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Research Article

The Effectiveness of Using The Design Thinking Model in Mathematics Achievement and productive Thinking Skills Among first Intermediate Class Females Students

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Abstract

The present research aims to identify The Effectiveness of Using The Design Thinking Model in Mathematics Achievement and Productive Thinking Skills Among First Intermediate Class Females Students.

The sample of the research was intentionally chosen and it was represented by females students of the first intermediate grade in (Elaaf Secondary Girls School) followed to the General Directorate of Education in Baghdad / Rusafa 2nd, and the sample consisted of (50) students (after excluding repeated). (24) female students who were studied according to the design thinking model, and Division (C) to represent the control group with (26) students who were studied according to the usual method. previous achievement in mathematics, previous information in mathematics, and productive thinking).

The experiment was conducted in the first semester (first course) of the academic year (2020-2021) and on the semesters (Semester Two: Rational Numbers, Chapter Three: Polynomials, and Chapter Four: Open Sentences), from the mathematics book for the first intermediate grade, Part 1. Edition 4, year (2019), and the researcher adopted the experimental method, and the two research tools were prepared: the achievement test according to Bloom levels (remember, comprehension, application, analysis, synthesis, and evaluation) consisting of (30) paragraphs of the type of multiple choice with four alternatives And using the Keoder Richardson equation (KR-20), the value of the reliability coefficient was (0.84), and the productive thinking test consisted of (30) items (15) items of the multiple-choice type, and (15) essay items, and using the equation (Alpha - Cronbach) The value of the reliability coefficient was (0.88), and after applying the test and processing the data statistically using the t-test for two independent samples and the Levens' test, the results resulted in the following:

There is a statistically significant difference between the experimental and control groups in the achievement tests and productive thinking skills in favor of the experimental group.

In light of the results of the research, the researcher recommended teaching mathematics at different academic levels according to the design thinking model and conducting training courses for mathematics teachers on the use of various models in teaching, including the design thinking model, and suggests conducting a study similar to the current study on other variables such as complex thinking skills and skills. Mathematical communication or behavioral variables such as tendencies or attitudes towards mathematics.

Problem of The Research

The two researchers noticed, by looking at many previous studies, such as the study (Al-Azzawi, 1995) and the study (Ahmed, 2016), the weakness in the level of the achievement of first-grade female students in the middle school in mathematics as well as other academic levels, and this decline led to weakness in level of thinking skills among learners moreover, critical thinking skills and creative thinking skills, which in turn led to the decrease the level of learners in productive thinking, which was confirmed by most studies as a study (Aswad, 2020), Design thinking model encourages learners to innovate, collaborative work, and self-responsibility in making decisions.

Hence, the two researchers see the need to use this model because it may contribute to raising the level of productive thinking skills for first-grade female students intermediate, by providing them with advanced thinking skills that make them able to deal with various situations.

Therefore, the two researchers considered the necessity of conducting this study, which sought to identify the answer to the following question: ((What is the effectiveness of using the design thinking model in mathematics achievement and productive thinking skills among First Intermediate Class Females Students?)).

Significance of the research:

1. The importance of the present research lies in recognizing the effectiveness of using the design thinking model in the achievement of first-grade female students intermediate , as well as its effectiveness in their productive thinking skills.
2. The design thinking model contributes to demonstrating, developing and improving the creative abilities of female students.
3. Emphasis on the inclusion of the mathematics curriculum for the first intermediate stage of productive thinking skills by those in charge of planning the mathematics curriculum.
4. The design thinking model (to the knowledge of the researcher) is considered the first use in teaching mathematics in Iraq.
5. The current research presents a productive thinking skills test that can be relied upon in other research.

Aim of the research

The current research aims to identify the effectiveness of using the design thinking model in the achievement of mathematics and productive thinking skills among first-grade female students intermediate.

Hypothesis of the research

To achieve the two objectives of the research, the two researchers put the following null hypotheses:

1. There is no statistically significant difference at the level of significance (0.05) between the average scores of the experimental group female students who will study mathematics according to the design thinking model and the average scores of the control group female students who will study the same subject in the usual way in the achievement test.
2. There is no statistically significant difference at the level of significance (0.05) between the average scores of the experimental group female students who will study mathematics according to the design thinking model and the average scores of the control group female students who will study the same subject in the usual way in the productive thinking skills test.
3. There is no statistically significant difference at the level of significance (0.05) between the average scores of the experimental group female students in the pre and posttest of productive thinking skills.

Limits of the research

The present research was limited to the first semester of the academic year (2020-2021 AD), and to the female students of the first intermediate grade in the daytime middle schools of the General Directorate of Education in Baghdad / Rusafa 2nd, and the content of three semesters, which are the second semester: (relative numbers), and the third semester : (Polynomial), and the fourth chapter: (Open Sentences), from the mathematics book for the first intermediate grade, part 1, edition 4, year 2019, and productive thinking skills (induction, recognizing assumptions, deduction, interpretation, evaluating arguments, fluency, flexibility, originality, sensitivity to problems, details or elaboration).

Define of the basic terms:

1. **Effectiveness**: defined by (Good, 1973:207) as: “the ability to achieve the desired results with an saving of time and effort.”

2. **Model**: defined by (Mayer, 1989: 43) as: "a set of guiding principles that provide the learner with a framework that enables him to comprehend the nature of the learning process."
3. **Design Thinking**: defined by (Goldman & Kabayadondo, 2017:32) as: a model that uses appropriate methods to solve complex problems, proceeds according to steps, stages, skills and logical mechanisms, aims to help learners find new creative solutions to the problems they face inside or outside the classroom. **Procedural:** It is a creative problem-solving process that includes five non-linear stages (empathy, identification, idea generation, modeling, and testing) and allowing first-grade female students intermediate to move between these stages freely to obtain new creative solutions.
4. **Achievement:** (Good, 1973:7) defined it as: "efficiency or attainment in performing a skill or knowledge."
   Procedural: The grades obtained by the female students of the first intermediate grade after passing the educational experiences related to mathematical subjects in the achievement test prepared for this purpose.
5. **Productive thinking**: defined by Hurson (2008:241) as: "a type of thinking that generates new difficult ideas and is important for innovation, growth, capacity building and differentiation, and helps the student to think and work better, and the thinking is organized, disciplined and repeatable, which leads to making the student's thinking better. Creative and innovative."
   Procedural: It is the set of skills that enable first-grade female students intermediate to think creatively and critically, and it is measured by the degree to which they will obtain in the test of productive thinking skills prepared for this purpose.

Theoretical framework and previous studies:

Firstly, The Theoretical framework:

Design Thinking Concept:

The term Design Thinking refers to the processes and methods used to solve complex problems, acquire information, analyze knowledge, and propose solutions in the fields of (design and planning), meaning that design thinking refers to (the cognitive activities related to design) that designers apply during the design process (Visser, 2006: 24).

(Martin, 2016:513) states that design thinking is concerned with all the ways in which designers think, and the mental processes that stakeholders use to design models and services.

The stages of development of the design thinking model

The design thinking model is based on building knowledge and generating a set of ideas, as it focuses on the cognitive and creative aspects, and the following is a chronological order for some of the important contributions to the development of the design thinking model:

1.Model (Brown, 2009):

A. Understanding, meaning arriving at an important bright idea.

B. Exploration means presenting an idea.

C. Implementation any application of visualization in the ground.

These stages included six sub-stages (empathy, identification, idea generation, prototype, testing, and implementation) (Brown, 2009).

2**.Model (d.school):** focuses on the most important active steps (understanding - observation - viewpoints - visualization - building the model - and testing) and can be used as an educational method. (Kembel, 2009).

3. **Model (Ambrose & Harris, 2010):** They identified seven stages of design thinking in their book (Design Thinking), which are (identification, research, thinking, prototype, testing, implementation, and learning).

4. **Model (IDEO, 2012):** He referred to five stages that the design thinking model goes through, which are (discovery - interpretation - visualization - experimentation - and development), and in each of these stages it is possible to use various tools, including (observation - interview - and storytelling). and role-playing) where specific methods are used that guide actionable steps to discover user needs and design required solutions. (IDEO, 2012)

5. Model Dr.School Stanford, (2016)

In 2016, Dr. School at Stanford University presented a model that includes the skills of a design thinking model consisting of five skills (empathy - identification - visualization - model building - and testing).

After reviewing the stages of developing the design thinking model, the stages of the design thinking model were approved (Brown, 2009).

The following is an explanation of each of the stages:

1. **Empathy**: during which an accurate understanding of the problem is achieved by knowing the difficulties faced by the learners as well as understanding their desires and needs. This stage begins by asking about needs and sympathizing with the data and collecting examples of various attempts to solve the same problem and how to identify obstacles.
2. **Exploration and identification**: This stage takes place by analyzing the information collected in the empathy stage, where the problem is accurately framed, motives and needs are identified, and answers are sought for the questions asked, by formulating a framework for the problem centered around the learner.
3. **Idea generation**: At this stage and based on what was gained in the previous two stages, the largest possible number of ideas that are innovative solutions to the problem are generated, where the most appropriate ideas and possibilities are selected to meet the needs that were identified through recording brainstorming sessions in Inside the mind and not discuss or judge ideas in advance because that reduces or limits creativity.
4. **The prototype**: This stage is done by producing a number of inexpensive prototypes and building one or more representations of the proposed possibilities and preparing to present them for discussion, to verify the effectiveness of the solutions that were produced in the idea generation stage, and the goal of this stage lies in determining the most appropriate solutions to be Test it later.
5. **Testing**: the solutions identified in the modeling stage are tested by evaluating the learners according to the results and seeking to know the reactions of a group of learners and conducting an objective review to determine whether the proposed solution exists with the objectives and discussion about what can be developed and improved or returned to the stages Previous to search for another problem or idea.
6. **Implementation**: At this stage, the design is developed and finally handed over to the session chair (Brown, 2009: 64-86).

Productive Thinking

Productive thinking is a mode of thinking related to mathematics that allows learners to unleash their minds to produce and generate unfamiliar and non-repetitive ideas, a mental process by which sensory perception interacts with experience and with internal and external motives or both. (Hurson, 2008:85).

Productive Thinking Skills

By reviewing the literature on productive thinking skills, it was agreed that it includes two types of thinking skills (critical and creative) as follows:

1- **Critical thinking**: It is a way of thinking related to the realization of a phenomenon by individuals, and its application using different methods and new ideas, because it is an opportunity to look at situations and things differently. (Ciltas, 2012: 105)

Critical thinking skills:

One of the most famous classifications is Watson and Glaser, which is based on numerous studies and is divided into five critical thinking skills:

Deduction skill: It refers to a person's ability to infer from some observable or supposed facts and the ability to perceive the correctness or wrongness of a result in light of the facts presented.

The skill of recognizing assumptions: It means that the individual has the ability to verify some of the information available to him so that he can assume that it is possible or impossible based on that information.

Inference skill: It is represented in the ability to draw relationships between given facts so that a judgment is made on the extent to which the conclusion derived from those facts is true or not.

Interpretation skill: the ability to recognize logical explanations, define a problem, generalize based on specific information, and determine whether the results are acceptable or not.

The skill of evaluating arguments: is the ability to distinguish between strong and weak arguments, a strong argument is an important argument that is directly related to a particular situation, and a weak argument is an argument that is not important or related to aspects of a situation, a secondary link (Watson-Glaser, 1994: 120).

2- Creative thinking: creativity, thinking, thinking, fluency and originality in ordinary ideas in different situations, and the ability to deal with a specific real problem, this ability revolves around looking at a situation, idea or other problem from different points of view, new details, observing it and observing it in it. And creative thinking is beyond creativity, which is the higher levels of thinking, as it is the levels of thinking. (Turkmen 74: 2019).

2. Creative thinking skills:

Fluency: The ability to elicit as many responses as possible over a specified period of time.

Flexibility: the ability to think through different ideas.

Authenticity: The ability to show unfamiliar and distinct responses that are common.

Sensitivity to the following problems: Sensitivity to problems, difficulties and problems.

Details or overflow: means the ability to add new and useful details to an idea or solve a problem that helps it develop, enrich and implement it. (Hokanson et al, 2015: 171).

Previous Studies Table (1)

Studies that dealt with the design thinking model and productive thinking skills.

NO.	Researcher's name, year and country	Aim of the Study	Educational Level	Approach of the study	Sample size and gender	Tools	Statistical means	independent variable	dependent variable	Results

There is a statistically significant difference at the level (0.01) between the mean scores of the students of the experimental and control groups in favor of the teaching strategy based on the design thinking approach in the self-efficacy scale.	Self-efficacy	A strategy based on the design thinking approach	- Statistical Package for Social Sciences (SPSS)	self-efficacy scale	60 Students	semi-experimental	Third Intermediate	To identify the effect of using a strategy based on the design thinking approach in teaching mathematics on the self-efficacy of middle school students in the city of Makkah.	(Rizk, 2018) Saudi	1
There are statistically significant differences between the mean scores of the experimental and control group in the post-productive thinking skills test in favor of the experimental group.	Self-efficacy Development of productive thinking skills	A program based on the dimensions of learning according to Marzano	t- test for two independent samples	Productive thinking skills test	Sixty Students	Experimental	Ninth grade	To identify the effectiveness of a program based on the learning dimensions of Marzano for developing productive thinking skills in mathematics for the ninth graders.	(Radwan, 2016) Palestine	2

Research Methodology and Procedures: The experimental method was followed for its suitability to the two objectives of the current research and its hypotheses.

1. **Experimental Design**: The quasi-experimental design with partial control for two groups (experimental and control) was used for equal groups with pre and posttests, suitable for the purposes of the current research,
   as shown in Table (2)

Tools of the study	dependent variable	independent variable	equivalence	The group
• Collection • Productive Thinking	• Collection • Productive Thinking	Design Thinking Model	• intelligence The educational level of the parents • Chronological age in months • Previous achievement in mathematics • Previous information in mathematics • Productive Thinking	Experimental
		Traditional Method		control

2. The research community and its sample: The research community consisted of first-grade middle school students in the morning and middle schools for girls affiliated to the Baghdad Education Directorate - Al-Rusafa for the academic year (2020-2021), and (Elaf High School for Girls) was chosen in an intentional way to implement the experiment.
3. Control procedures: parity between the two groups (experimental and control) was statistically performed in some of the variables that are expected to affect the safety of the experiment, namely (intelligence, parental educational level, chronological age calculated in months, previous mathematics achievement, and information. Precedent in mathematics, and productive thinking). The following explains the statistical equivalence processes in the variables:

Table (3)

The value of $\chi^{\wedge 2}$ for the difference in the IQ of the female students in the experimental and control groups

Statistical significance at the level (0.05)	Value X^2		Total	IQ level			Study Division	Group
	Tabled	Calculated		Upper Average 75% -95%	Average 25% -75%	Below average 5% -25%		
nonfunctional	3.84	0.087	24	7	11	6	A	Experimental
			26	7	13	6	C	Control
			50	14	24	12	Total	

Table (4)

The results of the chi-square test ($X^{\wedge 2}$) to find out the significance of the difference between the two research groups in the educational level of the parents

Statistical significance	chi value		degree of freedom	Total	diploma and above	Preparatory	Intermediate and Below	variables	Study Division	Group
	Tabulated	calculated								

nonfunctional	10.38	2	24	7	9	8	Academic achievement father	A	Experimental
			26	5	11	10		C	Control
5.99	0.328		24	5	9	10	Academic achievement Mother	A	Experimental
			25	5	8	13		C	Control

Table (5)

Statistical description of the two research groups (experimental and control) in the variables (chronological age calculated in months, previous achievement in mathematics, previous information in mathematics, and productive thinking)

The confidence interval for the arithmetic mean		The standard error of the mean arithmetic	standard deviation	SMA	Sample NO.	Variables	Study Division	Group
Lower limit	Upper limit							
2.98	1.98	0.69	3.39	146.79	24	Chronological age	A	Experimental
2.95	1.76	0.94	4.81	147.38	26		C	Control
8.64	8.74	2,82	13.80	74.63	24	previous collection	A	Experimental
8.58	8.68	3.24	16.51	74.58	26		C	Control
1.09	1.68	0.55	2.71	7.33	24	Previous information	A	Experimental
1.09	1.69	0.42	2.13	7.04	26		C	Control
3.98	2.88	1.01	4.95	18.88	24	thinking the product	A	Experimental
3.94	2.84	1.35	6.87	19.42	26		C	Control

Table (6)

Congruence test to check the equivalence between the two research groups (experimental and control) according to the variance in the variables (chronological age calculated in months, previous information in mathematics, previous achievement in mathematics, productive thinking)

Statistical significance at the level (0.05)	t-test		Freedom degree	Levenes' test		Variable
	Significance	T Value		significance	F Value	
Nonfunctional	**0.619**	**0.50**		0.473	0.523	Age in months
	0.991	**0.11**		0.301	1.095	previous collection
	0.669	**0.43**		0.27	1.24	Previous

			48			information
	0.750	**0.321**		0.566	0.333	Product thinking

4. Search supplies:

Determining the scientific material: The content of the material to be learned included the three chapters (Chapter Two: Rational Numbers, Chapter Three: Polynomials, and Chapter Four: Open Sentences), from the mathematics book for the first intermediate grade, 4th floor, for the year 2019, which is scheduled to be taught during the semester. The first academic year for the academic year 2020-2021.

Formulating behavioral objectives: The importance of behavioral objectives as a guide to the researcher's work during the application of the experiment, and after reviewing the general and specific educational objectives of mathematics for the first intermediate grade, a number of behavioral objectives were formulated according to Bloom's classification in the cognitive domain of levels (remembering, understanding, and application And analysis, synthesis, and evaluation) amounted to (160) behavioral objectives, and they were presented to a group of arbitrators in the field of mathematics teaching methods to express their opinions on their safety and suitability for their cognitive levels. An agreement percentage of (85%) or more was adopted, and in light of their opinions and their observations reformulate some behavioral purposes according to this ratio.

Teaching plans: The number of teaching plans is one of the requirements for successful teaching. A daily (48) teaching plans have been prepared to teach experiment topics to the students of the two research groups (the experimental, according to the design thinking model, and the control one according to the usual method). These plans were given to a group of arbitrators in the field of mathematics teaching methods to benefit from their opinions, directions and suggestions to improve the formulation of those plans. Some modifications were made to them in order to reach its final form and become ready for implementation.

Adjust the extraneous variables:

1. **Differences in the selection of the sample members**: To avoid the effect of this variable on the results of the research, the two researchers conducted statistical equivalence between the students of the two research groups in six variables whose interaction with the independent variable (design thinking model) could have an effect on the dependent variable (achievement and productive thinking skills), as well as The selection of the sample members at random.

2. **Teaching**: The two groups of research were taught by the two researchers to reduce the impact of the school difference and its methods of teaching and dealing with students.

3. **Confidentiality of the research**: The two researchers were keen on the confidentiality of the research, in agreement with the school administration, not to inform the students of the nature and purpose of the experiment, so that their activity or their dealings with the experiment would not change, which might affect the safety of the experiment and the accuracy of its results.

4. **Duration of the experiment**: The duration of the experiment was uniform and equal for the students of the experimental and control groups, as it started on Saturday 5/12/2020 and ended on Saturday 13/2/2021.

5. **Study environment and teaching aids**: The two researchers studied the two research groups in two identical classes in terms of ventilation and lighting, and used educational aids equally, represented by the similarity of blackboards and colored pencils.

6. **Associated Accidents**: The experiment in this research has not been exposed to any emergency or accident that hinders its functioning.

7. **Experimental extinction (leaving the experiment)**: There were no cases of school leaving, interruption or death of one of the female students in the research sample, except for absenteeism with slight and approximately equal percentages between the two groups.

8. **Maturity-related processes**: There were no differences in maturity between the female students of the experimental and control groups, as the duration of the experiment was the same for the two groups, in addition to the fact that their ages were close.

9. **Distribution of quotas**: This variable was controlled through the equal distribution of quotas between the experimental and control groups, as the researcher taught (6) lessons per week for each group, according to the mathematics quota distribution method in force in middle and secondary schools, and according to the curriculum of the Ministry of Education, as The two researchers agreed with the school administration to organize a schedule for distributing classes for mathematics for the first intermediate class to ensure equal time for each class (one day in person and five days electronically).

5. **Research tools**: Two tools were prepared to measure the two dependent variables in the current research, which are (the achievement test in mathematics and productive thinking skills).

Achievement test

1. **Determine the objective of the test**: The objective of the achievement test is to measure the achievement of first-grade intermediate students in the content of the scientific subject covered by the research.

2. **Determining the scientific material:** The scientific material that will be taught during the experiment period has been determined for the two research groups represented by the three chapters, namely (Chapter Two: Rational Numbers, Chapter Three: Polynomial, and Chapter Four: Open Sentences) from the mathematics textbook for the first intermediate grade,4, for the year 2019).

3. **Formulation of behavioral goals**: (160) behavioral goals were formulated based on Bloom's classification of the cognitive domain at its six levels, which are (remember, comprehend, apply, analyze, synthesis, and evaluate) and were presented to a group of arbitrators, and after taking their opinions and observations and modifying the formulation of some of them, Maintain all behavioral goals.

4. **Determining the number of test items**: (30) multiple-choice objective test items were selected based on the opinions of the arbitrators in the methods of teaching mathematics.

5. **Preparing the specification table (experimental map)**: The specification table was prepared for the content of the three chapters of the mathematics book for the first intermediate grade, and for the six levels of the cognitive domain of Bloom's classification (remember, comprehension, application, analysis, synthesis, and evaluation) and the weights of the content of the three chapters were determined in light of The time spent in teaching it.

6. **Formulation of test items**: (30) test items of the objective type (multiple choice with four alternatives) were formulated according to the specification table.

7. **Answer instructions and correction key:** The instructions on how to answer the achievement test paragraphs were formulated by giving an illustrative example at the beginning of the test paper and included instructions for correcting the test and distributing marks on the paragraphs. One point was given for the correct answer for each paragraph, and a score of zero was given for the answer. Erroneous, abandoned, or indicated by more than one alternative, so the achievement test scores range from (0-30), and the students 'answers were corrected by the researcher in the light of the correction key prepared for this purpose.

8. **Validity of the test**: In order to verify the validity of the test, two types of validity were relied upon:

8.1 **Apparent honesty**: the items of the achievement test were presented to a number of arbitrators with specialization in the field of mathematics teaching methods, to express their opinions and observations on the clarity of the paragraphs and their formulation in a new way, and the extent to which they measure the behavioral objectives specified for them and the logicality of the alternatives,

and any other observations that are useful in improving the quality of the test. A slight modification was made to the question formula for some paragraphs, and some alternatives, thus achieving the apparent validity of the test.

8.2 Content validity: The use of the specification table in preparing the achievement test is one of the evidence of content validity. The researcher prepared the paragraphs of the achievement test according to the specification table, to find out the extent to which the test paragraphs represent the content of the study material and behavioral objectives, and thus verify the validity of the content.

8.3 **Paragraph difficulty coefficient**: The difficulty factor was found for each of the test items, and after applying the formula for that, it was found that it ranges between (0.35 - 0.71), which is an acceptable ratio.

8.4 **Paragraph discrimination coefficient**: the discriminatory strength of the achievement test items was found according to its equation, and it was found that it ranges between (0.34 - 0.73), and this ratio is acceptable.

8.5 **The effectiveness of the wrong alternatives**: The effectiveness of the wrong alternatives was calculated after applying the special equation. It was found that all the wrong alternatives were negative, which means that they attracted the students of the lower group more than the students of the higher group.

8.6 **Test reliability**: The reliability coefficient was calculated using the Couder-Richardson equation (KR-20), and it was found that the reliability coefficient is (0.84), which is a good stability coefficient, as the literature indicates that the test is characterized by stability if its stability value is (0.80 or more) Allam 2000. 543).

9. The final version of the achievement test: After verifying the test's validity, stability, difficulty and distinction, the test is ready for application with a total score of (30) degrees.

Productive Thinking Skills Test: After the two researchers reviewed the literature and previous studies related to productive thinking, and due to the lack of a ready test or scale for the research sample (first intermediate grade), and based on the theoretical framework for this type of thinking, a productive thinking test was prepared as follows:

1. **Determining the objective of the test:** The objective of the test is to measure the ability of the first intermediate grade students (the research sample) to think productively to know the effectiveness of the independent variable (the design thinking model) in it.

2. **Defining the concept of productive thinking and its skills**: The theoretical concept of productive thinking was defined within the framework of the theoretical research that was presented in the second chapter, where the two researchers adopted a definition (Tishman, 2000) of productive thinking as the result of the components of the mental processes of both critical thinking and creative thinking, and these components are They overlap in many situations and one depends on the other.

3. **Preparing the test paragraphs in their initial form**: the same approach was followed in a manner commensurate with the capabilities of first-grade intermediate students and their productive thinking abilities, which can be found as a solution through understanding and good attention to the details of situations, and by relying on the opinions of the referees in the methods of teaching mathematics, measurement and evaluation, the test is formed in its form The initial one consisted of (30) paragraphs and by (3) paragraphs for each of the ten sub-skills of critical and creative thinking skills.

Preparation of test instructions:

A. Answer instructions: The test instructions were prepared targeting the nature of the test, its purpose and how to answer it, taking into account reading each paragraph carefully and then answering and not leaving any of the test paragraphs unanswered and not choosing more than one alternative.

B. Correction Instructions: A model answer was developed, a key to correct the test was prepared, and criteria for correction were set as follows:

- **Correcting the substantive paragraphs**: (one mark) was allocated for the correct answer and (0) for the wrong or left answer, according to the student's answer in the substantive paragraphs of the type (multiple choice), and thus the total score of the substantive paragraphs was (15) degrees in the critical thinking skills paragraphs.
- **Correcting the Essay Paragraphs**: The Essay Paragraphs on Creative Thinking Skills were corrected as follows:
    - **Fluency skill**: one score was calculated for each correct response written by the student. Thus, the degree of fluency of the student's thinking = the number of ideas written by the student after deleting the ideas that are not related to the question and repeated, as the maximum responses of the students in each paragraph were (4) correct responses and thus be The total score for each paragraph is (4) degrees, and the total score for the fluency skill is (12) degrees.
    - **Flexibility skill**: one score was calculated for each group of ideas belonging to one category. Thus, the student's thinking flexibility = the number of categories in the student's answer for each paragraph of the test, where (3) correct responses for each paragraph, and thus the total score for each paragraph is (3) degrees, and the total sum of the degrees of flexibility skill is (9) degrees.
    - **The skill of originality**: one score was calculated for each correct, unfamiliar and uncommon response, and zero for the false, familiar and traditional response.
    - **The skill of sensitivity to problems**: one score was calculated for each correct response and zero for the incorrect response.
    - **Detail skill**: one score was calculated for each correct response and zero for the wrong response.

Validity of the test: Validity was extracted in two ways as follows:

- **Virtual honesty**: The apparent honesty of the test is achieved by presenting it to a group of arbitrators and specialists in the field of mathematics teaching methods, measurement and evaluation to judge the validity of the paragraphs in measuring productive thinking, representing skills for the subject of research and their suitability for the age group (the research sample). (85%) of the arbitrators' opinions.
- **The validity of the construction**: The validity of the construction was confirmed by finding the relationship between:

1. The degrees of each paragraph with the degree of skill to which it belongs: Pearson's correlation coefficient was used to reveal the relationship of the degree of each paragraph with the skill degrees to which it belongs. It was found that the correlation coefficients ranged between (0.31 - 0.50), which are significant coefficients when compared with the tabular value of the correlation coefficient (0.19).

2. The scores of each item in the total score of the test: Pearson's correlation coefficient was used to reveal the relationship of each item's score with the total score of the test. It was found that the correlation coefficients ranged between (0.32 - 0.51), which are significant coefficients when compared with the tabular value of the correlation coefficient (0.19).

3. The degrees of each skill in the total test score: Pearson's correlation coefficient was used to reveal the relationship of each skill's degree to the total test score.

This indicates the characterization of the items of the productive thinking test with constructive validity.

First exploratory application: The test was applied to a randomly selected survey sample from the research community consisting of (30) female students from the first intermediate grade in Al-Takhi Secondary School for Girls affiliated to the General Directorate of Education in Baghdad / Al-Rusafa II on Saturday corresponding to (1/23/2021). The time taken to answer all the test items was calculated by calculating the answer time (the first five students) and (the last five students), and after calculating the average for them, I found that the time period for answering the test items is (40 minutes).

The second exploratory application: The test was applied to a second exploratory sample of (150) female students from the first intermediate grade in Al-Ma'ali Secondary School for Girls affiliated to the General Directorate of Education in Baghdad / Al-Rusafa II on Saturday (30/1/2021), and after correcting the test, the order was arranged The scores were taken in descending order, and the highest (27%) of the female students' answers were taken to represent the upper group, and the lowest (27%) of the female students' answers to represent the lower group. Then, statistical analyzes were conducted on two axes (articles and objective paragraphs) as follows:

Article paragraphs

- **Paragraphs difficulty coefficient**: The difficulty coefficient was found for each of the essays of the test, which consisted of (15) paragraphs, and after applying the equation for that, it was found that it ranges between (0.54 - 0.70), which is an acceptable ratio because it ranged between (0.20 - 0.80).). (Odeh & Yousef, 1998:297)
- **Paragraph discrimination coefficient**: The discriminatory strength of each of the essay paragraphs of the test was found according to its equation, and it was found that it ranges between (0.27 - 0.49) and this ratio is acceptable.

substantive paragraphs

- **Paragraphs difficulty coefficient**: The difficulty coefficient was found for each of the substantive clauses of the test, which consisted of (15) clauses, and after applying the relevant equation, it was found that it ranges between (0.50 - 0.78), which is an acceptable percentage.
- **Paragraph discrimination coefficient**: The discriminatory power was found for each of the objective clauses of the test according to its equation, and it was found that it ranges between (0.24 - 0.63) and this ratio is considered acceptable.
- **The effectiveness of the wrong alternatives**: The effectiveness of the wrong alternatives for the objective paragraphs of the test was calculated after applying the special equation. It was found that all the wrong alternatives are negative, which means that they attracted more female students from the lower group than female students from the upper group.

The stability of the test: The reliability coefficient was calculated using the (Alpha-Cronbach) equation for the objective and article paragraphs, as the value of the reliability coefficient was (0.88), and it is a good stability coefficient.

Stability of correction for essay paragraphs: To ensure the stability of correction for essay paragraphs, the test paragraphs were corrected by the two researchers, then after a period of (10) days, the correction was repeated by the two researchers, and based on the (Cooper) equation, the results showed that the percentage of agreement reached (96%), which is a high percentage, after which the test was corrected by another corrector, as the percentage of agreement between the two corrections was (93%), which is a high percentage, and thus the test is considered stable.

The final version of the Productive Thinking Test: After the test's validity has been verified. And its stability, the difficulty of its paragraphs, and its distinction, the test is ready to be applied to the basic study sample and in its final form.

Implementation of the experiment: The researcher began applying the experiment from Saturday (5/12/2020) until Saturday (2/13/2021), and adjusting the equivalence variables, as the previous knowledge test was applied on Saturday (5/12/20) 2020), and the intelligence test on Saturday (12/12/2020), and the pre-productive thinking test on Saturday (19/12/2020), and the post-productive thinking skills test was applied on Saturday (6/2/2021). Inform the students of the test date one week before it is to be taken.

Statistical Means: The statistical program (SPSS) issued (23) was used to process the data obtained by statistical means.

Presentation and interpretation of results

First, show the results:

Results of the first null hypothesis: It states that "there is no statistically significant difference at the level of significance (0.05) between the average scores of the experimental group students who studied mathematics according to the design thinking model and the average scores of the control group students who studied the same subject in the usual way in Achievement Test "And for the purpose of verifying the validity of the first null hypothesis, the answers of the students of the two research groups were corrected in the achievement test, as shown in Table (7).

Table (7)

The values of the Levine test and the T-test for the two groups in the achievement test

Statistical significance at the level (0.05)	T. Value		livin test To equal variances		standard error	standard deviation	SMA	NO.	Study Division	Group
	Tabulated	Calculated	Significance	F						
Non functional	2.00	7.53	0.09	2.99	**0.37**	**1.83**	**24.71**	24	A	Experimental
					0,50	**2.54**	**19.97**	26	C	Control

Results of the first null hypothesis: It states that "there is no statistically significant difference at the level of significance (0.05) between the average scores of the experimental group students who studied mathematics according to the design thinking model and the average scores of the control group students who studied the same subject in the usual way in the test Productive Thinking Skills" and for the purpose of verifying the validity of the first null hypothesis, the answers of the students of the two research groups were corrected in the Productive Thinking test, as shown in Table (8)

Table (8)

Levine's two-group test of the Productive Thinking Test

Statistical significance at the level (0.05)	livein test To equal variances		Standard error	standard deviation	SMA.	NO.	Study Division	Group
	Significance	F						

Functional	0.14	2.30	1.11	5.43	34.43	24	A	Experimental
			0.89	4.55	28.35	26	C	Control

Results of the second null hypothesis: It states that "there is no statistically significant difference at the level of significance (0.05) between the mean scores of the experimental group students in the pre and post productive thinking test."

For the purpose of verifying the validity of the second null hypothesis, the scores of the experimental group were calculated in the productive thinking test before and after the experiment, as shown in Table (9).

Statistical significance at the level (0.05)	T. Value		livin test To equal variances		standard deviation of differences	Arithmetic mean of differences	standard deviation	SMA	Group
	Tabulated	Calculated	Tabulated	Calculated					
Non functional	2.04	12.81	2.20	0.81	**5.94**	**15.54**	**4.95**	**18.88**	Pretest
							5.43	**34.43**	posttest

Secondly Interpretation of the results:

1. The design thinking model presents the educational content in the form of problems that challenge the students' thinking and their abilities to creatively solve these problems and raise their desire to learn and thus increase their achievement.
2. The student's conscious thinking helped to develop and improve her brain abilities, and this generates an organization of ideas in the student's mind to reach the correct solution, and this in turn leads to linking the experiences gained by the students in the lessons with the experiences of daily life.
3. The design thinking model provides the students with an opportunity to cooperate positively with each other, and form a common language to understand the problem through the details that they interact with during the discussion, which leads to the growth and acceleration of their productive thinking, and that learning in small groups gives the students self-confidence, and cooperation among them in order to discover correct and creative answers.
4. Productive thinking skills are compatible with the stages of the design thinking model, which led to raising the level of productive thinking among students.
5. Teaching according to the design thinking model encouraged cooperative work among the students in the survey by forming small groups and providing them with a specific problem to work on finding appropriate solutions for them and discussing these solutions with other

groups, and generating a set of ideas, building prototypes and testing them led to raising the level of students' grades The experimental group in the post-productive thinking test.

Third: Conclusions: In light of the results that have been reached, the following can be concluded:

1. Teaching mathematics using the design thinking model helped first-grade intermediate students to raise their level of knowledge in productive thinking skills.
2. Teaching according to the design thinking model provided the opportunity for the experimental group students to link their previous information and experiences with new information to gain new knowledge.
3. Teaching according to the design thinking model contributed to the development of productive thinking skills among first-grade intermediate students.

Fourth: Recommendations: In light of the research results, the two researchers recommend the following:

1. Conducting training courses for mathematics teachers on the use of various models in teaching, including the design thinking model.
2. Inclusion of the design thinking model within the vocabulary of the Mathematics Teaching Methods course, which is taught to students of the faculties of education and basic education, with an indication of the main steps during their qualification for the teaching profession.
3. Mathematics books include enrichment exercises whose solution requires the use of productive thinking skills.

Fifth: Suggestions

1. Conducting a study similar to the current study on other variables such as complex thinking skills and mathematical communication skills, or behavioral variables such as tendencies or attitudes towards mathematics.
2. Conducting a comparison study between the Design Thinking Model and other models, to show which one is more effective in productive thinking skills.
3. Conducting studies aimed at knowing the effect of using other models in teaching mathematics on productive thinking skills.

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