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Imaginative Interconnection and its Relationship to Spatial Thinking Among Preparatory School Students in Mathematics

Salam Kadhim Inad[1], Dr. Lina Fouad Jawad[2]

Abstract

The aim of the research is to identify the nature of the correlation between imaginative interconnection and spatial thinking. Correlational descriptive methodology has been adopted. The research community, which represents fourth-grade students in governmental preparatory and secondary schools affiliated to the General Directorate of Education of Karbala / Center, was identified for the academic year (2022-2023). The number of the sample was (381) male and female students (156) male and (225) female students, and for the purpose of collecting data for the research, two tests were constructed: the imaginative interconnection test and the spatial thinking test. The psychometric properties of them were confirmed, and then the appropriate statistical methods were adopted to analyze the results, and the results indicated that the students of the research sample do not possess imaginative interdependence or spatial thinking, and there is a direct positive correlation between imaginative interconnection and spatial thinking in the research sample.

Keywords: *Imaginative interconnection, spatial thinking.*

1. Introduction

Students suffer from difficulty in understanding mathematics and not absorbing it in the required manner. Many students face difficulty in employing knowledge based on space, which includes complex concepts, because the educational reality of mathematics within school classrooms teaches scientific concepts in a way that requires students to think abstractly, and this constitutes difficulty for them in acquiring concepts, and thus building scientific knowledge. Curricula and teaching methods used in schools to this day still cannot properly develop mathematical abilities such as the student's ability to solve mathematical problems, not to mention other skill abilities, such as the student's ability to spatial visualization. Students suffer from problems of spatial perception so that it is difficult for them to translate what they see, they do not distinguish the relationship of things to each other or to themselves in a fixed and predictable way, here they may not be able to estimate the distance, or they see things in a double or confused way, and they may suffer from problems in judging identical or similar shapes or the size of shapes, or these students suffer from weakness in visual memory or visual spatial perception, (NCTM, 2000) that the students' inability to understand geometric shapes and their properties and poor understanding of concepts, properties and relationships Their low ability to solve and prove engineering problems is due to the traditional teaching methods used in teaching geometry and the scarcity of using teaching aids [1].

[1] College of Education for Pure Sciences - Ibn Al-Haitham, University of Baghdad, salam1987ro@gmail.com
[2] College of Education for Pure Sciences - Ibn Al-Haitham, University of Baghdad, lina.f.j@ihcoedu.uobaghdad.edu.iq

1.1. Research question:

Is there a correlation between the Imaginative interconnection among preparatory school students in mathematics? And spatial thinking?

1.2. The Importance of Research

1.2.1. Theoretical importance:

a) Highlighting the importance of imaginative interconnection patterns in the educational process by training and developing students to use imagination to evoke a number of diverse and different ideas through their knowledge of the problems of study subjects.

b) The importance of spatial thinking in the educational field because of the basics of successful learning.

c) It is a scientific addition to teaching mathematics, especially in the field of imaginative interconnection and spatial thinking.

1.2.2. Applied importance;

a) Investigating the possession of students of the fourth scientific grade in the schools of the General Directorate of Education of Karbala the imaginative interconnection patterns in order for students to acquire higher-order thinking processes, which enable them to store and retrieve information and apply it in all areas of practical life.

b) Providing the research field with a test and spatial thinking of mathematics for the fourth scientific grade, which has psychometric properties, so that mathematics teachers can benefit from preparing their tests for students in the same way and moving away from the traditional achievement test.

c) This research gives feedback to the trainers of training programs by focusing on courses that develop imaginative interconnection and spatial thinking.

1.3. The Aim of Research:

The research aims to identify the nature and direction of this correlation between imaginative interconnection and spatial thinking among the students of the study sample.

1.4. Hypothesis of Research:

a) There is no statistically significant difference at the level (0.05) between the mean scores of the real and hypothetical performance of the research sample students in the imaginary interconnection test.

b) There is no statistically significant difference at the level (0.05) between the mean scores of the real and hypothetical performance of the research sample students in the spatial thinking test.

c) There is no correlation at the level (0.05) between the imaginative interconnection and spatial thinking among the research sample students.

1.5. Limits of Research:

a. Students of the fourth scientific grade in the holy city of Karbala, / center

b. Mathematics book for the fourth scientific grade, ed. 13, which is to be taught by the Ministry of Education.

c. The second semester of the academic year 2022-2023

1.6. Definitions of the Terms:

1.6.1. Imaginative interconnection:

Encoding, organizing, storing, and retrieving information based on unrealistic associations between elements, images, or bodies that take the form of similarity, causation, simultaneity, or self-creation for the purpose of better cognitive processing of tangible perceptual information. [1]

The researchers define it procedurally as: (the process of encoding, organizing, storing and retrieving information carried out by the students of the fourth scientific grade in its four patterns (similar bonding, causative bonding, creative bonding, sequential pictorial bonding) for the purpose of better cognitive processing of tangible perceptual information measured by the total score obtained in the imaginary bonding test prepared for this purpose.

1.6.2. Spatial thinking:

A set of mental treatments and scientific practices that the student undertakes to solve a problematic situation, linked to two- and three-dimensional shapes in space, and these treatments and practices are represented in the ability to perform mental visualization, comparison, comparison, discrimination, description, mental rotation, construction, installation, and representation of flat and solid forms. [2]

The researchers define it procedurally as: a set of mental manipulations carried out by students of the fourth scientific grade with its seven skills, which are (the skill of verbal description of shapes, the skill of matching between the body and its constituent network, the skill of spatial visualization, spatial memory, the skill of representation of shapes, the skill of construction and composition, the skill of mental rotation) to solve a problem related to two- and three-dimensional shapes measured by the total score obtained in the spatial thinking test prepared for this purpose. [3]

2. Theoretical background:

2.1. Imaginative interconnection:

2.1.1. The concept of Imaginative interconnection:

The scientist took interest in Taylor (1963, Taylor) in the sixties of the last century when he studied how individuals interpret artificial images that he made that include interconnected fantasies representing fantasies known to individuals such as (an old man carrying gifts for children on birthdays or a stork carrying a baby), and asked them to indicate the level of representation of these Imaginative interconnections and their reasons. [4] [5]

And (Kosslyn, 1982) conducted a study on how individuals embody imaginary illusions in realistic images in order to master cognitive production and reduce the effort expended in cognitive processing. Participants were asked to comment on sentences that represent imaginary associations such as (the sun disk looks angry on a hot summer afternoon) and (the watermelon in the fields brings a smile to the farmer) and (the sunflower disk is joking).[6] [7]

The deep processing of environmental information is based on the basis of the easiest and best understanding, and this form is most preferred automatically by the cognitive arrangement in dealing with the inputs, which sometimes results in the process of imaginary interdependence. He believes that it needs additions for the purpose of good proficiency, and sometimes he works the opposite, so he deletes certain characteristics, and then after that he classifies such as saying this drink is similar to orange juice or orange juice, except that he is more dexterous than he raises a specific characteristic for

the purpose of mastering the imaginative perception, that the process of interdependence is not completely and completely realistic and may occur consecutively or sequentially, and it may be regular or irregular, similar or interconnected, and this does not mean that the two imaginary forms or patterns are interconnected. But we are the ones who put this connection in order to facilitate or clarify the cognitive process and simplify it in order to deal with stimuli and spend less time and easier effort for better imaginative perception. [8] [9]

2.1.2. Imaginative interconnection patterns:

2.2.1.1. Analogy Interconnection:

This type of interconnection is based mainly on the idea that there is a similarity between imagination and reality or a part of reality. For example, we can point to an imaginary Interconnection image (an angry train). This is an analogy for the classic train shape and its moderate path and the smoke coming out over its head, and then there is an analogy for the occurrence of a state of anger, as if from its annoyance smoke comes out of it. Among them is the nature of the imaginary realization or the pattern or type of the imaginary that they use in order to prove their point of view or bring out their images and their creative output, and this analogy may be in the body or in the act or in connection. The action is real and the action is not real. The plant actually moves towards the sun, but it is not conscious and does not smile at all. Therefore, the action is analogous within this mode of associative imagination. As for the connection, the actions may be real and the objects are real, but the connection is imaginary. So the imaginary connection here is only for the type of interconnection between the two actions in the symbolic imaginary, for example (very tall trees that penetrate the clouds). The trees are real and the clouds are real, but the connection is imagined. [1] [10]

2.1.2.2. Causal interconnection:

This type of interconnection is to add a reason to an event, and here the correlation is imaginary, and this causative interconnection has irrational roots, for man is always inclined to give reasons for events that occur on the ground of reality, but he is unable to understand why and how they occurred and he cannot predict when they will occur again, and then he is inclined to give reasons from his own. For example, (a dragon that flies in the sky and shoots at villages) and this causes fires to occur in homes, huts and farms in the harsh winter season, as the use of fire stoves was uncontrolled and widespread, which causes many fires, especially late at night when everyone sleeps and no longer pays attention to the fire. around them. So they give reasons and these reasons for the incidents that they do not find an explanation for, so that they use imagination for the purpose of giving the embodied meaning to the magical (fabulous) scene that their imagination makes.[1] [11]

2.1.2.3. Creative interconnection:

It means inventing and finding new formulas that have not been touched previously on a kind of relationship of the imagined with objects or between the imaginaries themselves, or creativity with the pattern and form of the verb or movement, or giving the formula of life to inanimate objects. Not an idea as an idea. The connection between the shape of the stick and the person riding it, just like riding a horse and flying with it, is an old and innovative idea, as well as the idea of the flying rug, and accordingly there is a kinetic imaginary connection or a connection to the act produced from inanimate objects. The formula of creativity is to give the verb form, movement, or the possibility of self-movement to inanimate bodies that do not have the elements of actual movement. There is no engine or any means that helps in roaming or propelling bodies to move (such as the sail for ships, for example). Therefore, the creative formula is in adopting the idea that there is embodied magic or a magical idea about the possibility of inanimate objects from action and movement. This is to satisfy the human desire to do action and movement.

Creativity is very advanced for the period in which it was invented, and creativity in the process of imaginary interconnection is in the process of movement or giving movement to rigid bodies and they become mobile and take movement orders from the human who controls them, and all of this includes an imaginative creative interconnected idea .[1] [12]

2.1.2.4. Sequential pictorial interconnection:

This type of Imaginative interconnection includes the ability to give an imaginary connection based mainly on the pattern of the real image sequence, and this sequence gives a kind of imaginative possibility that connects the parts of these successive images observed by the individual. Or the organization that is based mainly on the sequence of images perceptually, that this perceptual organizing feature also means the possibility of the imaginary sequence at the same time, which is either real with creating an imaginary movement or activity, or a reality that is related to imagined objects at that moment, that is, it does not exist at the moment of processing, or it is basically imaginary. For example, the imaginary connection between the farm and a barrel of milk and the presence of the farm dog, so there would be an imaginary connection (for the farm dog carrying a barrel of milk around its neck and distributing the milk to the farmers on the farm). The truth is that the dog is beloved and friendly and helps the farmers, and there is a barrel inside which there is cold milk that the farmers drink from, and therefore the connection is in the sequence of mentally imagined images. This pattern is not common, but it is realized in Imaginative interconnection.[1] [13]

The four imaginary association patterns are originally forms of mental manipulations based on the rules of imaginative mental activity in the original process of imagination, which is that mastery means simplicity in arranging imagination, and this arrangement is speed and speed lies in good dealing with the environment, but in recent periods psychology has become very complicated and the principles in general are not sufficient in detail in order to understand the pillars and the mechanism of action of each imaginary act, which refers to the plot and intelligence of imaginary associations at a high or medium level and quantity Its comprehensiveness and saturation, the origin and reality of imagination is not far from reality, but it is the reality itself, and that new fantasies are not far from reality and this imaginary process is not isolated from the system of general mental activity, these basics include the realism of observation, the realism of the mind, and the realism of treatment, and this is very complex and is not often found among psychological researchers. Scientific research in the path of imagination will collide with the reality of the technology behind it in order to identify it and the huge costs of measurement and verification. [14]

2.2. Spatial thinking:

Spatial thinking is closely related to human daily life, as it plays an important role in understanding how to organize things around us, describe them, identify their parts relative to each other, and ways to differ between them, and then easily build explanations, predictions, and hypotheses.

Spatial thinking itself is not a content-based system in the way that mathematics, physics, biology, or economics are disciplines, but rather a way of thinking that permeates those disciplines. The spatial reasoning process is its strength, versatility, and applicability. Spatial reasoning is multifaceted in its process, just as there is no single recipe for how to think verbally or mathematically, nor is there a single way to think spatially. Instead, the spatial reasoning process includes broad sets of interrelated competencies that can be taught.[15]

2.2.1. Spatial thinking skills:

2.2.1.1. Verbal Shapes Description:

The ability of the individual to translate the distinctive characteristics of the visual form into words and concepts associated with it, or translate visual stimuli into verbal stimuli.

2.2.1.2. Net and Solid Card Matching skill:

The ability of the individual to distinguish and discover the similarities between the shape in the case of folded (hologram) and in the case of unfolding it (flat), and to carry out the operations of comparison, debate and matching between them.

2.2.1.3. Spatial Visualization:

A special ability that includes understanding and awareness of spatial relations, circulation of mental images, and visualization of different situations in the imagination.

2.2.1.4. Spatial Memory:

The ability to recall the image of an object and the properties associated with it and other objects. Or the ability to retrieve the image of the shape after seeing it for a specified period of time.

2.2.1.5. Shapes Representing:

An individual's ability to make a layout conforming to the visual or verbally described form.

2.2.1.6. Generating:

The ability of the individual to construct units of flat and stereoscopic shapes that are in front of him in the form of a visible stereoscopic model or in the light of an audible pronunciation.

2.2.1.7. Mental Rotation:

The ability to move or rotate the mental image of an object or the ability to perceive the shape from different angles when changing position and direction. Or the ability to rotate shapes in the mind.[16]

3. Search procedures:

3.1. Research Methodology

In the current study, the researchers adopted the descriptive approach, in order to achieve the objectives of the research.

3.2. Research Population:

The community includes all students of the fourth scientific grade in government preparatory and secondary schools affiliated to the General Directorate of Education of Karbala / Center for the academic year (2022-2023), after determining the number of students from the original community, whose number is (8014).

3.3. Research Sample:

It includes students of the fourth scientific grade in government preparatory and secondary schools affiliated to the General Directorate of Education of Karbala / Center for the academic year (2022-2023). Their number reached (381) male and female students, with (156) male and (225) female students.

3.4. Tools of Research:

Two tests were built, a test to measure imaginative association, and a test to measure spatial thinking:

3.4.1. Imaginative interconnection test:

The researchers relied on the Imaginative interconnection patterns of (Paivio, 1971). The test consisted in its initial form of (28) items, (25) of the type of objective questions, (3) of the type of essay questions.

To ensure statistical analyzes and psychometric characteristics, based on the opinion of a number of arbitrators in the field of mathematics and its teaching methods, paragraphs (14, 19, 23) were deleted due to their difficulty. Regarding the rest of the paragraphs, it received the approval of 80% or more, so that the number of test items became (25) items.

The researchers applied the test to a second survey sample consisting of (150) students who were randomly selected from the research community.

The correction key (0, 1) was adopted for the correction method, and since the Imaginative interconnection test consists of (28), the highest score that the student can obtain in the Imaginative interconnection test is (28) degrees, and the lowest score obtained by the student is zero (0). The values of the discrimination coefficient ranged between (0.22 - 0.54), and paragraph (14) was deleted. Also, all the wrong alternatives were highly effective. The validity of the test was verified and the Pearson correlation coefficient was adopted to extract the correlation coefficient between the score of each paragraph and the total score of the test. The degree of stability of the test items, Calculated by the Cronbach alpha equation for Imaginative interconnection test (0.76), this result is good.

3.4.2. Spatial thinking test:

The researchers relied on the skills (the skill of verbal description of shapes, the skill of matching between the body and its constituent network, the skill of spatial perception, the spatial memory, the skill of representing shapes, the skill of construction and composition, the skill of mental rotation) in constructing the spatial thinking test, and the test in its initial form consisted of (24) items of the objective type. In order to ascertain the statistical analyzes and psychometric characteristics based on the opinion of a number of arbitrators in the field of mathematics and teaching methods, paragraph (18) was deleted due to its difficulty. Regarding the rest of the paragraphs, it received the approval of 80% or more, so that the number of test items became (23) items. The researchers applied the test in a second survey sample consisting of (150) students, who were randomly selected from the research community. The correction key (0, 1) was adopted for the correction method, and since the spatial thinking test consists of (24), the highest score that the student can obtain in the imaginary correlation test is (24) degrees, and the lowest score that the student obtains is zero .

The difficulty coefficient ranged between (0.46 - 0.78), and the coefficient of ease ranged between (0.22 - 0.54), as most sources indicate that the test items are acceptable and good and it is advised to keep them, so the paragraph that is outside this ratio was deleted, and this paragraph is (18) due to its difficulty. The values of the discrimination coefficient ranged between (0.29 - 0.59), except for paragraph (18) that was deleted. Also, all wrong alternatives are effective. The validity of the test was verified, as the researchers used the Pearson correlation coefficient to extract the correlation coefficient between the degree of each paragraph and the total score of the test. As the stability of the test items reached its degree, which is calculated using the Cronbach alpha equation for spatial thinking test (0.78), and this result is considered good.

3.5. Search Tools Application:

After conducting statistical treatments for each of the Imaginative interconnection test, which became consisting of (25) items after deleting (14,19,23) by statistical analysis, and the spatial thinking test, which became composed of (23) items after deleting (18) by statistical analysis, the researchers applied the two tests and appropriate environmental conditions were taken into account during their application, and thus the data and information became ready for the purposes of statistical analysis.

Display and interpretation of results:

4.1. Results related to Imaginative interconnection:

The validity of the first hypothesis related to comparing the real performance of the students with the hypothetical performance was tested, and the results were: When observing the scores obtained by the sample students, it was found that the arithmetic average of the real performance of the students of the research sample amounted to (10.28) degrees, and compared with the hypothetical average of the test, which is equal to (12.5) degrees, we note that the real average performance is less than the hypothetical average performance, and this leads us to conclude that the students (the research sample) do not have Imaginative interconnection (as a whole).

Table (1) Results of the t-test to measure the difference between the real and hypothetical average of the students of the research sample in the Imaginative interconnection test

Sample size	average		standard deviation	standard error	t value		Freedom Degree
	real	hypothetical			computed	tabular	
381	10.28	12.5	4.442	0.228	9.763	1.96	380

It is clear from Table (1) that the calculated t-value is higher than the tabular t-value, and therefore the null hypothesis is rejected and the alternative is accepted, meaning that the research sample individuals do not have the imaginary connection, and the researchers believe this result is logical, since the research sample students do not have.

4.2. Results related to spatial thinking:

When observing the grades obtained by the students of the research sample, it was found that the arithmetic average of the real performance of the students of the research sample amounted to (9.63) degrees, and compared with the hypothetical average of the test, which equals (11.5) degrees, we note that the average real performance is less than the average hypothetical performance, and we infer that the students (the research sample) do not possess spatial thinking (as a whole),

The t-test was adopted for one independent sample, and the results were as shown in Table(2) :

Table (2) Results of the t-test to measure the difference between the real and hypothetical average of the students of the research sample in the spatial thinking test

Sample size	average		standard deviation	standard error	t value		Freedom Degree
	real	hypothetical			computed	tabular	
381	9.63	11.5	4.415	0.226	8.255	1.96	380

It is observed from Table (2) above that the calculated t-value (8.255) at a degree of freedom (380) and a level of significance (0.05) is greater than the tabular t-test value of (1.96) and because the calculated t-value is greater than the tabular t-value, then we reject the null hypothesis and accept the alternative, i.e. there is a statistically significant difference.

4.3. Results related to the correlation between Imaginative interconnection and spatial thinking:

The Pearson correlation coefficient (Pearson cor.) was used to test the validity of the null hypothesis above to calculate the correlation coefficient between the scores of the students (the research sample) as a whole on the test prepared to measure their Imaginative interconnection and their scores on the spatial thinking test, and to find out the value of the significance of the correlation coefficient, the researcher used the t-test of the correlation coefficients to test the validity of the above hypothesis, and a table (3) shows the results of the correlation coefficients and the t-value of the significance of the correlation

Table (3) Correlation coefficients between Imaginative interconnection and spatial thinking and the t-value of the Correlation significance of the research sample

Type of test	Sample size	average	Standard deviation	Standard error	coefficient value	The t-test value
Imaginative interconnection	381	10.28	4.442	0.228	0.985**	110.8
spatial thinking		9.63	4.415	0.226		

From the table (3), where the value of the correlation coefficient calculated between the Imaginative interconnection and spatial thinking for the grades (sample of the research) of fourth-grade scientific students in government schools in the Holy Karbala Governorate / Center (0.985), and it is considered a positive and very strong correlation coefficient if it exceeds 0.75.

The correlation coefficient is statistically significant at a level of significance (0.05) and a degree of freedom (379), and since the t-value (t-test) for the significance of the correlation coefficient amounted to (110.8), which is greater than the tabular t-test value of (1.96), and this indicates the rejection of the null hypothesis above and the acceptance of the alternative hypothesis.

That is, the results indicate that there is a strong correlation between the two variables (Imaginative interconnection - spatial thinking), and the direction of the relationship between them is direct, that is, the greater the Imaginative interconnection of students, the more spatial thinking increases with it.

5. Conclusions:

In light of the results of the current research, the researcher can conclude the following:

a) The students of the fourth scientific grade in the schools of the Holy Karbala Education Directorate do not have Imaginative interconnection.

b) The sample students in the holy city of Karbala do not possess spatial thinking.

6. Recommendations:

In light of the findings of the current research, the researchers recommend the following:

a) Emphasis on students' imagination by the General Directorate of Curricula when preparing mathematics curricula in general and the fourth grade science curriculum in particular, and developing students' Imaginative interconnection.

b) The provision of appropriate educational activities by the Equipment Department in the Directorate of Education, which develop their Imaginative interconnection patterns and spatial thinking skills.

c) The Directorate of Preparation and Training to educate teachers and train them on modern teaching strategies that will develop Imaginative interconnection and spatial thinking among students by holding workshops to focus on them in the classrooms.

d) Recommending to the General Directorate of Curricula to include Imaginative interconnection and patterns and how to develop and develop these patterns among students in a guide for secondary school mathematics teachers.

e) The Directorate of Preparation and Training to reconsider the teaching methods, and work on training for teaching in the style of imagination and thinking in the void to keep pace with modernity in teaching, and this is what we need in order to develop teaching methods that suit the change in the curricula, and the state must reduce official holidays.

7. Proposals:

In light of the findings of the current research, the researcher suggests the following:

1. Conducting more studies to identify the extent to which mathematics books for other school stages include Imaginative interconnection and spatial thinking.

2. Conducting a similar study at different stages of study.

3. Conducting a study on Imaginative interconnection and spatial thinking for other variables not covered by the current research.

4. Conducting a similar study for the same stage in another governorate and comparing the results.

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