

The effect of using Lorsche Model on Generative Thinking Skills of Fourth Scientific-Class of Females students in Mathematics

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Abstract

The aim of the current research is to identify: "The effect of using Lorsche model on generative thinking skills of fourth scientific class of females students in mathematics." The experimental design was chosen for two groups (experimental and control), and the research sample consisted of (64) female students of the fourth scientific class at AL-Ta'akhi high School for females, affiliated to the Baghdad Education Directorate - Rusafa / 2, for the academic year (2020 -2021).

The research was limited to chapters (second, third and fourth), the choice was made by simple random selecting method, when classes (3 and 4) chosen to be represented by (32) females students in the experimental group that studied mathematics according to the (Lorsche) model, classes (1 and 2) to be represented by (32) females students in the control group that studied mathematics according to the ordinary method. The two groups of the research were rewarded with the following variables: (IQ test, test of previous knowledge in mathematics, previous achievement in mathematics, chronological age calculated in months).

The scientific material and behavioral goals were determined according to Bloom's six cognitive levels, where the number reached (135) goals. The teaching plans were prepared for the two research groups. The generative thinking skills test, consisting of (28) objective and article paragraphs. The researchers used the Alpha-Cronbach equation and the Pearson correlation coefficients to find stability of the research tool, and the T-test for the two independent samples. The data were processed using the statistical bag (SPSS). The results of the research indicated that there is a statistically significant difference at the level of (0.05) between the average scores of the experimental group and the control group in favor of the experimental group which was taught mathematics according to the (Lorsche) model in the generative thinking skills test.

Definition of the research

First: The research problem

Teaching generative thinking skills has achieved positive effects with regard to generative thinking (Hassouna, 2006: 1), as many studies have indicated, including the study of (Al-Yasiri, 2019). The previous study showed that teaching generative thinking skills have positive effects on generative thinking for females students. Through the foregoing, it becomes clear to us that mathematics in our schools is still offered to students in the traditional way that focuses on acquiring information, especially generative thinking skills that reflect in-depth thinking about the problems they face, and this is what encouraged the researchers to think about finding a treatment for the weakness of students' thinking through the use of a modern model, which leads students to memorize this subject without the availability of meaning and sufficient understanding; which limits the growth of their thinking skills, and that is the Lorsche model. Therefore, it is possible to determine the problem of the research in an attempt to answer the following question: ((What is the effect of using Lorsche model on generative thinking skills of females students of fourth – class in mathematics?)).

Second: The importance of the research

The importance of the current research is reflected in the following:

- 1- The importance of Lorsche model in the learning process, and its emphasis on the role of the student and making her the focus of the learning process. The student builds her own knowledge through research and discovery, and the practice of various educational activities.
- 2- The need to pay attention to teaching methods and models that depend on constructivist theory according to Lorsche model.

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3- The absence of an Iraqi or Arab previous study, to the best of the researchers' knowledge, that dealt with the effect of Lersbach model on generative thinking in mathematics for fourth-class females students, and the time of the study.

4- Lersbach model provides an interactive environment that gives opportunities for discussion and reflection in thinking, solving problems , sharing ideas and evaluating solutions. Lersbach model considers the teacher as a model for the student to follow in dealing with mathematical topics when studying.

5- This study is a response to recent trends in teaching, which lead to the development of thinking, and generative skills, which help learners to deal with the problems they face in their daily life.

6- The use of modern models, such as ; Lersbach model, leads to an interest in generative thinking skills, it is not limited to the interest in student's achievement only.

7- The current research helps on developing and updating school curricula in order to stimuli students to use generative thinking skills.

8- Contributes to providing the library with studies that help teaching generative thinking.

Third: The objective of the research

The current research aims to (the effect of using Lersbach model on generative thinking skills among fourth scientific –class of females students in mathematics)

Fourth: the research hypothesis

There is no statistically significant difference at the level of (0.05) between the average scores of the experimental group who studied mathematics using Lersbach model and the average scores of the control group who studied mathematics using the ordinary method for testing generative thinking skills.

Fifth: Research limits

The current research was limited to the first semester of the academic year (2020 - 2021), to the students of the scientific fourth class , chapters (second: equations and inequalities, third: foundations and roots, fourth: trigonometry) from the mathematics book for the fourth scientific class - the Twelfth Edition of 2019 Ministry of Education, General Directorate of Curricula, Republic of Iraq, in addition to the generative thinking skills (fluency, flexibility, imposing hypotheses, predicting in light of data, inference, expansion, representation).

Sixth: Terms Definitions

1- Lersbach's Model: It was defined by (Lersbach) as an educational model prepared by the British scientist (Anthony W. Lersbach) from the University of (Illinois) in the United States of America, in which he presented a diagram and an explanation of five stages ; (attracting attention - the investigation - the explanation - the expansion of the concept – evaluation) He stated that these stages are interrelated and cannot be separated from one another "(Lersbach, 2002: 1)

2 - Generative thinking skills: (Asfour, 2011) defined generative thinking skills, “It is the mental capacity that enables the learner to use the available social and philosophical information and data and to process them in a way that leads to reaching new information, ideas and solutions.” (Asfour, 2011: 38)

The researchers have defined the generative thinking skills as a set of mental abilities and activities practiced by the student that lead to generating new, unconventional ideas to solve problems included in the classrooms. It is measured by the degree that the student obtains in the generative thinking skills test, prepared for this.

Theoretical background and previous studies:

Lersbach Model was prepared by the British scientist Lersbach (Anthony W. Lersbach, 2002), University of Illinois in the United States of America.

1- Arousing attention phase

At this stage the teacher wants to stimulate the curiosity, generation and interest of the students with the topic of the lesson, by asking questions, and deducing answers from them. Here the teacher will have an idea

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about the previous experiences that the students have . This is a new opportunity for the teacher to identify the misconceptions in the students' understanding. During this phase, the teacher must ask students questions such as: “Why is this happening? What can I find out about this concept? How can I figure out ?”, (Lorsbach, 2002: 1).

2- The investigation phase

During this stage, students are given an opportunity to work together without direct instructions from the teacher, so that the teacher's work at this stage is facilitating and helping the student to form questions by framing questions , asking questions and observing the students' answers only (Piaget's theory). It is noticed here that the students access to a state of confusion and imbalance, which provides the opportunity for the student to test hypotheses and predictions or form new alternatives, to discuss what the student has reached with her/his colleagues, record ideas and observations and suspend judgments, (Lorsbach, 2002: 1)

3- Explanation phase

The teacher should encourage students to explain the concepts on their own according to their own style, clarifying their interpretations, listen critically to each other's explanations, to explain the teacher's instructions as well. The teacher at this stage uses the following questions to help him in guiding students to self-interpretation of the concept as follows: (What descriptions should the student give to the concept? What justifications, the teacher provides to the students when they asked why this concept is important?), (Lorsbach,2002:1).

4- The expansion phase of the concept

During this stage, students must apply concepts and skills in new situations during the program using formal names and definitions while reminding students of alternative explanations and looking at existing data and evidence to explore new situations. It was applied in the investigation phase because students must use previous information to ask questions and suggest solutions, making decisions, making experiments and recording notes. The teacher must give sufficient time for students to apply what has been learned in new situations and link the concept with other concepts. The following questions help the teacher guide students in organizing their ideas properly; (What are the example that clarify how encourage students to see the benefits of mathematics to them? (Lorsbach, 2002: 2).

5- Evaluation phase

Evaluation should take place throughout the learning experience and the teacher must monitor students' knowledge and skills. The teacher applies new concepts and change in thinking to evaluate their own learning. The teacher , then poses open-ended questions that encourage investigation and exploration, looking for useful answers through observation, evidence and pre-accepted explanations. The questions raised should encourage future investigations and exploration. (Lorsbach, 2002: 2).

Generative thinking skills:

The two researchers, and through having close look at the researches with generative thinking skills and their classifications, it became clear to them that there are common skills in all classifications, which made them choose specific skills from all classifications to fit the school stage, the content, the research topic, the research problem. The two researchers chose the following classifications of skills for generative thinking.

1- Fluency skill: “It is the ability to recall the largest possible number of suitable ideas in a specific time period for a problem or an exciting” (Maghraoui, 2011: 192), and among the forms of fluency are (fluency of words, fluency of association, fluency of change, fluency of forms, fluency of movement).

2- The skill of resilience: represents the ability to generate various ideas, different from the type of ideas normally expected, and the shift from a certain type of thought to another when responding to a specific situation, where the state of mind changes by changing the situation, (Hassan, 2014: 77). They are (automatic flexibility and adaptive flexibility).

3- Imposing hypotheses: “It is a skill involves the student presenting a set of ideas or proposed solutions to the problem of the subject, by the teacher's encouraging. (Ali, 2001: 39).

4- Predicting in light of the data: “the student's ability to anticipate certain results from a specific situation,” these results may be future events. (AL-Qahtani, 2018: 111).

5- Inference skill: it is intended to reach conclusions by relying on some evidence. It is the student's ability to generate new knowledge using strategies and specific rules based on information available to him (AL-Sayed, 2005: 247).

6- The skill of expansion: it is the student's ability to include more details, explanation, and information related to previous knowledge. The importance of this skill comes through generating a mental image, or new linguistic phrases that work to link the new with what is available in the student's cognitive structure (AL-Hawwiji and Muhammad (2012: 71).

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7- The skill of representation: it means adding a new meaning to the information to change its image by using symbols, charts, or graphic figures (Saada, 2011: 291).

Previous studies:

Table (1)

Previous Studies on the Lersbach Model and Generative Thinking Skills

N o.	Name of the researcher , year of the study and country	Title of the study	Independ ent variable	Dependent variable	Size of the sample and its quality	The used approach	Study tools	Results of the study
1	(Al-Rafai'i, 2017) Iraq	The effect of the Lersbach model on the literary achievement of fifth -class students in the subject of geography and the development of their scientific exploration	Lersbach model	Achievem ent and Developm ent of scientific exploration	(46) students with an average of (22) students for trial and (24) students for the control	Experimen tal method	Scientific Achievem ent test to Measure the scientific achievement	Outperforma nce of The experimental group that was taught using the Lersbach model on the control group that was taught in the ordinary way. The use of Lersbach model led to the development of scientific inquiry among the students of fifth-class literary branch.
2	(Al-Mohamm adi, 2019) , Iraq	The Effectiven ess of Lersbach Model in acquiring and Preserving Islamic Concepts for Female Students of the fourth Preparatory class in the Subject of	Lersbach Model	Acquiring and keeping concepts	The research sample consisted of (68) female students, with an average of (34) experime ntal group and (34) of control group	Experimen tal method	Concept acquisition scale and retention test	There is a statistically significant difference between the average of the experimental group scores and the control group scores in the post application of the test of the acquisition of Islamic concepts and

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		the Holy Quran and Islamic Education						retention, in favor of the experimental group
3	(Mikhail, 2011), Egypt	The effectiveness of a proposed program based on the molecular approach in teaching chemistry for development achievement and generative thinking among first-class of secondary students	Suggested program based on partial entrance	Achievement And generative thinking skills	78 of experimental students	Semi - experimental, descriptive	Achievement test, generative reasoning test	Clear superiority in favor of the experimental group in achievement test and generative thinking.
4	(AL -Ani, 2018), Iraq	The effect of the pinterish model on achievement and generative thinking among students of fourth class literary branch in the subject of Arabic grammar	pinterish model	Achievement, generative thinking	54 students, with an average of (27) experimental students and (27) of control students	Experimental method	Achievement test, generative reasoning test	There are statistically significant differences between the average of the two groups of the experimental and control , in favor of the experimental group that was taught according to the pinterish model in the post-achievement test and which was taught according to the Pinterish model in the generative thinking test. They were all taught

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								according to the Pinterish model in generative thinking skills
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Research methodology and procedures:

The two researchers followed the experimental approach to achieve the goal of their research; it is the most suitable approach to the research procedures, and to reach conclusions. Experimental research can be defined as “an intentional and controlled change of the specific conditions of an event, noting the changes occurring in the event, and their interpretation” (Mulhim , 2002: 388).

First: Experimental Design:

The design was chosen with partial control for two equal groups with a post-test of generative thinking skills, as appropriate to the nature and conditions of the current research and an attempt to provide accuracy in the results as shown in the following table;

Table (2)

The experimental design of the research sample

The groups	The groups equivalence	Independent variable	Dependent variable	Research tools
1 – Experimental group	1- Intelligence test.	lorsbach model	Generative thinking skills	Post-generative thinking skills test
2 – control group	2- Examining previous information in mathematics. 3- Previous achievement in mathematics. 4- Chronological age.	Ordinary method		

Second: The research community and its sample

The research community is determined by students of fourth scientific –class , in the secondary and high school, daytime schools for females, of the State Directorate of Education in Baghdad – AL - Rusafa /2 , for the academic year (2020 -2021). Intentionally, the two researchers chose (AL-Takhi School for females), affiliated to the State Directorate of Education in Baghdad - AL - Rusafa /2 , to be their research sample. The sample consisted of (64) students, (32) for the experimental group and (32) for the control group .

Third: Control Procedures

The two research groups were rewarded for the variables (intelligence, previous knowledge, previous achievement, chronological age) as shown in the following table;

Table (3)

The results of the T-test for the two independent samples of the students of the two groups of research in variables (intelligence, previous knowledge, previous achievement, chronological age).

Variables	Group	Number of individual s	Mathematical medium	Standard deviation	Freedom degree	T – value		Indication level
						Counted	Tabular	
Intelligence	Experimental	32	35.44	5.91	62	0.26	2.00	Not significant
	Control	32	35.78	4.82				
Previous knowledge	Experimental	32	18.88	2.80	62	0.20	2.00	Not significant
	Control	32	19.03	3.43				
Previous achievement	Experimental	32	62.41	8.32	62	0.25	2.00	Not significant
	Control	32	61.91	7.51				

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Chronologic al age	Experimental	32	186.47	6.02	62	0.58	2.00	Not significan t
	Control	32	187.38	6.38				

Fourth: Research requirements

1- The scientific subject

The teaching subject was determined to be taught to the students of the research sample during the period of the experiment, depending on the content of the mathematics book for the fourth scientific class, twelfth edition of (2019), including three chapters (second , third and fourth)

2- Formulating behavioral objectives:

A number of behavioral objectives were formulated depending on the content of the scientific material after having knowledge about the educational objectives of the mathematics book content for the fourth scientific class. The number of behavioral objectives was (135), in accordance with Bloom's classification in the cognitive domain for the six levels, where the number of the semester's objectives were as followed; the second chapter (24 goals), the third chapter (42 goals), and the fourth chapter (69 goals). They were presented to a group of arbitrators in the fields of education, psychology, methods of teaching mathematics, measurement and evaluation.

3- Preparation of educational plans

Daily teaching plans were prepared in light of the behavioral objectives of the scientific subject for both the experimental and control groups. A sample of the plans was presented to a group of arbitrators specialized in the field of education and methods of teaching mathematics, measurement and evaluation, to benefit from their opinions and experiences of the samples validity.

Adjust for extraneous variables

1- Time : is the period of time during which the experiment is conducted. The two researchers were keen to ensure that the period of conducting the experiment is uniform for the experimental group and the control group. The experiment started on 1.12.2020, and ended on 17.2. 2021.

2- Study material : The two researchers studied the same academic subjects for the experimental and control groups, including chapter two: Equations and Inequalities, chapter three: Foundations and Roots, and chapter four: Trigonometry of the mathematics book, which is taught to students of the fourth scientific class for the academic year (2020-2021)

3- Measurement tools : The researchers used the same measurement tools for the experimental and control groups. The generative thinking skills test was used for both groups.

4- Instructor : The two researchers, personally taught mathematics for the experimental and control groups during their experiment, their interaction was the same with the two research groups. This gives the experiment accuracy and objectivity. To assign a teacher for each group makes it difficult to attribute the results to the effect of the independent variable. This is due to the strength of one teacher, and her mastery of the material, or to her personal characteristics, or otherwise.

5- Experimental Extinction : It means the discontinued of the students after the pre-test and before the post-test from the two experimental and control research groups due to (transfer of housing - travel - leaving the study permanently - illness ... etc.), which affects the progress of the experiment and its results. (Hales 2006: 169) The current research did not experience any such leakage except for some individual absences in a very small percentage that did not affect the course of the experiment.

6- The classroom learning environment: The experiment was applied to the two groups in the same school, the system used in the school is the fixed classrooms system for each class, and all the classrooms are similar in size, design, lighting and all other physical characteristics.

7- Daily lesson schedule: This variable was controlled through the equal distribution of classes between the experimental and control groups. The two groups were taught six lessons per week for each group, according to the curriculum of the Ministry of Education. The rest of the weekdays, teaching was electronically under the instructions of the Ministry of Education, and the healthy crisis cell of Corona virus pandemic in Iraq.

Fifth: the test tool

1- Determining the purpose of the test

The aim of the generative thinking test is to measure the generative thinking of fourth - scientific class students in the subject of mathematics.

2- Determination of generative thinking skills

The generative thinking sub-skills were identified in the second chapter .

3- Determining the number of test paragraphs

The skills paragraphs (fluency, flexibility) were formulated in the form of open-ended article questions, while the other skills were formulated according to the objective questions of the multiple choice type so that all the

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paragraphs are consistent with the definition of each skill contained in the theoretical background. Taking into consideration, the objectives for which the test was set, in order to suit the mental abilities, and the age stage of the students of the research sample, where the test in its initial form consisted of (28) paragraphs, and depending on the opinions of the referees in the subject of mathematics and its methods of teaching. It was agreed to develop (4) Items for each skill, where the final exam consisted of (28) items, and a schedule for the test was prepared to include the distribution of items between skills and the degree of each paragraph, and as followed ;

Table (4)

Items of generative thinking skills test

No.	Skill	Paragraphs distribution	Number of questions	Score of the first paragraph	Score of the second paragraph	Score of the third paragraph	Score of the fourth paragraph	Total score for the skill
1	Fluency	1,2,3,4	4	5	5	5	5	20
2	Flexibility	5,6,7,8	4	5	5	5	5	20
3	Imposing hypothesis	9,10,11,12	4	1	1	1	1	4
4	Prediction in the course of results	13,14,15,16	4	1	1	1	1	4
5	Inference	17,18,19,20	4	1	1	1	1	4
6	Expansion	21,22,23,24	4	1	1	1	1	4
7	Representation	25,26,27,28	4	1	1	1	1	4
	Total		28	15	15	15	15	60

4- Preparing test instructions

A- Response Instructions:

The two researchers relied on understandable, clear, and appropriate instructions to answer the test, including the mechanism for answering questions, information about students, the time allocated for answering, and an emphasis on not leaving any paragraph without answer, with an explanation that there are questions have a specific time to answer within the test.

B - Correction Instructions:

One score was for the correct answer on the objective paragraph of the multiple choice type, and a zero was for the wrong answer, while the abandoned paragraph was treated as the wrong answer. The total score for the substantive paragraphs of (20) was determined with a range between (0-20) scores . As for the (8) article paragraphs, their range was between (0-5) for fluency and (0-5) for flexibility according to the correct answer steps for each paragraph, where the score of fluency was measured by the student's ability to mention the largest possible number of appropriate answers in a specific time, subtracted from it the repeated answers, which have nothing to do with the subject of the test. As for the score of flexibility, it was measured by the student's ability to vary the appropriate answers, and the greater the number of various answers, the greater the score of flexibility. Its range is between (0-40), and therefore the total score of the test is (60) score.

5- Validity of the test:

A- Apparent truthfulness

The test was presented in its initial form to a group of referees and experts in methods of teaching mathematics to express their opinions regarding the test, its paragraphs and how to judge it. The necessary adjustments were made based on the opinions of the arbitrators. The two researchers took the acceptance of the paragraph with an approval rate of (% 80 or more than) with this procedure; the apparent truthfulness is achieved in the test.

B - Logical truthfulness

"It is the truthfulness that is closely related to the steps of the test design." To ensure its availability in the test, an analysis of the topic aiming to measure it and determine its details should be carried out. This type of validity has been verified by developing a definition of generative thinking and its skills, and by designing the test items, so that these skills were covered, in a balanced way, and the test was presented to the arbitrators to express their opinions.

6- Exploratory sample

To ensure the validity, clarity of the instructions and its paragraphs, the time taken to answer the thinking test, the test was applied to an exploratory sample consisting of (100) students of scientific fourth class of the

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research community. They were intentionally chosen, on Tuesday, corresponding to 2.2.2021, from the basic sample, AL-Maali High School for females, affiliated to the State Directorate of Education in Baghdad - AL-Rusafaa/ 2, and after an agreement with the school administration. The students were informed of the test a week prior to the date of conducting the test. Through the researchers' supervision of the application, they noticed that the answer instructions and test paragraphs were clear, except for some paragraphs that were clarified for all members of the group. As for the time taken to answer it, the researchers attain the average time for answering the test items by calculating the average time of the students, by recording the time on each student's answer sheet when she finished the answer, and the researchers used the following equation to extract the time for answering the questions;

$$\text{Time of the test} = \frac{\text{Time of the first student} + \text{time of the second student} + \text{time of the last student}}{\text{Total number of the females students}}$$

(Obaidat, and Suhaila, 2005: 108), and the appropriate time for thinking test was (45) minutes.

7- Statistical analysis of paragraphs

The following statistical analyses were performed

A- The power of discernment of paragraphs

paragraph strength mean "the extent of its ability to distinguish between students with higher levels and those with lower levels in relation to the characteristic that the test measures." The paragraph strength of each of the paragraphs of the thinking test was calculated which ranged between (0.24 – 0.74), Distinguishing it with more than (0.20) is considered an acceptable and distinct paragraph, while a paragraph that is less than (0.20) is considered weak and it is advised to delete it (Odaa, 1998: 295), the test items are acceptable and valid in terms of their discriminatory ability.

B- The relationship of the paragraph score to the total score of the test

The relationship of the score of each paragraph to the total score of the test was calculated by the Pearson correlation coefficient. The value of the Pearson correlation coefficient ranged between (0.27 - 0.58). To ensure the statistical significance of the correlation coefficients, the values of the correlation coefficients were converted into corresponding T values. The calculated T values ranged between (2.78 - 7.05), which is greater than the tabular T value, which is (1.98) at the level of significance (0.05), the degree of freedom is (98).

C- The difficulty and easy factors

The difficulty factor is the "percentage of students who answered correctly to the paragraphs" (Odaa, 1998: 289). The difficulty factor for each paragraph of the paragraphs was calculated and ranged between (0.26 - 0.72), while the easy factor ranged between (0.28 - 0.74). The test paragraphs are acceptable if the difficulty rate ranges between (0.20 -0.80), whenever the difficulty percentage approaches %50 and the paragraph is appropriate, which means that all the paragraphs are acceptable (Bloom, 1971: 66).

D - Effectiveness of false alternatives

Subjective tests were of the multiple-choice type. The wrong alternative is effective when it attracts more students from the lower group than the higher group. The more effective the alternative, the higher its value in the negative (Al-Hashemi, 2013: 114). After using the effectiveness formula of the wrong alternatives for all the paragraphs, it was concluded that the effectiveness coefficients of the alternatives are negative; which means that the wrong alternatives have obscured a number of students with weak levels, which indicates the effectiveness of wrong alternatives , therefore all the wrong paragraphs are considered effective.

8- Test reliability

The reliability of the test was calculated in two ways

A - The (Alpha Cronbach) equation

The stability of the test was calculated by the equation of (Alpha cronbach). It is one of the equations that is suitable for measuring the stability of the paragraph and the objective tests at the same time (Alam, 2000: 165). The acceptable reliability coefficient is (0.80). The test reliability was (0.88), and the stability of the test was

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good (Odaa, 1998: 366). Thus, all the paragraphs of the test were kept and the test became ready to be applied in its final form to the basic research sample.

B- The correction reliability

Correction reliability is calculated by the correlation between individuals' scores, estimated by the corrector, and their scores estimated by another corrector (Odaa, 1998: 152), without any references on the forms. To calculate the reliability of the correction, the two researchers withdrew (20) answer forms randomly, another corrector was used to correct the form which were clear of any references⁽¹⁾. The stability coefficients were extracted for the two corrections, as follows: fluency (0.83), flexibility (0.87), hypothesis (0.90), prediction in light of the data (0.89), inference (0.87), expansion (0.92), representation (0.89). The test reliability as a whole was (0.88); by using the scores of the statistical analysis sample for the paragraphs of (100) students, which represent high correlation coefficients between the two researchers' correction and the other corrector, which makes the test highly reliable, and thus the test was ready in its final form.

9- Final exam

After preparing the test, verifying the validity of its paragraphs, presenting it to the arbitrators to ensure its validity, and applying it to an exploratory sample to know the clarity of the instructions for its paragraphs, its time, and its stability, the test became ready to be applied in its final form to the two research groups (experimental and control). The test was applied on Tuesday, corresponding to 9. 2.2021, on both groups.

Sixth: Procedures for applying the experiment:

A- Requirements for applying the experiment: Among the requirements that were conducted are;

- 1- Selecting the two groups (experimental and control) randomly.
- 2- Conducting parity for the two groups (experimental and control) in variables (mathematical knowledge test, intelligence test, chronological age, previous achievement in mathematics).
- 3- The female students of the experimental group were divided into small cooperative groups, with each group comprising (4-5) females students.
- 4- Teaching the experimental group according to the Lorsch model.
- 5- Preparing students' minds, increasing their motivation, and arousing their interest in the subject of the lesson, and then following the below steps;
 - A- The researchers present the concept of the lesson, and the female students put forward positive and negative ideas.
 - B - Presenting logical and illogical solutions to generate new and different ideas.
 - C- At the end of the lesson, the two researchers provide a summary of the topic of the lesson with the participation of the students, and then close the lesson.
 - D- An evaluation of the students' concepts gained from the lesson.
 - E- Determine the homework for female students.
- 6- Teaching the control group according to the regular method, following the below steps;
 - A- Defining the goal of the lesson.
 - B- Preparing the students' minds for the topic of the lesson, and increasing their motivation.
 - C- Presenting the scientific material according to the sequence used in the book.
 - D- Summarizing the topic of the lesson by the two researchers and closing it.
 - E - Evaluation of the students' concepts acquired from the subject of the lesson.
 - F- Determining the homework of female students, which is to solve the exercises in the textbook.

B- Date of implementation of the experiment:

The application of the experiment started on the two groups (control and experimental), in the first semester, on Tuesday 1.12.2020, and ended on Wednesday, 17.2. 2021, as the two research groups were taught by six lessons per week, one of them in attendance and the five electronically for each group. The two groups studied the following academic chapters; (chapter two, Equations and Inequalities, chapter three, Foundations and Roots, and chapter four, trigonometry) from the mathematics textbook for the fourth scientific class, twelfth Edition, 2019. The two researchers taught the experimental group according to Lorsch model, and the control group was taught according to the ordinary method.

Seventh: Statistical methods

Collecting and analyzing data with the help of the Statistical Package (SPSS) for the social sciences, in treating the data statistically and obtaining at results. Appropriate statistical methods were used for the research.

Presentation and interpretation of results:

First: Presentation of results

The results of the null hypothesis related to generative thinking

((Miss Intisar was the Mathematics teacher at AL-Ta'akhi high School for females)). -¹

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For the purpose of verifying the null hypothesis, which states that “there is no statistically significant difference at a level of significance (0.05) between the average scores of the experimental group students who studied using the Lorschbach model, and the average scores of the control group who studied using the ordinary method for the generative thinking test.” The two researchers did the following:

Using the T-test for the two independent samples to find out the differences between the experimental and control groups. It was concluded that the arithmetic mediator of the experimental group is equal to (47.13) with a standard deviation of (2.94), while the arithmetic mediator of the control group is equal to (39.44) with a standard deviation of (2.95), and after using the T-test for two independent samples, the calculated T value is (10.45), which is greater than the tabular T value of (2.00) at the level of significance (0.05), and the degree of freedom (62), as in Table (5), which means that there is a statistically significant difference at a level of (0.05), in favor of the students of the experimental group, and thus this hypothesis is rejected, and this indicates the superiority of the students of the experimental group who studied using the Lorschbach model over the students of the control group who studied using the ordinary method in the post-test of generative thinking. The results are consistent with the results of previous studies such as the studies of (Michael, 2011), and (AL - Ani, 2018).

Table (5)

The results of the T-test of two independent samples to test generative thinking between the two research groups.

Groups	Size of sample	arithmetic mediator	Standard deviation	Freedom degree	T – value and statistical significance		
Experimental group	32	47.13	2.94	62	Counted	Tabular	Significance
Control group	32	39.44	2.95		10.45	2.00	Significant

Second: Interpretation of the results:

- 1- The Lorschbach model provided the students with an opportunity to collaborate positively with each other and to form a common language of understanding on the topic through the details that they interact with during the discussion, which leads to growth and acceleration of their generative thinking.
- 2- The students' response to the model steps accurately contributed to the exchange of knowledge, concepts, and discussion of the proposed ideas to reach the correct information, as well as the researchers' role in monitoring and directing, which enabled the students to create generative thinking and make the right decisions.
- 3- Teaching according to the Lorschbach model led to the encouragement of freedom of opinion and discussion in a democratic atmosphere, away from authoritarianism, which is considered an obstacle to thinking.

Third: the conclusions

1. The use of the Lorschbach model helped to raise the level of students in the generative thinking test, and to organize the teaching process in a sequential, coherent, and integrated way.
2. The use of Lorschbach model in teaching mathematics helped to the emergence of desirable behaviors among the students, including attention during the lesson and interest in mathematics. Lorschbach model aroused the students' desire to follow and interest in studying mathematics.

Fourth: Recommendations

- 1- Teaching mathematics in different school stages according to the Lorschbach model for its effect on generative thinking.
- 2- Inclusion of the Lorschbach Model in the textbooks of the Mathematics Teaching Methods course taught to students of the colleges of Education and basic education, with an explanation of the main steps during their qualification for the teaching profession.
- 3- The necessity of training faculty members to use generative thinking skills, and then teaching students about them in different educational situations, to achieve effective learning in proportion to their abilities and attitudes.
- 4- Mathematics textbooks should be contained exercises that solve the problem of generative thinking skills.

Fifth: The Proposals

- 1- Conducting a study aimed at identifying the effect of Lorschbach model for other educational stages in mathematics and other study materials, with other variables.
- 2- Conducting a study to compare the Lorschbach model with other teaching methods and methods in generative thinking skills, to indicate which one is more effective and possible to serve the educational process.

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