ii). Mental rotation,



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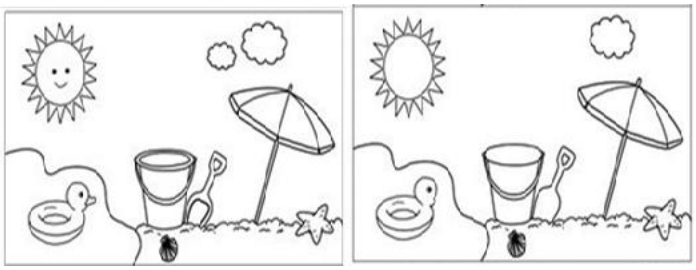
(iii). Perception of spatial position,

(iv). Perception of spatial relationship,

(v). Visual discrimination.



Data Collection

Primary data were collected through test/ observation in a way that fifteen items related to (a) Perceptual constancy, (b) perception of spatial relation, and (c) visual discrimination were collected through a test made of five items each and ten items related to (d) mental rotation, and (e) perception of spatial position were collected through observation 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 among the rural and urban secondary schools' students, t-test was applied.

H_{01}: There is no statistically significant difference among the urban and rural secondary schools' students on spatial abilities.

Table 1. Comparison of Urban and Rural Schools Regarding Different Aspects of Spatial Ability

Five Aspects of Spatial Ability	No. of Rural schools	No. of Urban schools	Mean value		Standard Deviation	
			Rural	Urban	Rural	Urban
Perceptual constancy	08	08	1.595	2.120	0.970	1.230
Mental Rotation	08	08	3.090	3.315	1.040	1.140
Perception of Spatial Position	08	08	3.295	3.820	1.364	1.080
Perception of Spatial Relationship	08	08	3.48	4.560	1.851	1.0333
Visual Discrimination	08	08	1.160	1.405	1.064	1.321

Table 1 shows that the perceptual consistency mean value (1.595) of rural schools' student was much lower than urban schools mean value (2.1200). It means that perceptual constancy of urban schools was much better than the rural schools students. Similarly, the mean values (1.090,3.295, 3.48 and 1.160) of rural sectors schools' students were much lower than the mean values of urban sector schools' students (3.315. 3.82, 4.56 and 1.405) regarding the aspects mental rotation, perception of spatial position, perception of spatial relationship and visual discrimination. It means that in all the

aspects of spatial ability (perceptual constancy, mental rotation, perception of spatial position, perception of spatial relations and visual discrimination) the performance of urban schools' students was much better than rural schools' students.

Table 2. Comparison of spatial ability of the urban and rural secondary school students

School Location	N	Mean	SD	t-value	p-value
Urban	200	13.8750	3.71462	1.516	0.130
Rural	200	13.3350	3.40304		

df = 398 Table value on 0.05 level = 2.011

Table 2 shows that there was a non-significant difference between the urban and rural schools' students regarding the spatial ability. The t calculated value 1.516 was less than table value of (2.011) at 0.05 level. There was no statistically significant difference in the mean values of urban and rural schools' students on spatial ability.

Discussion

The study was carried out at observing the spatial ability in geometry among secondary school students. The study was conducted in urban and rural areas of Khyber Pakhtunkhwa. The result of the study reveals that the performance of students of spatial ability regarding five aspects of perceptual constancy, mental rotation, perception of spatial position, perception of spatial relationship and visual discrimination was determined. Overall discussion of the study is as under:

The results of the study concluded that the urban student was greater than mean value (14.38) rural school students.

Recommendation

On the basis of conclusions, following recommendations were made, the study explored that there was a significance difference among all schools students' scores regarding spatial ability of the students. Comparably the spatial ability of private schools students with reference to the different aspects of spatial ability like perceptual consistency, mental rotation, perception of spatial position, perception of spatial relationship and 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 spatial ability 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 spatial ability tools in their teaching. Due to this, the teachers will be able to use these spatial ability tools while teaching mathematics in real classes of their schools. In this way, the students' academic performance in the subject of mathematics will increase.

References

Ahmad, A. (2017). *An investigation into number conservation ability among elementary schoolchildren of Pakistan according to Piaget's theory of Cognitive development.* Unpublished PhD Thesis. Northern University Nowshera, Pakistan.

Baykul, Y. (2005). ølkö÷retimdematematikö÷retimi. Ankara: Pegem A YayÕnlarÕ, 8. BaskÕ, s.38-41, Ankara.

Eliot, J. & Smith I. M. (Ed.) (1983). *An international directory of spatial te*sts. Windsor, Berkshire: NFER-Nelson; Atlantic Highlands, N. J.: distributed in the USA by Humanities Press, 1983.

Farooq, R. A. & Tabassum, R., (2018). *Understanding Reasearch in Education: (2nd ed..).* Rawalpindi: Universityof Arid Agriculture.

Govt. of Khyber Pakhtunkhwa, 2017

Guillot A., Champely S., Batier C., Thiriet P., & Collet C. (2007).Relationship between spatial abilities, mental rotation and functional anatomy learning. *Advance Health Science Education Theory Practices* .12:491–507.

Gutirrez, A (1996). Visualization in 3-dimentional geometry: *Proceedings of the 2 conference of the international group for the psychology of mathematics education* (vol. 1, pp,3-19). Valencia: Universidad de Valencia

Information Resources Management Association IRMA, (2018). Early Childhood Development: Concepts, Methodologies, Tools, and Applications: Concepts.

Kinnear, V.,Lai, M.Y & Muir, T.(2017).*Forging Connections in Early Mathematics Teaching and Learning*. Springer Singapore.

Meadmore, K. L., Dror, I. E., & Bucks, R. S. (2009). Lateralisation of spatial processing and age .*Laterality: Asymmetries of Body, Brain and Cognition,14*(1),17–29.

Patkin, D., & Dayan, E. (2013). "The Intelligence of Observation: Improving High School Students' Spatial Ability by Means of Intervention Unit." International Journal of Education in Science and Technology 44 (2):179–95.

Olkun, S. (2003).Making Connections: Improving Spatial Abilities with Engineering Drawing Activities, *International Journal of Mathematics Teaching and Learning*, 1-10.

Phillips, L. M., Macnab, J. S., & Norris, S. P. (2010). Models and modeling in science education: Visualization in mathematics, reading and science education (vol. 5).

Phillips, L.M., Norris, S. P., Macnab, J. S. (2010). Visualization in Mathematics, Reading and Science Education. The Netherlands: Springer https://books.google.com.pk/books?id=_g6fCJEaVoC

Robihaux, R. R. (2002). *Predictors of Spatial Visualization*: Structural Equations Modeling Test of Background Variables, Journal of Integrative Psychology,2.

Rouadi, N & Husni N. (2014). Demonstration in Euclidean Geometry. *American International journal of Social Science, 3(1).130-138.*

Safaei, l., Bafrooee, K. B., & Yarmohammadian, A. (2014).Effectiveness of Visual Perception Skills to Improve Reading Performance of Elementary Second Grade Students with Learning Disabilities.*Indian.J.ScRes.7(1):269-274.*

Sorby, S. A. (1999a). Developing 3-d spatial visualization skills. Engineering Design Graphics Journal, 63(2), 21-32.