

## **Mathematical understanding and its relationship to learning patterns based on the hemispheres of the brain among middle students**

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### **Abstract:**

The current research aims to identify the direction and strength of the correlation between the mathematical understanding methods (instrumental-relational-abstract) and each preferred style (A-B-C-D) of the learning styles based on the brain hemispheres among the second intermediate grade students, the correlational descriptive approach was used. and the research community was determined, which consisted of (5328) students in the second intermediate grade from (36) secondary and intermediate schools for boys affiliated to Wasit General educational Directorate in Wasit Governorate center, then the basic research sample was determined, and consisted of (372) students in the second intermediate grade. In order to achieve the research objectives, the researchers built a test to determine the mathematical understanding methods, the test consisted of (45) objective items (multiple choice), divided into three tests for the mathematical understanding methods (instrumental, relational, abstract), (15) items for each method equally, in addition to the adoption and modification of a scale to determine the cerebral hemispheres based-learning styles, the scale based on Hermann quadrilateral model from the study (Al-Nawafila, 2008), and consisted of (60) items divided into (15) items for each of the four learning styles (A-B-C-D).

Then, the test and the scale were applied to the main research sample and the following results were obtained:

- 1- The students of the second intermediate grade (the research sample) possessed diversity in their mathematical understanding methods (instrumental, relational, abstract) generally, they possess the instrumental and relational understanding methods, with low possession of the abstract understanding method.
- 2- Second intermediate grade students possess various cerebral hemispheres based- learning styles (A-B-C-D).
- 3- There is a correlation between the instrumental understanding style and each of the preferred learning styles (A-B-C), and there is no correlation between the instrumental understating style and the preferred learning style (D).
- 4- There is a direct correlation between the relational understanding style and the preferred learning styles (A-B-D), and there is no correlation between the relational understanding style and the preferred learning style (C).
- 5- There is a direct correlation between the abstract understanding style and the preferred learning styles (C-D), and there is no correlation between the abstract understanding style and the learning styles (A-B).

### **First, the research problem:**

The results of several studies conducted in Iraq and on different samples at different educational stages indicated low levels of understanding and achievement in mathematics, such as the study of (Al-Uqabi, 2002), (Qaeed&Faris, 2021) study, the study of (Muhammad &Faris, 2021), and (Hussein &Faris, 2021) study

The researchers also believe, through their work experience in the field of mathematics teaching, that there are several problems that lead to students' weak ability in understanding, success and achievement in mathematics and one of these problems is the students' adoption of cognitive preferences styles, or a certain style in learning problem solving method. As a result of the presence of individual differences in their mathematical understanding, the research problem was reinforced by a questionnaire of a sample consisting of (20) male and female teachers of mathematics. And this was done by distributing a questionnaire among them about their determination of mathematical understanding methods and cerebral hemispheres based-learning styles among their students and the relation between these methods and patterns. Only (40%) of the mathematics teachers answers confirmed that their students have different abilities for mathematical understanding and a diversity of its styles, and that (35%) of the answers confirmed that their students have individual differences in their cerebral hemispheres based-learning styles, while (45%) of the teachers' answers indicated that they believe that there is a correlation between the mathematical understanding methods and cerebral hemispheres based-learning styles among their students, and accordingly, the research problem can be identified by answering the following question:

Is there a correlation between the mathematical understanding methods and the cerebral hemispheres based-learning styles among the intermediate school students?

**Research importance:** The importance of the current research is represented by the following:

- 1- The importance of the mathematical understanding methods is highlighted as they represent the mathematical understanding styles that the learner possesses and which he needs in his academic life.
- 2- The results of the current research can also contribute in solving the problems faced by students with low achievement, by presenting the study materials in a way that matches the learning style used by the individual, and it can also be useful in using appropriate teaching methods according to the students' needs and their preferred learning style.
- 3- Identifying the nature of the correlation between the mathematical understanding methods and their brain-based learning styles.

**Research Objectives:** The current research aims to:

- 1- Identification of the mathematical understanding methods among the second intermediate grade students (research sample).
- 2- Identification the cerebral hemispheres based-learning styles, which are preferred by the second intermediate grade students, (the research sample).
- 3-The study of the direction and the strength of the correlation between each of the mathematical understanding methods (instrumental -relational-abstract) and each preferred pattern of learning styles (A-B-C-D) according to the Hermann model.

**Research limitations:** The current research was limited by the following:

- 1- The second intermediate grade students in the day schools of Wasit Governorate Center affiliated to Wasit Education Directorate in the academic year 2022/2021.
- 3- Mathematics book for the second intermediate grade, 1st edition, 2017, part one, included in the Ministry of Education curriculum.
- 4- Mathematical understanding methods (instrumental, relational, abstract)
- 6- Cerebral Hemispheres based learning styles according to Hermann's model of cerebral hemispheres based learning styles.

**Terms identification:**

**First, mathematical understanding:**

It was defined by Al sharf 1996 as follows "this type of learning is more than just memorizing of the subject , hence it includes patterns that provide partial understanding for the communication subject , so if the learner faces a specific communication subject , he needs here realizing this subject and the ability to use and apply it totally and partially in another situations without the necessary of lining it to other subjects "

**Procedural definition of mathematical understanding:** Identifying the mathematical understanding methods (instrumental, relational, abstract) among the second intermediate grade students, according to the scores they obtain through answering the test for the determination of the mathematical understanding methods prepared by the researchers for this purpose.

**Second: the cerebral hemispheres based Learning styles:** It was defined by:

(Gabris, 1985) as "One part of the brain is dominant over the individual's behavior through the nerve centers located in this part, which are more active and influential on the individual's behavior than the nerve centers in the other part." (Gabris, 1985: 182)

**Procedural definition of the cerebral hemispheres based Learning styles:**Identifying the cerebral hemispheres based Learning styles according to (Hermann learning styles) model among the second intermediate grade students, through the scores obtained by the students by answering the scale of learning and thinking styles adopted by the researchers for this purpose.

**Research Methodology:** The researchers adopted the descriptive approach (the approach of studying the correlations, relation and analysis).

**Research community:** It consisted of the intermediate and high day schools for boys in Kut district of Wasit General education Directorate of Wasit for the academic year (2021-2022), which reached (36) schools, and the student community, where the number of students in these schools reached (5382).

**Research sample:** The research sample was selected randomly from the second intermediate grade male students in a simple, to ensure the largest possible homogeneity among its individuals, which amounted to approximately (7%) of the original students community individuals, this is indicated by the sources concerned in the curricula the educational statistics, including (Afana, 1997: 325), and thus the size of the main sample became (372) students.

**Research tools:**

**First: Testing the mathematical understanding methods: the stages of preparing a test to determine the mathematical understanding methods:**

**1. Determining the test objective:** The current test aims to determine the mathematical understanding methods (instrumental, relational, abstract) among the second intermediate grade students.

**2- Determining the mathematical understanding methods and presenting them to specialists:** The researchers prepared a list of the mathematical understanding methods, and presented it to a group of arbitrators specialized in the mathematics teaching methods, where it was confirmed according to the arbitrators' opinions to choose three of the mathematical understanding methods, which are: instrumental understanding, relational understanding and abstract understanding.

**3- Determining the educational subject:** The study subject was determined by identifying the four chapters of the mathematics book's first part for the second intermediate grade students for the academic year 2021-2022, and the content was analyzed on the basis of the mathematical knowledge areas and presenting it to a group of arbitrators, experts and specialists in the field of mathematics teaching methods.

**4- Formulating the test items:** In light of the content analysis results, and after determining (20) main items, each of them is divided into three sub-items with a sequence (1, 2, 3) so that each of these sub-items represents a mathematical understanding method, i.e. (instrumental understanding, relational understanding and abstract understanding) respectively. Thus, the test consists of (60) objective items, each one of the multiple-choice type, followed by four answer options and only one of them is correct.

**5-Preparation of the test instructions:** a. Answer instructions: This included clarification of the answer steps that the student should follow while answering the test items.

B. Correction instructions: The researchers developed a model answer to correct the answers and then they presented this model and the test items to a number of mathematics specialists, teachers and supervisors.

**6- The initial form of the test:** The researchers omitted (6) main items related to the fourth chapter as the curricula were not accomplished and they were replaced with items from the third chapter, so the total number of the main items became (15) items subdivided into (45 sub-items).

**7- Applying the test to the exploratory sample:** The researchers applied this test to the first exploratory sample of the second intermediate grade students, consisting of (30) students, and it came out that the time required for the test was 45 minutes.

**8- Applying the test to the statistical analysis sample:**

The researchers applied the determination of the mathematical understanding methods test on the statistical analysis sample, which consisted of (100) students in the second intermediate grade who did not belong to the research sample.

**9- Statistical analysis of items:** the test was corrected and the final scores of the research sample students were extracted and arranged in a descending order, and then the highest (27%) of the students' scores were chosen to represent the higher group and the lowest (27%) of the exploratory sample students' scores were chosen to represent the lower group and the number of correct answers for the upper and lower group were calculated.

**1- Difficulty index:** Calculated through the equation (items' difficulty index + ease index = 1). It was found that the difficulty index for these items ranged between (0.37 - 0.57).

**2-The items' discriminating power:** the discrimination index was calculated for each item, and the index value ranged between (0.33 - 0.74), and in light of this result, all items were considered acceptable and valid for application in terms of discrimination among students, according to the opinion of (Al-Zahir et al., 1999).

**3- Effectiveness of distractors:** The effectiveness of the wrong distractors values were obtained and these values showed that all the wrong distractors are characterized by distraction.

**4- Psychometric properties of the test:**

**A - Validity**

**1- Face validity:** It was found through presenting the test to a group of (30) expert professors and arbitrators in the field of mathematics and its teaching methods.

**2- Content validity:** To ensure the validity of the test content, it was presented, attached to a copy of the second intermediate grade mathematics book, to a group of mathematics arbitrators and its teaching methods.

**3-Construct validity:** internal consistency was confirmed through:

- Correlation coefficient of the score of each of the test items and the total score for this test: We recognize that all the items were at an acceptable level of consistency, as their values ranged between (0.316\*\* - 0.638\*\*).

- Correlation coefficient between each item and the mathematical style to which it belongs: The correlation coefficient was found using Pearson's correlation coefficient and ranged within (0.323\*\* - 0.638\*\*).

- Correlation coefficient between the scores of each of the mathematical understanding methods and the overall test scores: The researchers found these correlation coefficients using Pearson's correlation coefficient, as their values ranged between (0.857\*\* -0.902\*\*).

2- Reliability: The test reliability was found using Cronbach's Alpha equation, and the Cronbach's alpha method of calculating the reliability is considered appropriate to the definite answer tests(0or 1), the reliability value was (0.92) , which is a high reliability value.

**Second: the scale of the brain-based learning styles**

After reviewing the literature and the previous studies in the field of identifying and measuring the brain hemispheres based learning styles, these studies varied in terms of the countries in which they were conducted, including Iraq and Arab studies such as the studies of (Abdul Hamid, 1998), (Habib, 2003) ,(Al-Shahri, 2005), (Al-Dulaimi, 2005), (Ammar, 2006), (Al-Nawafila, 2008) and the study of (Al-Salout, 2012).

The scale of (Al-Nawafila, 2008) was adopted, which is a scale based on the Hermann Brain Control Tool, This scale was developed by (She in the Chinese), and (Al Nawafilah, 2008) Arabized it, the scale consisted of (60) items describing a set of educational activities that students could prefer in their learning process, distributed over the four lobes of the brain (15) items for each lobe.

**The face validity of the scale:** The scale was presented to a group of experts, arbitrators, and specialists in psychology, psychological counseling, measurement, evaluation and teaching methods, and their number is (30) arbitrators.

**The scale reliability:** The reliability of the cerebral hemispheres based learning styles scale was calculated through two methods:

1. Re-application of the scale: The scale was re-applied to verify its reliability, as it was applied to a random sample consisting of (35) students (Al-Nagah) intermediate school for boys, with an interval of (14) days from the first application, and Pearson correlation coefficient between the two scores was calculated, Where the reliability coefficient was (0.83), which is a high reliability value.

2. Using the Cronbach's alpha equation: to calculate the scale reliability, in addition to calculating the reliability of each of its four domains, and after conducting the necessary statistics, the value of the overall reliability of the scale came out (0.89), which indicates that it is a high and acceptable reliability value.

- **Final application:** The test for the mathematical understanding methods determination and the cerebral hemispheres based learning styles scale were applied to the main research sample, which consisted of (372) male students during the period of 9/1/2022 to Sunday, 16/1/2022, as the Test and the scale were applied to (7) schools affiliated to Wasit General Education Directorate.

**Presentation and interpretation of results:**

**First axis: mathematical understanding methods:** The researchers will present the first axis results through testing the validity of the first and second null hypotheses, by reviewing the following table we identify:

The results of the T-test that measure the difference between the actual and theoretical performances means of the mathematical understanding methods among the second intermediate grade students

Group	Scores' mean	Standard deviation	Standard error	Calculated t value	Tabular t value
Mathematical understanding methods	24.66	2.68	0.14	15.60	1.96
Theoretical mean	22.5				
Instrumental understanding	9.02	1.51	0.09	19.46	1.96
Relational understanding	8.67	1.40	0.08	16.10	1.96
Abstract understanding	6.98	1.38	0.07	-7.27	1.96
Theoretical mean	7.5				

1- The T-value was calculated, and came out to be equal (15.46), which is higher than the tabular value (1.96), so we reject the null hypothesis and accept the alternative hypothesis with the presence of these statistical differences at the significance level (0.05), in favor of the arithmetic mean of the learning style A.

2- The T-value was calculated, and was found to be equal (13.16), which is higher than the tabular value (1.96), so we reject the null hypothesis and accept the alternative hypothesis with the presence of these statistical differences at the significance level (0.05), in favor of the arithmetic mean of the learning style B.

3- The T-value was calculated and its value was (14.38), which is higher than the tabular value (1.96), thus we reject the null hypothesis and accept the alternative hypothesis in favor of the actual performance mean of the learning style C.

4- The T-value was calculated with a value of (23.4), which is higher than the tabular value (1.96), so we reject the null hypothesis and accept the alternative hypothesis at the significance level (0.05) in favor of the arithmetic mean of the learning style D.

**Second: Determining the preferred styles among the research sample:** - After correcting the students' choices, and by reviewing the table below, we find:

Detailed results of the frequencies and percentages of the preferred styles that appeared in the research sample

Styles	Preferred style	Number of students that have preferred styles	Frequency	Total number
Mono styles	A	97	0.26	360
	B	48	0.13	
	C	101	0.27	
	D	114	0.31	
Binary styles	AB	2	0.005	8
	AC	2	0.005	
	AD	2	0.005	
	BC	1	0.003	
	BD	1	0.003	
Trilateral styles	ABC	2	0.005	4
	ABD	1	0.003	
	BCD	1	0.003	
Total	12	372	100%	372

The learning styles that were identified were in three forms:

1- **Mono-styles:** It included four styles with various rates, the highest was the (D) style of the right cerebral hemisphere, which represents the most common style among the research sample with a frequency of (114) and a rate (0.31%), and the lower learning style was (B) of the left hemisphere with a frequency (48) and a rate (0.13%).

2- **Binary styles:** these styles are preferred by a few research sample students, such as (AB) in the right cerebral hemisphere.

3- **Trilateral styles:** these styles are preferred by a small group of the research sample students, such as (ABC) in the right and left hemispheres of the brain, with two frequencies and a rate (0.05),

In light of these frequencies, the research sample was classified into (360) preferred mono-styles, (12) binary styles, and (8) trilateral styles, for a total sample of (372) students.

**The third axis: Presentation and interpretation the results of the correlation between the mathematical comprehension methods and the cerebral hemispheres based learning styles:** Pearson correlation coefficient was used to calculate the values of the correlation coefficients between the students' scores in each mathematical understanding method test (instrumental, relational, abstract) with each of the cerebral hemispheres based preferred learning styles (A-B-C-D), and to measure the significance of these coefficients, the researchers used the correlation coefficients T-test, and by reviewing the following table of the correlation coefficients and their significance, we find:

Understanding methods  Learning styles	Correlation coefficients values			T value of the correlation significance		
	Instrumental understanding	Relational understanding	Abstract understanding	Instrumental understanding	Relational understanding	Abstract understanding

<b>Preferred style A</b>	0.357**	0.438**	0.125	3.722	4.742	1.226
<b>Preferred style B</b>	0.381**	0.389**	- 0.103	2.793	2.862	0.700
<b>Preferred style C</b>	0.417**	0.025	0.392**	4.560	0.249	4.234
<b>Preferred style D</b>	-0.074	0.507**	0.478**	0.790	6.219	5.767

The correlation coefficient between the instrumental understanding method and the preferred learning style A is (0.3573), at the significance level (0.05) with degree of freedom (95), and the t-value calculated for the significance of the correlation coefficient is (3.722), which is greater than the tabular t-value (1.98), so we reject the previous null hypothesis and accept the alternative hypothesis. Thus, the rest of the results of the correlation between the mathematical understanding methods and the cerebral hemispheres based learning styles appear as shown in the table above.

**Interpretation of the third axis' results:** The learning style A has a direct correlation and a statistical function with the instrumental understanding and the relational understanding methods, and this is logically consistent with the indices of style A, as the student who prefers style A is characterized by being analytical and able to fragment and divide thoughts and things, as He is a mathematician who understands, recognize and processes things in order to reach certain results. (Atiya, 2016: 113)

This is consistent with their instrumental understanding which is based on the follow-up and the continuous training on mathematical exercises, retaining mental images, memorizing numbers and data by developing mental schemas for them, and their relational understanding in terms of the relations between the primary and secondary concepts, and conceptual structures in order to create an integrated construct of the mathematical process in the learner's mind, i.e. When the learner faces a problem (math problem) and he is required to solve it relationally, he must realize the connection between the parts and components of this problem, and he must connect these relations to deduce solving methods that may be new, especially for this particular situation.

The table above indicates that there is no correlation between style (C) and the relational understanding method, and this can be concluded clearly through the inconsistency between the preferred learning activities of style (C) in the study sample, where the students who prefer this style are characterized by being poetic and emotional, in contrast to their understanding style, in which the learner is not concerned only with the way he uses mathematical facts, but rather is aware of the reasons for their use.

**Conclusions:**

- 1-A correlation between the instrumental understanding style and each of the preferred learning styles (A-B-C), and there is no correlation between the instrumental understanding style and the preferred learning style (D) was found.
- 2-There is a direct correlation between the relational understanding style and the preferred learning styles (A-B-D), and there is no correlation between the relational understanding style and the preferred learning style (C).
- 3- A direct correlation between the abstract understanding style and the preferred learning styles (C-D), and there is no correlation between the abstract understanding style and the learning styles (A-B) was found.

**Recommendations:**

- 1- Holding training courses by special departments of the General Education Directorates to inform the teachers with the importance of using the tests of the mathematical understanding methods determination and the scale that determine the learning styles of their students as well as benefit from this research results in achieving the goal of raising the achievement level of their students in mathematics.
- 2- Using strategies such as (contradictions, constructivist learning, express-plan-evaluate) in teaching students with learning styles (A, B) (the left hemisphere) of the brain, and those who have methods of understanding (instrumental, relational) as there is a correlation between these styles and these methods According to the results of the current search.
- 3- The use of the strategies (Suchman inductive model, cooperative learning, analogy) in teaching the students of learning styles (C, D) (the right hemisphere of the brain), and those who have understanding styles (relational, abstract) because there is a correlation between these methods and these styles according to the results of the current research .

**Suggestions:**

- 1- Conduction of more correlative studies and research that address the mathematical understanding methods in various educational stages and their relations to other variables.
- 2- Designing a training program for the teaching staff based on the mathematical understanding methods and the cerebral hemispheres based learning styles.
- 3- Building an instructional-learning program in light of the correlations that was found between the mathematical understanding methods and the cerebral hemispheres based learning styles:
  - A - An instructional-learning program based on the relation between the learning styles (A and B) and the instrumental and relational understanding methods.
  - B - An instructional-learning program based on the relation between the learning style C and the abstract and instrumental understanding methods.
  - C - An instructional-learning program based on the relation between the learning style D and the abstract and relational understanding methods.

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