

Impact of Thinking Keys Teaching on Achievement and Formal Thinking among Math 3rd Graders

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Abstract:

The aim of the research is to identify the effect of teaching according to thinking keys on the achievement and formal thinking for third-grade intermediate female students

To achieve this aim, the following null hypotheses were formulated:

1- There is no statistically significant difference at the significance level (0.05) between the average scores of the experimental group students who will study according to the thinking keys strategies and the average of the control group students who will study in the usual way in the mathematics achievement test

2- There is no statistically significant difference at the significance level (0.05) between the average scores of the experimental group who will study according to the thinking keys strategy and the average scores of the control group students who will study in the usual way in the formal thinking test in mathematics.

The research sample was intentionally selected from Al-Zohour High School for Girls, and the research sample consisted of (61) female students from the third intermediate grade female students, and two groups were selected, with (30) students for the experimental group, and (31) for the control group.

To collect the research data, two tests were developed, one of which measured achievement and consisted of (31) items, and the other test measured the skills of formal thinking, as the test in its final form consisted of (40) items of the objective type multiple-choice.

The appropriate statistical analyzes were conducted out using the program (spss), as the results indicated that: -

1- The students of the experimental group outperformed the students of the control group in the achievement test.

2-The students of the experimental group outperformed the students of the control group in the test of formal thinking skills.

The research concluded with a number of conclusions, recommendations and suggestions

Keywords: thinking keys, achievement, formal thinking, middle school students.

First, the research problem:

Survival in the era of globalization and informatics requires us to prepare learners to face the repercussions of rapid changes that are no longer able to be dealt with by traditional methods. Where the researchers noticed, through her experience in teaching mathematics, the weak level of achievement and thinking in mathematics, especially for the third intermediate grade

One of the most important reasons for the low level of achievement and formal thinking for students is the lack of teachers' knowledge of modern methods and strategies that stimulate thinking, as this was shown through the questionnaire directed to male and female mathematics teachers randomly. It was found that 90% of them use the usual methods of teaching that are limited to conveying concepts and information to students in an abstract manner. These methods are not compatible with the modern curriculum, which contains symbols, concepts and generalizations, and not linking it to reality, and these methods do not provoke the students to think differently and unfamiliarly from what they are accustomed to on a permanent and routine basis

Therefore, the current research showed a modern strategy in teaching, which is the keys to thinking, including (brainstorming key strategy, prediction key strategy, and interpretation key strategy). And what it offers to improve the achievement and formal thinking of the students, so the research problem can be determined by the following question:

What is the effect of teaching according to thinking keys on the achievement and formal thinking of third-grade female students in mediation in mathematics?

Second, the research significant :

The researchers can summarize the importance of the research as follows

1) The theoretical side

The importance of the current research lies in:

- 1) The research is a scientific attempt by the researchers, given the absence of a local and Arabic study to the knowledge of the researchers that works according to the strategies of the twenty keys of thinking and its impact on the achievement and formal thinking of third-grade students in mathematics.
- 2) The current research encourages teachers to use modern strategies and models in teaching mathematics.
- 3) Research provides the educational field and curriculum planners with a way to adopt thinking strategies.

2) the practical aspect

The importance of the research practically lies in the following:

- 1) It presents daily teaching plans in which the researchers follow the strategies of thinking keys, which shows in an applied way how to use them
- 2) It presents a test for achievement and for abstract formal thinking in mathematics that the researchers will build, as those in charge of curricula and researchers can benefit from it.
- 3) It benefits those in charge of teacher training in the department of preparation and training before and during the service in teaching by including methods and strategies that contribute to the development of mathematics teaching.

Third: Objective of the research:-

The research aims to identify the effect of thinking keys strategies on the achievement of formal thinking for third-grade female students in the middle school in mathematics.

Fourth: Research Hypotheses:

For the purpose of verifying the research objective, the following null hypotheses were formulated:

- 1- There is no statistically significant difference at the significance level (0.05) between the average scores of the experimental group students who will study according to the thinking keys strategies and the average of the control group students who will study in the usual way in the mathematics achievement test
- 2- - "There is no statistically significant difference at the significance level (0.05) between the average scores of the experimental group who will study according to the thinking keys strategy and the average scores of the control group students who will study in the usual way in the formal thinking test in mathematics."

Fifthly: Research Limits:

The current search is determined by:

- 1) The third intermediate grade students in the middle and secondary day schools affiliated to the General Directorate of Education in Baghdad / Al-Karkh II for the academic year (2021-2022).
- 2) 2) The content of two chapters of the mathematics textbook for third-grade intermediate students (Part 1), third edition, 2021 AD

Sixth: Defining Terms:

1) Achievement :

The two researchers agree with (Al-Jamal 2005) definition , who defines achievement as "the extent to which the student has achieved goals, as a result of his study of one of the academic subjects" (Al-Jamal, 2005: 149).

The researchers define it procedurally as the final outcome of the student's acquisition of information and knowledge to achieve certain goals for a particular subject or subjects of study. It is measured by the score obtained by the student in the test prepared by the researchers.

Third: Thinking Keys,

defined by: Abu Al-Hajj (2016) as: Twenty effective strategies to update the quality of creative and critical thinking and develop the ability to make decisions and solve problems The program is a fun and unique job to teach young people how to think skillfully.(Abu Al-Hajj, 2016: 41)
 The researchers adopt the definition of (Abu Al-Hajj, 2016) as a theoretical definition for it.

They define it procedurally: as twenty effective strategies in the development of thinking that were launched from Australia by (Tony Ryan) and have proven their global success in developing critical and creative thinking and making the thinking process an enjoyable and distinctive work, and this effect is evident through the results reached by the research.

Fourth: Formal thinking : it is defined by: (Razzooqi and Istabraq, 2015): It is a homogeneous internal mental process, and this concept develops through interaction with things and subjects, which puts the adolescent in front of new and developing mental capabilities, so he can liberate with his thinking from the limits of tangible reality to the world of mental perceptions, principles and theories.(Razzooqi et al., 2015:349)

The researchers adopted the definition of (Razouki and Istabraq, 2015), where it is confirmed as a theoretical definition.

procedural definition:

The ability of the individual to move from the tangible to the symbols, concepts and relationships To solve problems using logical relationships and theories This is evident from the scores obtained by the students in the formal thinking skills test prepared by the researchers.

Second Chapter:

Thinking Keys:

(Tony Rayan, 1990) tells about his beginnings in designing the keys to thinking, That the motivation behind his ideas was based on two wonderful books on teaching thinking, and the first of these books is by the author (Thornburg & Thornburg, 1989), which relied on sixteen different strategies for teaching which were known as thinking tools, which are very suitable for the study stages, The second stimulus to his thinking It is from the wonderful (Adventures in Thinking) by the writer and author (Joan Dalton, 1986), One of the features of this book was the section known as (Scientific Ideas Festival), as the author presented a set of innovative activities arranged in a systematic and objective manner. So Tony Rayan emphasized that it seems clear that the new keys to thinking must be connected with the objective approach of teaching as stated in (Adventures in Thinking) (Barell, 1991, 43),

when using the thinking keys, individual differences (unity, stage, and time) must be taken into account. To achieve their use, we must start with simple shapes. Such as (I start with the answer, ask the question) and there are several benefits when using the keys to thinking, including:-

- 1- It is an effective way to introduce different higher-order thinking skills.
- 2- Thinking Keys can be used as part of the multiple competency approach.
- 3- Provides an enjoyable environment by incorporating it into reading and daily comprehension activities.
- 4- It is a means of releasing the student’s knowledge from the fields of education. (Ryan, 1990: 18)

Thinking keys can be used in a variety of ways and situations. They are a really effective tool that can be used to help bring out the critical and creative thinking abilities that all learners have (Al-Sabaab, 2017: 343-345).

The old version of Thinking Keys focused on creative thinking only, While the updated version focused on critical thinking in addition to creative thinking, and therefore the twenty thinking keys can be divided into two groups;critical thinking keys and creative thinking keys , as in Table (1) as follows:

Table (1)Twenty thinking keys

Critical thinking keys	creative thinking keys
Purpose key	Brainstorming key
Rubrics key	Combination key

Info key	Improvements key
Action key	Challenge key
Perspectives key	Inventions key
Reflection key	BAR key
Question key	Brick Wall key
Three Whys key	In Common key
Decision key	Reverse key
Consequences key	Prediction key

These keys can be clarified according to what was reported (Shamaila, 2018):

Creative thinking is associated with novelty, the ability to create something, implement new forms and solve problems, Generating a lot of imaginative skills or transforming something that already exists into something new.

Therefore, the keys to creative thinking are used to produce new creative ideas.

These keys include:

Brainstorming key: Through which the student learns to produce many ideas and solutions to problems.

Combination key: the student acquires by merging two or more ideas in order to reach a solution to a problem.

Improvements key: The student learns the skill of developing and improving things to become better.

Challenge key: The student challenges himself to think completely differently to implement unusual ideas.

Inventions key: The student acquires the courage to come up with new ideas for innovation.

- Increase/add/replace BAR key: The student learns to break out of the norm and make some changes.

Brick Wall key: Through it the student learns to persevere and overcome the obstacles facing him.

In Common key: The student acquires the skill of finding common points between two different things and thinking deeply.

Reverse key: The student learns the skill of thinking in a reverse way to arrive at new ideas.

Prediction key: The student acquires the skill of predicting what will happen based on current data.(Shamaila, 2018: 107)

After the two researchers were briefed on the twenty keys of thinking that were mentioned, she suggested a teaching strategy according to the thinking keys of the thinker (Tony Ryan). In accordance with the school stage (the third intermediate) and the age group of the female students, according to the following steps:

- 1- Brainstorming: through this key, the student learns to produce many ideas and solutions to problems.
- 2- Prediction: that is, the student acquires the skill of predicting what will happen based on the current data taken from the ideas obtained in the first step
- 3- Interpretation: it helps to expand ideas and generate new ideas through interrelated processes, and to move from the idea to its details.

Formal thinking concept

(Badir, 2008) believes that formal thinking reveals the relationships between things or elements of the subject and does not form in the adolescent except when he has a repertoire of information and concepts, and this puts the (teenager) in front of developing and new mental potentials, as his thinking is freed from the limits of tangible reality, down to abstracts and mental perceptions, generalizations and principles and theories (Badir, 2008: 114)

The main systems of coding are language, through which the student is able to represent experiences, and the adolescent reaches this stage when actions and sensory perceptions are replaced by different symbolic systems (such as language, logic, and mathematics). (Abujado, 2009: 131-132)

As for (Al-Absi, 2010), he sees formal logical thinking (abstract) as the process of using the rules of logic to reach conclusions from data or introductions and this type of thinking helps in avoiding fallacies and

falling into them and increases the adolescent's acquisition of analytical thinking skills, (and formal logic) is a study of the logic of phrases according to their form where phrases and logical linking tools are represented by And apply the results to all statements of the same shape. (Al-Absi, 2010: 272)

Formal Thinking Skills After studying the classifications of formal thinking skills, the researchers decided that they should adopt the skills that were identified by (Razouki et al., 2016: 355).

1- The skill of hypothetical inference: that is, inference about possible outcomes, and it can be called prediction.

2- Deductive reasoning skill: Deductive reasoning is a kind of reasoning for individuals during the formal operations stage. It includes the formation of a general idea and the conclusion of specific hypotheses, that is, the individuals of this stage think deductively to form hypotheses that can be selected by examining the existing evidence or revealing the existing evidence.

3-The skill of proportional inference: This type of thinking requires the individual to infer the nature of the proportional relationship between a number of elements, and the relationships may be quantitative or qualitative, that is, inference through proportional relationships and ratios.

4-Synthetic reasoning skill: moving from simple principles to complex results.

5-Relational reasoning skill: determining if there are two events that are inevitable, that is, if this happens, the result will become such (cause and effect).

6-Probabilistic reasoning skill: The ability to study the quantitative relationships for each group separately and determine the ratios for each of them, then compare them, and finally give certain probabilities, ie, an estimation of the probability that an accident may occur.

7- The skill of suggesting solutions: It is represented in the learner's ability to distinguish and specify a number of proposed hypotheses to solve a problem, that is, through virtual, mental or symbolic relationships.

8- **Problem solving skill:** It is the set of operations carried out by the individual using the information and knowledge he has previously learned and the skills he has acquired in overcoming a situation well and unfamiliar to him in controlling it and reaching a solution to it.

Chapter Three

First:Research Methodology: In order to achieve the objectives and hypotheses of the research and to answer the questions of the research problem, the experimental research method was used.

Second: Experimental Design:

The researchers relied on the quasi-experimental design with partial control of the two equivalent groups with post-test and suitable for research purposes.

Third: the research community:

The current research community included third-grade middle school students in middle and secondary day schools of the General Directorate of Education in Baghdad / Karkh II for the academic year 2021-2022 AD, as the total number of the research community reached (30,134) students.

Fourth: The research sample: The researchers chose (Al-Zohour High School for Girls), which is affiliated with the General Directorate of Karkh Education, the second on purpose, since the researchers were a teacher in the same school, as the sample size was (61) students.

Fifthly: the search tools

First: Mathematics achievement test

1- Determining the objective of the test: measuring the achievement of third-grade intermediate students.

2- Determining the scientific subject: I identified the first chapter and the second chapter of the mathematics book.

3- Formulation of behavioral objectives: (112) behavioral objectives have been formulated.

4- Determining the number of test items: The test items were determined and reached (31) items.

5- Preparing the specification table: a specification table was made and the relative weight of each chapter and each behavioral goal was determined, and all the topics of the chapters were included in the test.

6-Formulation of the achievement test paragraphs: (31) paragraphs of the objective type of the achievement test were formulated.

- 7- Preparing the test instructions: instructions have been set for the test, including how to answer and choose the alternative correctly.
- 8- Validity of the test: The test was carried out with two types of face validity and content validity.
- 9- The exploratory application of the test: a random sample of (120) female students was selected and the exploratory application was conducted.
- 10- Statistical analysis of the test items. The coefficients of difficulty, discrimination, and effectiveness of the alternatives were calculated, and all items were acceptable.
- 11- Test stability: The test stability value was (0.86), which is a good percentage, so the test is considered to have good stability.
- 12- Final application of the test.

Second: develop a formal reasoning test:

The researchers built a formal thinking test for the third intermediate grade students according to the following steps:

1. Determine test objective : The test aims to measure the level of formal thinking among third-grade intermediate students.

2. Reviewing the literature and previous studies:

The researchers reviewed many studies that dealt with formal thinking, and these studies benefited the researchers in dividing skills and formulating test items.

3. Determine formal thinking skills:

The researchers identified eight formal thinking skills that were mentioned in the second chapter, which the test will measure among third-grade intermediate students.

4. Formulating the test items in light of the specified areas: The test items were formulated for each skill. The test consisted of (40) multiple-choice objective items.
5. Presenting formal thinking skills with test items to the arbitrators: The researchers presented the specific skills with the items that measure them, which amounted to (40) items, to a number of arbitrators, and all the notes were praising the test.
6. Preparing the test instructions: - These instructions targeted the nature of the test, its objective and how to answer it, in addition to writing down the total score for the test.

7. Statistical Analysis Sample (Exploratory Application):

The test was applied to a second exploratory sample of (120) female students of the third intermediate grade from the schools affiliated to the General Directorate of Education in Baghdad / Al-Karkh II on Sunday and Monday corresponding to 23 and 24/1/2022 A.D. After it was agreed with the school administration in the said school the application of the test carried out two days before the test date.

8. Statistical analysis of the test items: Statistical analyzes were conducted for the test items and the coefficients of difficulty, discrimination and effectiveness of alternatives were calculated, and all items were acceptable.
9. Validity of the test: The researchers presented the test items to a number of specialists in psychology and mathematics and their teaching methods, and all items were accepted, so the test became apparently honest.
10. Resilience of the formal thinking test: The Keuder-Richardson equation used the formula - 20 (K-R20) to calculate the reliability , as the value of the reliability coefficient of the test items was (0.92) and it is considered a good value and the test is read

Sixth: The final application of the experiment to the research sample

After the completion of teaching the content of the course subject to the third intermediate grade female students in the two research groups, the Formal Thinking Test consisting of (40) items was applied on Thursday, 27/1/2022 AD. After the (researchers) informed the students a week before the dates of the two exams, in order to prepare for it.

Seventh: Statistical means:

The appropriate statistical means were used for the research, including calculating means and standard deviations, (t-test), Keuder-Richardson equation formula - 20 (K-R20) and Pearson's correlation coefficient, in addition to the coefficients of difficulty, discrimination and effectiveness of alternatives.

The fourth chapter presentation and interpretation of the results The chapter includes presenting the results that have been reached in the current research, and then analyzing and discussing these results, and then interpreting them, in addition to the conclusions and recommendations, as well as the proposals that were made in the light of the results and as follows:

First: Presentation and interpretation of the results of the achievement test:

• **Results Presentation**

In order to verify the validity of the first null hypothesis, this states that:

There is no statistically significant difference at the significance level (0.05) between the average scores of the experimental group students who were taught using the thinking keys strategy and the average scores of the control group students who taught by the usual method in the achievement test.

After the researchers applied the achievement test on the basic research sample, they used the statistical program (SPSS version 23) to obtain a statistical description of the final data for the experimental and control groups in the achievement test, and table (2) shows this description:

Table (2) Statistical description of the two groups (experimental and control) in the achievement variable

Group	class	NO of female students	Arithmetic mean	Standard Deviation	The standard error of the arithmetic mean	95% confidence interval for the arithmetic mean	
						Minimum	Maximum
Experimental	B	30	21.900	4.686	0.855		
Control	A	31	17.645	4.729	0.849	1.842	6.668
						1.842	6.667

It is evident from the above that the average score of the experimental group students is (21.900) with a standard deviation (4.686), while the average score of the students of the control group is (17.645) with a standard deviation (4.729).

The researchers applied (s Test'Levene) to two independent samples to find out the significance difference between the variation in scores of the two groups students o(experimental and control), as the value of (F) reached (0.074) at the level of significance (0.787).

It is greater than the approved significance level (0.05), so the two groups are homogeneous in the achievement variable.

In order to find out the significance difference between the average scores of the students of the two groups (experimental and control), a t-test was used for two independent samples.

The t-value reached (3.529) at the significance level (0.001), which is less than the approved significance level (0.05) and with a degree of freedom (59).

This indicates the superiority of the students of the experimental group who studied by adopting the thinking keys strategy over the students of the control group and those who studied in the usual way, in the achievement test, and table (3) shows that:

Table (3) Levin's statistic and t-test for the experimental and control groups in the (achievement) variable

Variable	s Test'Levene		t-test		Freedom degree	Statistical significance at the level (0.05)
	F	Significant	T	Significance from both sides		
Achievement	0.074	0.787	3.529	0.001	59	Significant

In order to find out the effect size of the independent variable (thinking keys strategy) in the dependent variable (achievement in mathematics), the researchers used the Eta square test (η^2) and the value of ((d) is also calculated, which expresses the size of this effect, as it turns out that the effect size may be small orMedium or large, as shown in Table (4):

Table (4) The approved table to determine the size of the effect

The used tool	The size effect		
	Small	Medium	Large
η^2	0.01	0.06	0.14
D	0.2	0.5	0.8

Table (5) shows the value of (η^2) and (d):

Table (5) The value of (η^2) and (d) and the effect size in achievement test for the two research groups

Independent variable	Dependent variable	t value	Df	η^2 value	D value	Value of size effect
Thinking keys strategy	Achievement	3.529	59	0.174	0.917	Large

It is clear from Table (5) that the effect size of (thinking keys strategy) on the dependent variable (achievement) is large, because the (d) value is (0.917) which is greater than (0.8)

Interpretation of achievement test results:

The results concluded by the researchers indicated the superiority of the students of the experimental group who were studied using the (thinking keys strategy) over the students of the control group who studied in the usual way in the achievement test, and the reason for this is due to the fact that: -

The thinking keys strategy was adopted to follow organized and interconnected steps, which would have helped the students to understand the mathematical concepts of the topic of the lesson and the various ideas and exercises it contained, by going through the steps of the specific strategy.

Second: Presentation and interpretation of the results of the formal thinking test:

Results presentation :

To check the validity of the second null hypothesis which states that:

“There is no statistically significant difference at the significance level (0.05) between the average scores of the experimental group students who were taught by adopting the thinking keys strategy, and the average scores of the control group students who were taught in the usual way in the formal thinking test.”

The two researchers used the statistical program (SPSS version 23), after applying the formal thinking test, and correcting the answers, it was found that the arithmetic mean of the students’ scores for the experimental group is (26.100) and with a standard deviation (5.074), As for the arithmetic mean of the scores of the control group students , it was (21.355), with a standard deviation of (5.958), and as in Table (6) this description shows:

Table (6) Statistical description of the experimental and control groups in the variable (formal thinking)

Group	class	NO of female students	Arithmetic mean	Standard Deviation	The standard error of the arithmetic mean	95% confidence interval for the arithmetic mean	
						Minimum	Maximum
Experimental	B	30	26.100	5.074	0.926	1.906	7.585
Control	A	31	21.355	5.958	1.070	1.912	7.578

In order to find out the significant difference between the differences in the scores of the students of the experimental and control groups, the researchers applied the (s Test'Levene) test for two independent samples, as the value of Levin's statistic (F) reached (1.371) at a significance level (0.246), which is higher than the approved significance level (0.05), This indicates that the two groups are homogeneous in the formal thinking variable, and to identify the significant difference between the mean scores of the experimental group students and the average scores of the control group,

, (t-test) was applied for two independent samples, as the t-value amounted to (3.343) at a significance level (0.001) which is smaller than the approved significance level (0.05) and with a degree of freedom (59). This indicates the superiority of the students of the experimental group who were studied with the thinking keys strategy over the students of the control group who were studied according to the usual method in the formal thinking test, and table (7) shows that:

Table (7) The value of (F) and (t) for the experimental and control groups in the variable (formal thinking)

Variable	t-test for equality of the two means		s Test'Levene for equality of difference		Freedom degree	Statically significant at (0.05)
	T	Significance from both sides	Significant	F		
Formal thinking	3.343	0.001	0.246	1.371	59	Significant

The above table shows that the calculated (t) value is greater than the tabulated (t) value, so we reject the second null hypothesis and accept the alternative hypothesis which states that:

(There is a statistically significant difference at the significance level (0.05) between the average scores of the experimental group students who were studied using the thinking keys strategy and the average scores of the control group students who were taught in the usual way in the formal thinking test) In favor of the higher mean which is the average score of the experimental group.

In order to find out the extent of the effect of the independent variable (thinking keys strategy) on the dependent variable (formal thinking), the value of (d) was calculated, which expresses the size of this effect, and table (8) shows the value of (d):

Table (8) The value (d) and the magnitude of the effect In the formal thinking of the experimental and control group

Independent variable	Dependent Variable	T value	Df	D value
Thinking keys strategy	Formal thinking	3.343	59	0.869

Interpreting the results of the formal reasoning test: The results of the research that were presented in Tables (7) and (8) indicated the superiority of the students of the experimental group who were studied by adopting the thinking keys strategy over the students of the control group who studied according to the usual method in the formal thinking test. This superiority may be due to :

This strategy allows the students in the experimental group to employ their formal thinking through questions that provoke their mental ideas about the specific topic of the lesson, with enough opportunity for the students during the teaching session.

To participate in asking and producing intellectual questions and this is called brainstorming in addition to the questions posed by the researchers, and this in turn develops for students deductive and inductive reasoning and other types of reasoning.

The students also use explanation and justification for the results they reached for a specific issue in many topics in mathematics, especially life issues, a paragraph of thought and numerical sense. This in turn leads to an increase in the skill of cause and effect which is part of formal thinking.

The student has a great role in this strategy when studying the content of the subject, including its intense content and ideas, as most of the topics include many questions and examples and with different ideas. This prompts the student to use mental questions, deep thinking, and different types of inference. And then propose solutions and predict them in the future to solve complex mathematical problems, as all of the above is a basic rule that makes students have formal thinking skills.

Second: conclusions

The most important conclusions reached by the researchers are the following points:

- 1) Teaching the content of mathematics using the thinking keys strategy leads to an increase in the achievement of the experimental group students.
- 2) The three steps of the strategy (brainstorming, interpretation, and prediction), led to better interaction and cooperation between the experimental group students than the control group students who were taught in the usual way.
- 3) The strategy of thinking keys in teaching provided an opportunity for all the students of the experimental group to actively participate in the lesson and work on activating memory, linking ideas, thinking, inference, and giving solutions that support reinforcement and encouragement.
- 4) Teaching procedures using the thinking keys strategy made the students the focus of the learning process, and this is consistent with the modern trends of education.

Fourth: Recommendations:

Through the results reached, the researchers recommended the following: -

- 1) Urging and encouraging mathematics teachers to use the thinking keys strategy at all academic levels.
- 2) Holding training courses and workshops for in-service mathematics teachers to apply the thinking keys strategy and how to use it correctly in teaching mathematics.
- 3) Writing a teacher's guide for mathematics for all levels, especially the intermediate ones, and indicating how to apply the thinking keys strategy in the daily lessons.

Fifth: proposals :

To complement this research, the researchers suggest the following:

- 1) Conducting research similar to the current research in other academic levels which aims to identify the impact of using the thinking keys strategy on achievement, formal thinking and other variables.
- 2) Conducting a research on a training program for mathematics teachers based on the strategy of thinking keys and other modern strategies, knowing their impact on other aspects of learning, and developing other types of thinking, including creative, reflective thinking and engineering thinking in mathematics.
- 3) Conducting descriptive research to find out the extent to which female students of other school stages possess formal thinking.

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