DOI: 10.52131/pjhss.2024.v12i2.2356

Pakistan Journal of Humanities and Social Sciences

Volume 12, Number 02, 2024, Pages 2236-2247
Journal Homepage:
https://journals.internationalrasd.org/index.php/pjhss

Assessing Spatial and Quantitative Reasoning Abilities in Six-Year-Old School Children: A Comparative Study in Lahore, Pakistan

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ARTICLE INFO

Article History:

Received:	May 05, 2024
Revised:	June 27, 2024
Accepted:	June 29, 2024
Available Online:	June 30, 2024

Keywords:
Spatial
Quantitative
Reasoning Abilities

Funding:
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Spatial and quantitative reasoning abilities are important building blocks to navigate and understand our surroundings. Various psychologists had conflict on the onset and the age at which these two reasoning abilities become fully developed. This research paper highlights how spatial reasoning abilities prosper at the age of six years old children and how they imagine a two dimensional object using spatial reasoning ability into a three dimensional picture and answer the related relevant questions of the sample. The study examines the development level of spatial and quantitative reasoning abilities of school children (boys and girls) present at the age of six years. A quantitative study was conducted under a positivist paradigm approach involving a semi structured questionnaire; conducted with a sample of 200 (boys and girls) students of class 1 from LDA Model High school Allama Iqbal Town and The Punjab School, Johar Town campus using simple random sampling. The results were analyzed using descriptive statistics as frequencies and percentages in cross tabulations, while Pearson correlation was applied between spatial and quantitative reasoning abilities to find out the relationship between them. Many psychologists had conflicts about the age of children about the onset development of spatial reasoning ability. Therefore, the current study results are significant because they reveal that school children at the age of six have higher level of spatial reasoning abilities which is against Piaget's claim that spatial reasoning is achieved at the end of the concrete operational stage. Very few children had achieved quantitative reasoning abilities. The study concludes that quantitative reasoning development at the age of six is comparatively slower to spatial reasoning ability. The children at the age of six had middle level of quantitative reasoning ability.

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1. Introduction

Children's cognitive development is a complicated process that is predicted on the correspondence of individuals' sensory, motor and neurological systems. Children's intelligence is a prominent under-discussed field of study in viewpoint of many educationists and psychologists. Out of several reasoning abilities, only spatial and quantitative reasoning abilities have been studied in this research. Primarily, spatial reasoning is an ability that helps to visualize and understand how two-dimensional or three-dimensional shapes and objects work in a space or surroundings (Tejada, 2014). Spatial reasoning is the ability to remember and understand the spatial relations among objects. Huttenlocher, Vasilyeva, Newcombe, and Duffy (2008) stated that spatial skill is relatively an enduring trait which means that it is continuously developing attributes of long term learning and training processes. It can be improved through practice and training. Whereas, "Quantitative reasoning, both generally and for assessment purposes, has an essential problem-solving focus. It includes the following six capabilities: reading and understanding information given in various formats; interpreting quantitative information and drawing inferences from it; solving problems using arithmetic, algebraic, geometric, or statistical methods" (Dwyer, Gallagher, Levin, & Morley, 2003). By keeping a positivist approach, research towards spatial and quantitative reasoning ability would help in exploring a different perspective than the prevailing relevant research. There remains a conflict and lack of agreement between psychologists about the levels, steps and process of spatial and quantitative reasoning at different age levels. In this study, I have explored the relationship and correlation between them. Previously, very few researchers compared the public and private schools, they conducted research either on public schools or private schools, and this research is addressing the spatial and reasoning ability in both types of schools simultaneously and draws comparisons between both. Therefore, it fulfills a research gap prevalent in the literature. This has been discussed in the research paper.

2. Psychological Approaches

There are some very prominent psychological approaches towards cognitive development of spatial and quantitative reasoning abilities. Some of the renowned approaches include Piaget's theory of cognitive development and Gardener's theory of intelligence.

2.2. Piaget's theory of cognitive development

According to his theory, the human mind is developed in four stages which are distributed as sensorimotor(0-2 years), preoperational (2-7 years), concrete operational stage(7 to 11 or 12 years) and formal operational stage (11 years and above). He introduced a term called egocentrism in which a child in their early years only understands the world from their own point of view and has trouble seeing things from someone else's perspective. When a child learns to "decentre," they can start to understand that others may see things differently and can consider more than one point of view, which, according to him, occurs at a concrete operational stage. Piaget and Inhelder did experiments, like the three mountains task, to find out when children think this way and when they begin to understand other perspectives. In this experiment, he learned that the child's mind in the pre-operational stage is egocentric and in nature; that is, they locate objects in their environment according to their perspective ignoring the other person's viewpoint.

They understand limited spatial concepts, such as separation, proximity, and open/closed. By considering this perspective, spatial reasoning starts developing at the age of seven years where a child learns to "decentre," and consider more than one viewpoint. Whereas the last stage is the formal operational stage, which begins around the age of 11 and it constitutes understanding of high spatial relations such as estimating relative distance and proportional reduction of scale (1., 1964). Piaget mentions that spatial reasoning starts developing in the concrete operational stage which is 7 years and above. Whereas, few researchers have explored that the spatial reasoning ability could be developed at the age of 6 years and below. In this research, I have explored the level of spatial and quantitative reasoning ability at the age of six years in both public and private schools and found a correlation of spatial reasoning ability with quantitative reasoning ability which has not been done before in the research literature. Therefore, this research is significant in fulfilling the research gap in the literature.

2.3. Gardner's theory of multiple intelligences

According to Gardener, there are eight intelligences of human mind: (a) visual spatial, (b) Musical, (c) Bodily-kinesthetic, (d) Interpersonal, (e) Verbal-linguistic, (f) Logical-mathematical, (g)naturalistic, (h) Intrapersonal (Kurt, 2021, April 29). We have studied only two of the intelligences from Gardner's theory that are visual-spatial and logical-mathematical in this research.

Visual spatial intelligence deals with intra- or inter-object relationships that are spatial in nature, which means understanding how one object relates to another object in terms of actual or possible plane or dimension that can be measured. Such people can easily visualize things in their mind which allows them to be more effective in spatial problem solving skills. Following are some examples of skills and abilities in the area of visual-spatial intelligence:

2.3.1. Mental Rotation/Imagery

The ability to imagine things or visualize them from a different angle or perspective.

2.3.2. Spatial relations

The awareness of the relationship of objects within a given physical space and the potential movement of those objects or the arrangement of multiple objects.

2.3.3. Orientation

It is characterized by an approach to physical space and objects, including the perception of the environment and the ability to use the map.

2.3.4. Visual Art

Many times, the person who is high on visual-spatial will be also engaged at work requiring visualization of the final product such as drawing, sculpture, or designing in architecture.

2.3.5. Visual Puzzle Solving

The level of intelligence geared towards solving tasks that are presented in visual format that often require manipulative movements like shifting, rotating of components to fit together including games composed of such tasks, geo-fence features.
Some of the professions where this kind of Intelligence is predominant includes architects, artists, engineers, surgeons or pilots etc.

As per Gardner, it is this particular variety of intelligence that is totally separate and different from linguistic intelligence or logical-mathematical intelligence. Whereas, logical-mathematical is commonly referred to as the capacity to think with logic, reason, recognize patterns and solve abstract problems particularly those involving numbers and relationships. This is the type of intelligence which is generally referred to in regards to mathematical reasoning and scientific thinking. The simplifying characteristics of the logical-mathematical intelligence are:

1. Abstract Reasoning: This is the capability of thinking abstractly and conceiving ideas and understanding relationships among them with the help of logic.
2. Problem-Solving: This is the ability to engage in tasks that resolve issues in an orderly manner and arrive at a solution through a set process or procedures involving deductive and inductive strategies.
3. Pattern Recognition: This is the ability to detect patterns that link relationships among sequences, items, concepts or shapes.
4. Numerical Ability: High level inclination towards the use of numbers, doing operations with numbers and other such activities involving mathematics.
5. Scientific Thinking: To develop a hypothesis, perform an experiment, evaluate the result, and interpret it rationally.

Those whose logical-mathematical intelligence is of high levels have been found to perform best in mathematics, engineering, computer science, statistics and even natural sciences. They are good in problem solving activities like puzzles and problems of identifying structures and building theories. Describing these two intelligence abilities gives a clear direction about what the research objectives is demanding from the research method. In this research, if a child will be able to understand spatial concepts and logical-mathematical reasoning and calculation-would be considered an able student with profound reasoning intelligence at the age of six years.

2.4. Importance of Spatial and Quantitative reasoning abilities

Following are the researches that show the importance of spatial and quantitative reasoning abilities for school children.

2.5. Spatial reasoning ability of school children

A case study research conducted in Malaysia, studied the importance of intelligence and learning. It found spatial reasoning to be an important ability in converting a 2 dimensional image into an object. The researcher played clay with the children and asked them to form animal shapes. The research results showed that children tend to use learning styles similar to their intelligences (Wan, 2014). Further studies reveal that spatial reasoning abilities also improve other mathematical abilities (Clifford, 2008; Young, Levine, & Mix, 2018). Assel, Landry, Swank, Smith, and Steelman (2003) identified spatial reasoning as an important leading factor in understanding and development of basic quantitative skills and a path to problem solving. The findings of Assen suggest a link between early spatial reasoning of two and three years old and quantitative ability of 8 years old.

2.6. Quantitative reasoning ability of school children

Quantitative reasoning is correctly using numbers and symbols, studying measurement, properties, and the relationships of quantities, thinking clearly and analytically about quantitative problems is vital in importance to live in modern society. The need for quantitative reasoning is inevitable in all academic and professional fields, also imperative for decision making in daily life chores (Clifford, 2008). Moreover, NAEYC and NCTM (2002) laid emphasis on the significance of quantitative reasoning for young children as they struggle to fit into their surroundings (Carroll, 1993). Another study reveals that the procedure of reaching to a final decision with the help of proof and strategy is reasoning. Consequently, quantitative reasoning consists of analysis in which individuals employ mathematical relationships and properties to reach to an ending (Carroll, 1993). A recent study investigated the children's ability students to count and make quantitative comparison revealed that revealed that 89% of children (n=30) were able to do rote counting and 70% (n=24) were able to perform rational counting from the sample size of thirty four preschoolers (age=5 years) (Lee & Md-Yunus, 2016). From this research, it seems clear that many younger children can perform rational and rote counting as early at the age of four and a half years.

2.7. Relationship between quantitative and spatial reasoning ability

Some researchers have highlighted the connection between spatial reasoning ability and quantitative reasoning ability. The link between space and math may be based on common primary processes, suggesting an important avenue for mathematical enhancement. Brain imaging studies and neurophysiology reveal that analogous link or reactions are activated when people process spatial or number tasks (Walsh, 2003). Numerical magnitudes are mentally characterized by a spatial format (i.e., the SNARC effect). This discovery of having related mental processing opens the possibility that math can be enhanced with spatial training (Tian & Huang, 2009). Spatial skills are also linked in accomplishment to math and sciences leading to particular professions that need spatial reasoning. With the help of these skills doctors interpret X rays and architects plan and construct buildings. Hedman et al. (2013) recommended that possessing higher spatial reasoning abilities is vital for carrying out important surgical procedures.

2.8. Gender differences in spatial and quantitative reasoning abilities of school children

Psychologist and common men have been fascinated with the idea of gender differences in spatial ability. The difference of men and women spatial intelligence and quantitative abilities has been a popular topic of conversation. In a research conducted on the gender wise comparison of quantitative ability explored that girls from 4 to 5 years of age performed better in the test then boys (Lakin, 2013). Voyer, Voyer, and Bryden (1995) performed meta-analysis on the gender differences in spatial abilities. The results from both of the meta-analysis revealed no significant differences between the gender. The results reveal no sense to make general statement concerning gender differences of spatial reasoning ability. The results stated that the difference depends more upon the nature of the tests used to conduct researches (Caplan, Crawford, Hyde, & Richardson, 1997).

2.9. Objectives of the study

For the current study, following objectives were formulated:

1. To assess the spatial reasoning of school going children.
2. To assess quantitative reasoning ability of school going children.
3. To find the relationship exists between spatial reasoning ability and quantitative reasoning ability.
4. To find gender differences in spatial and quantitative reasoning of children in government and private schools.

3. Methodology and Procedures

The research was conducted in two steps. First, the tool validation was carried out through piloting of the instrument and then the actual sample was collected. The research was quantitative in nature that assessed spatial and quantitative reasoning abilities of primary school children. Also, it assessed the relationship between spatial reasoning and quantitative reasoning ability. The research also compared the results of students from public and private schools. For sampling purposes, a selective random sampling technique was used. The chi square test was found out between spatial and quantitative reasoning abilities.

3.1. Population

The population of the study was the primary school children from age 6 years of Lahore.

3.2. Sampling

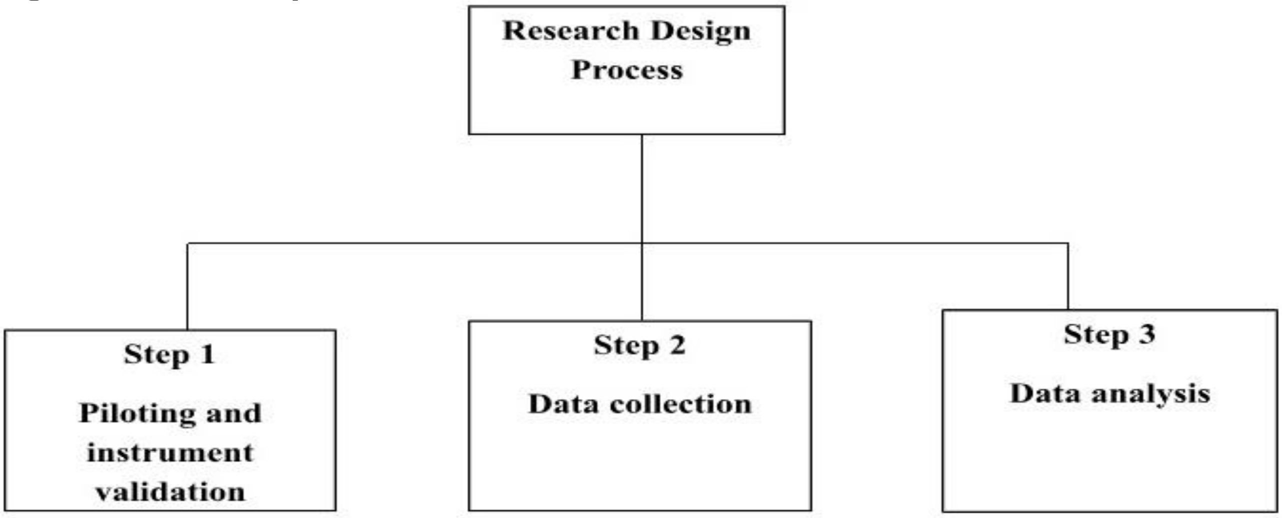
3.2.1. Pilot study Sample

The researcher took a sample of 15 girls from the (Government School) LDA School and 15 boys from the Misber School (private school) Valencia town Lahore of age 6 years.

3.2.2. Steps of research process

The research has been carried out in three steps. In the first step, piloting has been done on 30 students to ensure tool validation. In the second step, data was collected from the selected research population. In the last step, the data was analyzed statistically to answer the research questions.

Figure 1: Pilot Study



Step I: Pilot study

The current study Spatial and Quantitative reasoning of school children aimed to find out the Spatial and quantitative reasoning of school children aged 6 years from government and private schools, compare the reasoning ability of government and private schools, find the relationship between spatial and quantitative reasoning and also to find out the relative gender differences between the two mentioned abilities. For this purpose, a questionnaire was used to measure these variables. To check the reliability of the tool, pilot study was done. For this reason, 15 girl respondents were randomly selected from the LDA school Allama Iqbal Town branch which is a government school and 15 boys respondents were selected from the Misber school Valencia town which is a private school.

The responses were statistically analyzed and the results showed the validity of the tool used in the study.

3.2.3. Sampling

A sample of 200 boys and girls aged between 6 years (Grade 1) was taken from private and government primary schools of Lahore. From which a sample of 170 students were collected. Simple random sampling has been used for sampling procedure under the head of probability sampling.

3.2.4. Place of Work

The researcher took permission to conduct research in different schools. The data was collected from the following schools:

- The Punjab School Township Lahore. (Private School)
- LDA school Iqbal Town Lahore (Govt. school)

The Punjab school grade one has total nine hundred and eighty boys and girls students from which the researcher intends to take a sample of fifty boys and fifty girls. The LDA School is a Government school located in Iqbal Town Lahore. The class one has around two hundred girls. Whereas in the boys wing, class one has two hundred and forty boys. The researcher will take a sample of hundred from the government school constituting fifty boys and fifty girls.

3.2.5. Validity of the instrument

To find the validity of the instrument, the researcher refers the results of the pilot study with the original research in which the scale was used. The children spatial reasoning answer showed 100% result when carried out in government and private institution of Lahore for pilot study. Whereas in the research "A study of Spatial and Quantitative reasoning Abilities of School Children" by Zhong and Tian, explored 1782 children spatial reasoning abilities age from 4 to 7 in which 71.5% of all participants answered question no. 1 correctly. This shows that mostly children had high spatial reasoning ability. The results also showed that the participants from the age five and a half year old to five and eleven months have considerable increase in the success of this item. The results from the pilot study and from the refer research shows that the quantitative reasoning ability develops slowly compared with spatial reasoning ability. 23.33% of the students from the pilot study sample answered question no 2 correctly and from the refer research, 31.94% answered the same question correctly. In question no 3 from pilot study, 23.33% answered question no 3 correctly whereas in the refer research, only 40.76% answered the question correctly. The matching results show that the instrument is valid and fulfilling the desired purpose of the research objectives.

3.2.6. Instrumentation

The researcher developed a new semi-structured questionnaire with the help of an interview scale by Zhong and Tian. The tool validity was carried out when the children showed correct answers to the question no. 1, 2 and 3 and gave strong reasons to their answers during pilot testing. According to the scale, Question no 1 is specifically used to check the spatial reasoning ability of children. As the understanding of children regarding the icons of house greatly depend on the spatial reasoning ability, they have. According to the scale, there are three levels of spatial reasoning ability:

- High level is define as "Spatial level" and is characterized by the successful icon house connection meaning that a child can cognitively convert a 2 dimensional figure into a three dimensional object. If a child answers "3 rows of houses" in response to question 1, he or she will be categorized in the range of spatial level.
- Middle level is defined as the fuzzy level meaning the connection between the house and its icon is weak but present.
- Low level is defined as plane level and is characterized by an inability to make the icon-house connection, meaning the child has the images of houses but cannot make the connection to the icons of houses. If a child answers, one row of houses in response to Question 1, he or she will be categorized in the plane level.
- We are interested in whether children have to identify three rows in the picture in order to count the numbers of the doors and parterres. For the sake of this purpose,
- Correlation coefficients among the three questions will be computed. The participants include both male and female children.
- Questions 2 and 3 are structured to assess the quantitative reasoning of children since they require something in addition to spatial reasoning. Basic quantitative reasoning is required by the child's side to correctly answer the two questions. Because some of the doors and flower beds occluded in the picture, children would have to calculate the quantities of all the doors and flower beds by reasoning from some information such as the shapes of the roofs of houses and the patterns of the doors and flower beds that are not occluded in the picture.
- According to the scale, there exist three quantitative reasoning levels as follows:

1. Abstract computation level: correctly answer that there are 15 doors and 9 flower beds.
2. The conjecture computation level is characterised by answering that there are more than 12 doors (but not giving the correct answer of 15) and /or that there are more than 6 flower beds (but not giving the correct answer of 9).
3. Finally, the literal computation level is characterized by answering that there are 12 doors and/ or 6 flower beds.

Step II: Data collection

After checking the validity of the tool, the data was collected from two government and two private schools. The data was collected in two weeks' time duration.

Table 1: Data collection plan

Institution Name	No of participants per day	Days per week	Dates
The Punjab School	25 boys from class 1	Tuesday	7th April
	25 boys from class 1	Wednesday	8th April
	25 girls from class 1	Thursday	9th April
	25 girls from class 1	Friday	10th April
Total	100 participants	Days	Dates
LDA school	25 boys, class 1	Monday	13th April
	25 boys, class 1	Tuesday	14th April
	25 girls, class 1	Wednesday	15th April
	25 girls, class 1	Thursday	16th April
Total	200 participants		

3.3. Data collection process

3.3.1. Informed consent

In order to meet informed consent criteria, the researcher consent from the administration of the schools to conduct research. Identities of the students were kept hidden. The data was collected from the following schools:

- The Punjab School Township Lahore. (Private School)
- LDA school Iqbal Town Lahore (Govt. school)

Students were briefed about the questions on the questionnaire relevant to the picture (see appendix x). As all the students were minors,therefore, the interviewer asked the questions and assisted in filling up the responses on their behalf.

Step III: Data analysis

The data was statistically analyzed in the SPSS software. The Pearson correlation was conducted between the spatial reasoning ability and numerical reasoning ability to find out the relationship among them, the significant gender difference, government and private school difference of spatial and quantitative reasoning was found out through chi square test in spps software 19.

4. Results

Following tables shows the level of reasoning of spatial and quantitative abilities of children belonging to public and private schools.

Table 1: No. of rows of houses in the picture

Rows of houses	Frequency	Percentage
3 rows of houses	125	71.4
2 rows of houses	11	6.3
1 row	3	1.7
4 rows of houses	13	7.4
5 rows of houses	22	12.6
Total	174	100.0

Table 1 shows that 125 students answered 3 rows of houses meaning that 71.4% students are ranked under the high level which is spatial level. 7.3 % students had difficulty in making connections of the houses and its icon but it was present. Thus, they are ranked as under the fuzzy level. 1.7% students are placed in low level of spatial reasoning,

Table 2: Reasoning of students about rows of houses

Rows of houses	Frequency	Percentage
Counting	127	72.6
Guess or rough estimation	41	23.4
By multiplication	3	1.7
Total	171	100.0

Table 2 shows that 127 students counted the rows of houses. Whereas 23.4% students answered the question no 1 by guessing or rough estimation. Only 1.7 % students said that they used multiplication method.

Table 3: No. of doors of houses in the picture

Doors of houses	Frequency	Percentage
15 doors	13	7.4
14 doors	7	4.0
12 doors	129	73.7
10 doors	10	5.7
9 doors	16	9.1
Total	175	100

Table no 3 shows the demographic information of quantitative reasoning of the students. The table shows that 7.4 % of the students answered 15 doors of houses which places them under abstract computational level. They reasoned for their answer that they counted the hidden doors of houses as well. Some gave reasoning that if there are 5 doors of houses in one row then there will be 15 doors of houses in three rows. Whereas 73.7% students counted only the doors that could be seen by the child. The child missed the hidden doors

Table 4: Reasoning of students about doors of houses in the picture

Doors of houses	Frequency	Percentage
Counting	144	82.3
Guessing or rough estimation	26	13
By multiplication	5	2.9
Total	175	100.0

Table 4 shows the reasoning that children gave about the doors of houses in the picture. Nearly 82.3% children said that they counted the number of doors. 13% children said that they guessed or used rough estimation and 2.9% said that they used multiplication method to answer the question.

Table 5: No. of flower beds in front of the houses

Flower beds	Frequency	Percentage
9 flower beds	13	7.4
6 flower beds	134	76.6
7 flower beds	17	9.7
4 flower beds	8	6
3 flower beds	3	1.7
Total	175	100

Table 5 shows the responses of children about the rows of houses. Only 76.6% children responded 6 flower beds which places them in literal computational level. Table shows that 7.4% students achieved abstract computational level which is the highest level of quantitative reasoning ability while 9.7 % students achieved conjecture computational level because they answer more than 6 flower bed(see scale description).

Table 6: Reasoning of students about the picture having flower beds in front of the houses

	Frequency	Percentage
Counting	145	82.9
by rough estimation or guessing	24	13.7
by multiplication	6	3.4

Total	175	100.0

Table 6 shows the reasoning of children used to answer the question. Table shows that only 3.4% children responded that they used multiplication method to answer the question. 82.9% counted the flower beds. 13.4% children guessed or rough estimated to answer the question.

Table 7: Spatial reasoning ability level of school children

Rows of houses	Frequency	Percentage
Spatial level	125	71.4
Fuzzy level	11	6.3
Plane level	39	22.3
Total	175	100.0

Table 7 shows the demographical information of the spatial reasoning abilities of school children. 71.4 % students achieved the spatial level which is the highest level of spatial reasoning ability.

Table 8: Quantitative reasoning ability level of school children from doors of houses

Doors of houses	Frequency	Percentage
Abstract computational level	13	7.4
Conjecture computational level	7	4.0
Literal computational level	129	73.7
Total	149	100

Table 8 shows that 7.4 % students achieved Abstract computational level, 4.0% students achieved middle level "conjecture computational level" while 73.7% school children achieved literal computational level which means that majority of the children counted only the doors which were not hidden.

Table 9: Quantitative reasoning ability level of school children from flower beds

Flower beds in front of the houses	Frequency	Percentage
Abstract computational level	13	7.4
Conjecture computational level	17	10.36
Literal computational level	134	81.70
Total	164	100

Table 9 shows that only 7.4 % children answered correctly to the question no. 3 and achieved the highest level of quantitative reasoning ability which is Abstract computational level. Whereas, 10.36 % school children answered more than 6 flower beds and could not answer the exact figure of 9 flower beds, therefore, they are placed in conjecture computational level. Majority of the school children counted the flower beds which were not hidden and gave an answer of 6 flower beds which places them in literal computational level meaning that they have achieved the lowest level of quantitative reasoning ability.

4.1. Gender Differences

The gender comparison of spatial and quantitative reasoning was also found out by applying chi square test between the responses of boys and girls.

Table 10: Gender differences of spatial reasoning ability

Gender					
Rows of houses	**Boys**	**Girls**	**χ^2**	**Df**	***p***
Spatial level	72	53	1.896	2	0.387
Fuzzy level	7	4			
Plane level	18	21			
Total	97	78			

The table 11 shows no significant difference between the responses of boys and girls with reference to spatial reasoning ability. As shown in the table chi square value χ^2 (2) = 1.896, p= 0.387 which is not significant. Therefore, it can be concluded from the findings that there is no difference between the spatial reasoning of boys and girls.

Table 11: Gender differences about the quantitative reasoning ability (doors of houses)

Gender					
Doors of houses	**Boys**	**Girls**	χ^2	**Df**	***p***
Abstract computational level	9	4	3.205	2	0.201
Conjecture computational level	2	5			
Literal computational level	76	53			
Total	87	62			

Table 11 shows the gender comparison responses of students about quantitative reasoning (doors of houses). As shows in the table $\chi^2(2) = 3.205$, p = 0.201 which is not significant. It shows that there is no difference in response between boys and girls when compared on gender basis.

Table 12: Gender differences about the quantitative reasoning ability question asking about the number of flower beds in the picture

Gender					
Flower beds	**Boys**	**Girls**	χ^2	**df**	***p***
Abstract computational level	11	2	3.818	2	0.148
Conjecture computational level	10	7			
Literal computational level	76	58			
Total	97	67			

Table 12 shows the gender comparison of responses from boys and girls about their quantitative reasoning question asking about the number of flower beds in front of the houses. As shown in the table, $\chi^2(4) = 3.818$, p= 0.148 which is not significant. It shows that there is no significant gender difference between boys and girls quantitative reasoning responses provided by them.

4.2. Correlation between Spatial Reasoning and Quantitative Reasoning Abilities

Table 13: Pearson correlation between spatial reasoning ability (rows of houses) with quantitative reasoning (doors of houses, flower bedsCorrelations

Pearson correlation	**Spatial reasoning**	**Quantitative reasoning**	**Quantitative reasoning**
Spatial reasoning (rows of houses)	1	.034	.083
Quantitative reasoning (doors of houses)	.034	1	.335**
Quantitative reasoning (flower beds)	.083	.335**	1

**. Correlation is significant at the 0.01 level (2-tailed).

The pearson correlation has been found out between the question no 1 with question no 2 and 3 to analyze whether children were able to identify three rows of houses in picture or not. The table shows that the coefficient between question no 1 and question no 2 is 0.034 which is not significant. The coefficient between question no 1 and question no 3 is 0.083 which is also not significant. The coefficient between question no. 2 and question no 3 is 0.335 which is significant. Therefore, it means, no direct relationship between the spatial and quantitative reasoning abilities of children.

5. Discussion

A lot of psychologists and researchers are showing curiosity in cognitive development of children. Dong (2000) states that children who are 4 to 6 years old have less mathematical understanding (Tian & Huang, 2009). This research was carried out to find out the spatial and quantitative reasoning abilities of children age 6 years. More specifically, this study assessed which level children possess spatial and quantitative reasoning. It was found that majority of children who answered 3 rows of houses of question no 1 gave reasoning that they counted the three rows of houses. Piaget claimed that children numerical conception develops through the means of counting and understanding conservation of quantity (Fang, 2001). The researchers found that a 6 year old child studying in school was able to understand different conservation when the researcher asked the reasoning of how do they know 15 doors and 9 flower beds, they provided the logic that each row must have 5 doors and 3 flower beds and then they multiplied with 3 rows of houses. Here, conservation concept of children and numerical conception played a crucial role in counting the number of doors and flower beds. The children spatial and quantitative reasoning ability had no difference of gender when the researcher applied chi square for analysis. As we know from the scale description that there are three levels in which the scale for spatial reasoning has been categorized (Tian & Huang, 2009). The results from table 4 revealed that 71.4% children possess "spatial level" which is ranked as the highest or top level of spatial reasoning ability, 6.3 % of school children m achieved fuzzy level which is the middle level of spatial reasoning ability while 22.3 % of the students achieved the plane level which is the lowest level of spatial reasoning ability. The results from table 1.1 reflect the fact that majority of children who answered 3 rows of houses to question no 1 reasoned that they counted the three rows of houses which means that they used numerical conceptions. Piaget stated that an infant as young as five months old achieve object permanence. Baillargeon, Spelke, Wasserman also states same results that infants develop object permanence as young as five months old. Spatial reasoning ability is a part of object permanence (Baillargeon, Spelke, Wasserman, 1985). Table 2 shows that fewer children in the age of six was not able to identify the patterns of space in the picture. The reasoning ability of primary school children is of vital importance. Current research assessed 6 year old children quantitative reasoning and discovered the fact that only 7.4 % children could answer question no 2 and 3 correctly. Therefore, we may interpret that quantitative reasoning development is slower as compared to spatial reasoning ability in the age of six years.

6. Conclusion

The study concludes that quantitative reasoning development at the age of six is comparatively slower to spatial reasoning ability. This finding suggests that while children in this age group possess numerical conceptions, they may not yet have fully developed the capacity to apply these concepts consistently in quantitative reasoning tasks. Instead, they are more adept at integrating their numerical understanding within spatial contexts, which could indicate that spatial reasoning serves as a foundation for their early problem-solving abilities. The slower development of quantitative reasoning at the age of six indicates that there is a need to design interventions that target and increase numerical understanding. As children in this age show a middle level of quantitative reasoning ability, the teachers can focus on structured activities which bridge the spatial reasoning skills with the numerical skills of children. The results highlight the importance of a balanced approach to cognitive development, in which the spatial reasoning can be used to support the growth in quantitative reasoning. This can have further implications for how the curriculum of Mathematics can be structured in early childhood, with an emphasis on mixing spatial and quantitative tasks to promote holistic cognitive development. Further, this study can provide a base to the future researches analyzing the role of certain external factors i.e., socioeconomic background, access to resources or cultural approaches to early child education, in varying rates of cognitive development across different domains.

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