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The Effectiveness of a Proposed Teaching Strategy Based on Cognitive Load Theory for Student Achievement in Analytical Engineering and Engineering Thinking

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This research aims to ascertain the efficacy of a proposed teaching strategy based on cognitive load theory in the achievement of analytical engineering and engineering thinking among third-grade students. The experiment was applied to the students of the third intermediate grade in Al-Maali High School for Girls for the academic year 2017-2018. The research sample consisted of 81 students who were randomly divided into two groups. Having studied following a proposed teaching strategy based on the theory of cognitive load, the control group consisted of 41 students who studied according to the usual method. The two groups were rewarded in the variables (chronological age calculated in months and tested on previous mathematical knowledge and achievement). The experiment was applied in the second semester of the 2018-2019 academic year. Using the statistical treatment (t-test) and the Levin test, the research resulted in a statistically significant difference at the significance level (0.05) between the mean scores of the experimental group and the control group in the achievement test. For students as well as the experimental group there is a difference is statistically significant at the level of significance (0.05) between the mean scores of the experimental group and the control group in the test thinking skills for the benefit of grades students in the experimental group, researchers have made several recommendations and proposals.

Key words: *cognitive load theory, engineering thinking*

Introduction

In the past, math curricula were based on a few concepts and focused on skills. In current times we find abundant concepts in the math curriculum and most schools focus on conservation and retrieval, which generates the accumulation of information and thus overlaps. When learning is done, this memory has a capacity called mental capacity. Fatigue of mental capacity, or overloaded capacity, is one of the most important factors that can lead to learning difficulties, and therefore less efficiency of the student to learn math or other topics (Mohammed Saleh Abu Jadu,2003).

Over the years, we have focused on several strategies and we have not paid attention to the important aspect of the existence of a cognitive load is the lack of working memory (systems concerned with the preservation and retrieval of information) may be reduced this load through strategies based on the theory of cognitive load, and after reviewing the strategies of cognitive load theory Researchers have tried to propose a strategy based on this theory to reduce the load on working memory and thus may be an important contribution to improving the achievement of analytical geometry and engineering thinking in mathematics Ihsan AlaiwiAl-Dulaimi and Mahmoud Al-Mahdawi Adnan (2002).

The research problem can be summarized in the following question:

What is the efficacy of the proposed teaching strategy based on cognitive load theory in the achievement of analytical engineering and engineering thinking among the third-grade students in this study?

Research Significance

The process of teaching mathematics is organised and purposeful, not random, because both the teacher and the learner use mental processes and must keep pace with modern trends of contemporary education., Teaching strategies are effective tools and important in the educational process because of its importance in organising the lesson and in dealing with scientific material The teacher cannot, without the choice of the appropriate teaching strategy, achieve the educational objectives of the lesson (Mohsen Ali Attia (2008)).

The goal of using modern teaching strategies is to contribute to the elevation of the educational process as a whole and to help create a generation that keeps pace with modern scientific developments. This can be achieved through the adoption of modern teaching strategies and innovative curricula which helps ensure that the learner is the focus in the educational process (Mohammed Hussein Abu Rayash, 2007).

The goal of the proposed strategy is to help students increase learning and adaptability to the environment. Furthermore, it is to transform the educational process from one of indoctrination and re-memorisation of information to the development of mental skills and the use of those skills for comprehension and problem solving (Suhail Rizk Thiab, 2000).

This strategy may be considered as one of the means used to develop and activate the previous knowledge of the learner and thus contribute to the deepening of understanding and follow-up learning processes. This will enhance the knowledge abilities of learners and help achieve the objectives of the subject (Salahuddin Mahmoud Allam,2006).

The importance of this research can be summarised into two parts:

The Theoretical Side

1. The present research deals with a strategy based on theoretical concepts not previously addressed by researchers in mathematics. It is based on the theory of cognitive load and research into the causes and means of reducing the cognitive load of the learner, which may contribute to an increase in the motivation of learners and positive interaction with the subject.
2. The researchers did not find any studies dealing with a teaching strategy based on the theory of cognitive load and its impact on the engineering thinking of third-grade students.
3. Mathematics teachers may benefit from this research by learning how to reduce the cognitive load of learners, which can affect performance and their ability to solve mathematical problems.

The Practical Side

1. The results of this research may benefit the Ministry of Education when building curricula through the development of teaching methods using modern teaching strategies that supplement this theory, which subsequently leads to benefit when applied to learners.
2. Knowledge of the impact of using a teaching strategy based on the theory of cognitive load and knowledge of its impact on the achievement of analytical engineering and engineering thinking among third-grade students.

Objectives

The present research aims to find out the impact of a proposed strategy based on the theory of cognitive load on the achievement of analytical engineering and engineering thinking among third-grade students.

Hypotheses

To achieve the objectives of the present research, the following zero assumptions were made:

1. There is no statistically significant difference at the level of significance (0.05) between the average scores of the students of the experimental group (who study mathematics subject to them using the proposed strategy)and the grades of the control group students (who study the same subject using the standard method in the test of analytical engineering achievement).

H0: There is no association among the average scores of the students of the experimental group and the grades of the control group students.
H1: There is an association among the average scores of the students of the experimental group and the grades of the control group students.

2. There is no statistically significant difference at the significance level (0.05) between the average scores of the experimental group students (who study mathematics subject to them using the proposed strategy) and the scores of the students of the control group (who study the same subject using the usual method in the engineering thinking test).

H0: There is no association among the average scores of the experimental group students and the scores of the students of the control group.
H1: There is an association among the average scores of the experimental group students and the scores of the students of the control group.

Limits

The current research is determined by the following:

1. Students of the third intermediate grade for the academic year (2018-2019) in the middle and high school's morning in Baghdad city / Directorate of Education Baghdad / Rusafa
2. The fourth and fifth chapters of the book of mathematics, the second part to be taught for the third intermediate grade of the second course, which includes coordinate geometry page (5 - 35) and geometry and measurement page (37 - 67).

Determination of Terms

Teaching Strategy

This is defined by Odeh(2014) as a set of means that came to the outcome of a series of tests used to realise and achieve the goals set (Odeh, Ahmad Suleiman, 2014). Abu Zeina (1996) defines it as “a group of teacher movements within the class that occur regularly and sequentially to achieve the pre-set teaching objectives” (Farid Kamel Abu Zeina, 1996). The researchers agree with the definition of Abu Zeina as a theoretical definition of the purpose of this concept in the current research.

Cognitive load: defined by both

This is defined by Cooper (1998) as a set of mental activities that occupy working memory during a certain period (Cooper, 1988)

According to Al-Harbi(2015): the term represents the total amount of both the mental and cognitive effort exerted by the learner during the processing of information in the working memory, during a specified period and the number of inputs required to process this load (Al-Harbi, 2015).

The researchers have adopted the definition of Cooper (1988) whose theoretical definition is in line with the purpose of this research.

Achievement: Known by

Abu Jadu (2003) states: This is the result of what the student learns after passing a specific period of learning to see how successful the strategy used by the teacher is and plans to achieve his goals which can be measured by the degree obtained in the achievement test (Abu Jadu, 2003).

Mohammed Mahmoud Hamadneh & Mohammed Khalid Hussein 2012 state: This "is a structured procedure based on specific criteria which are set in advance aiming to learn what the learner did to acquire the facts, concepts and skills after studying a specific subject" (Hamadneh & Khalid, 2012, p147)

The researchers agree with the definition of Abu Jadu (2003) which offers a theoretical definition in line with the aims of this research.

Analytical Engineering

Khaled Abidi (2006) defines this as: "a branch of geometry in which the geometric relations between different curves are studied by algebraic relationships between equations representing those curves attributed to certain coordinates. Rene Descartes and Pierre de Verma discovered in isolation." (Khaled Abidi, 2006)

Engineering Thinking

Salameh (1995) defines this as the ability to deal with geometric shapes and analysis based on the relationships and components which overlap and determine the common characteristics of a group of shapes through experimentation (Hassan Ali Salama. 2005).
Shehata and Zeinab (2003) define this as a form of engineering thinking that depends on a set of mental processes (Shehata and Zeinab, 2003).

The researchers use the definition of Salama(1995) which offers a theoretical definition consistent with this research.

Theory Background

The theory of cognitive load originated in 1980 by the Australian educational psychologist, John Sweller, who concluded that learning is better in light of conditions that are consistent with the cognitive structure of the learner (Nadia Hayel Al-Surour, 2002). Cognitive load refers to the total amount of effort. Cognitive load is influenced by the subjective competence of the learner and the extent of his interaction with the subject of learning. This is in addition to the efficiency of the teacher when providing the material and the teaching aids used which help the learner to process new information contained in the learning materials.

From the standpoint of cognitive load theory, learning takes place through two types of memory: working memory and long-term memory. Working memory is the active component that handles the task of processing the required information that may be of a high level of difficulty. The catalyst has a significant role among the other types of load to which the learner is exposed, as it is necessary to acquire the cognitive structure (Sweller, 2003). Reducing the cognitive load faced by the learner's memory during the learning process, to obtain effective learning based on higher-order thinking skills and help in obtaining coherent information is the basis for learning. Good learning is to:

• Provide instructional designs for learning material that are consistent with the cognitive structure of the learner.
• Give the method of information building clear importance for the learner in a way that focuses on linking the structure of knowledge with the method of providing information leading to the achievement of a sound amount of learning (Lee, 2000).

One of the reasons that led to an increase in a cognitive load upon the learner (and led to difficulty in learning) is a low ability to understand and process information learning material. This leads to not investing the mind when reading and receiving new information and therefore results in a reduced ability to perform well, leading to a low level of mental skills for learners in the organisation and processing of information. (Khuzam and Isaan, 1993, p329).

The Importance of Cognitive Load Theory

The theory of cognitive load has focused mainly on the need to adapt educational materials to suit the controls and limits of the cognitive system of the learner's mind. This is because the main objective of this theory is to develop methods of providing educational materials to the learner so that the learning process is following the controls and limits of working memory and does not contribute to an additional load on the work of memory (Barakat, 2007). Reducing the cognitive load distributes basic processing or reduces photogrammetry (Christ, 2007).

Case (1974) used the idea of mental capacity to shape his theory of cognitive development, stressing that working memory is not alone in determining thinking (Abu Jadu, 2007, p110).

The learner can take advantage of the level of mental capacity, which is often active in the process of recalling the previous information, and thus can build knowledge, as mental capacity is the entrance to measure the knowledge load. We will identify the types of knowledge load and the causes of each type.

Types of Cognitive Load

Blayney & Sweller (2015) identified three types of cognitive load:

• Intrinsic Cognitive Load which is caused by the complexity of the learning materials that provide the learner difficulty in parts of the learning content and can be measured by the degree of correlation between the important elements contained in the information to be kept in working memory at the same time.
• Extraneous Cognitive Load is the kind of load that is determined by the type of composition of the learning material and includes the design of education and teaching methods used to present information to the learner, as the provision of educational materials sequentially and simply to reduce the cognitive load of the learner (Abu Riach, 2007).
• Germane Cognitive Load: This type of workload results from the learner's handling of the content of the learning material to do deeper processing of that content such as self-explanation by the learner or by the conscious application of learning strategies (Hassan Kamel Rassen Al-Kinani,2009).

The Foundations of Epistemological Load Theory

This theory is based on a number of factors which contribute to the process of reducing the cognitive load on the learner. A summary of these factors is:

1) Analysis: This is the process of analysing information accurately and clarifying the parts related to that information in the educational phrase that responds to the learner in the teaching materials.
2) Delete the duplicate: Delete duplicate information between text and image.
3) Supply: The supply of new ideas for the issue rather than research.
4) Presentation: Subtract the information received about the text simultaneously and non-sequentially. The presentation represents solved examples as alternatives to the normal examples contained in the subject submitted to the learner (Abu Riach, 2007).

Thinking

Some educators in the field of education contend that thinking is the most complex form of human behaviour as it is the highest level of mental activity in humans and thus this distinguishes humans from other creatures. Thinking occurs when the learner faces a particular problem and the solutions are not enough to resolve the problem. (Al-Sorour, 2002).

Thinking Qualities

Characteristics that distinguish thinking from other mental processes are:

• Thinking is based on information that has settled in the mind of the learner about the general laws of the subjects covered.
• The basis for the beginning of the start of thinking processes is from the sensory experience of the learner but is not limited or confined to them.
• Thinking may appear in the form of indirect mental activity, a reflection of relationships and ties verbally (Camel, 2001).

Mathematical Thinking Skills

Thinking skills were multiplied until exceeding twenty skills. Thinking skills related to mathematics were identified as follows:

• Skill observation and perception of relationships: This skill refers to the ability of the learner to analyse the information obtained from different learning sources and to recognise the relationship between parts. It also relates to the ability to identify the principles and provisions

governing these relationships. The goal is to prepare learners and motivate them to learn the skill.
• Skill of appreciation: The basis of the work of this skill through the learner's use of information that is within the scope of his prior knowledge to judge a new position or work in the light of an accurate standard knows.
• The skill of graduating results and the development of generalisations: This skill is to acquire the learner the ability to observe a set of characteristics or molecules that are called common traits or attributes that enable the learner to develop a general rule or generalisation applicable to all particles that have common features (Antoine Homsi 1996).
• Skill employ induction: This skill enables the learner induction process, which is a mental process in which the learner meditates a set of partial cases and examples and extracts a general rule applicable to all particles. (Diab, 2000: 71)

Aspects of Learning Engineering Thinking

The Association of Mathematics, citing UNESCO, stressed that the learning of engineering thinking is based on three basic aspects and has been summarised in the following.

• The ability of the learner to recognise properties through observation and experience, which leads to knowledge of the principles and memorization.
• Methods of measurement and calculation and depend on and depend on the properties of the vacuum, which contributes to the service of scientific purposes.
• Allow opportunities for reflection and a set of conclusions that can be reached by the learner through observation and experience. (UNESCO, 1986: 143)

Research Methodology

Depending on the nature of the research and its hypotheses, experimental research methodology was used.

Selecting Experimental Design

An experimental design with partial control of two equivalent groups using a pre-and-post-test design was considered suitable for research purposes. The proposed strategy represents the independent variable, and the achievement of analytical geometry and geometric reasoning represents the two variables in the experiment.

Table 1: Experimental Design the Design of research semi-experimental Table 1:

Measure Independent variable	Independent variable	Dependent variable	Equivalence between two gropes	Groups
test achievement - of analytical engineering **Test engineering thinking**	**-achievement of analytical engineering** **-engineering thinking**	**suggested strategy**	**-Intelligence otis lennon** **- Previous collection** **- Chronological age**	**Experimental**
		Normal way		**Control**

Research Society

The accuracy of the research depends on the procedures that accurately determine its community (Al-Hailah, 2001). The research community consists of 16325 students.

Research Sample

Al-Maali Secondary School for Girls was chosen after it was agreed with the school administration to experiment in the mentioned school. After excluding the 7 female students from the two groups, the research sample became 81 female students, as shown in the following table (2):

Table 2: Distribution of female students between two research groups (Experimental and Control)

Number of female students			**division**	**Experimental Control**
After making	**exclusion**	**Before exclusion**		
40	**3**	**43**	**A**	**Experimental**
41	**4**	**45**	**B**	**Control**

Control Procedures

Before the start of the research, experimental procedures were careful to control all factors and variables that are believed to affect the integrity of the application of the experiment and the truthfulness and accuracy of the results and agencies:

A) Internal integrity of the experimental design:

To verify the internal integrity of the experimental design and for the current research to be true to the criterion in which the difference between the two research groups can be attributed to the independent variable and not to any other factor or intruder variable, the previous mathematical knowledge was determined by preparing a test consisting of 18 paragraphs. Equivalence in the chronological age calculated in months, as well as parity in the achievement of the previous analytical engineering through access to the second-grade intermediate grades, and parity in the grades of the first semester (the first cup), were presented via a general test in engineering thinking, consisting of 15 paragraphs to establish a baseline for parity and dish. In this respect, the two groups were equal on all the variables compared (Firas Al-Siliti, 2008).

B) Control of extraneous variables (external safety of experimental design):

The researchers sought to control the extraneous variables and verify the external integrity of the experimental design by controlling the experimental conditions, seeking not to expose the two research groups to the experimental extinction (leave in the experiment), and take into account the maturity factor, as well as the secrecy of the experiment. The same test tools were used in both groups (Al-Hailah, 2001).

Research Requirements

1. Determination of content (scientific material):
The scientific material was determined from the book of mathematics for the third intermediate grade (2017_2018 m / the first edition) and was represented in the fourth chapters (coordinate geometry) and the fifth (geometry and measurement)

2. Content Analysis:
The content of the chapters (fourth and fifth) was analysed according to mathematical knowledge components, as well as according to Bloom's classification of cognitive domains (154), and behavioural objectives were formulated and distributed over the two chapters, as shown in table (3).

Table 3: Distribution of behavioural purposes among the cognitive domain in the content of scientific material

totl	Cognitive domain levels						Chapter Title	Chapter
	evaluation	Installation	analyzing	Impementation	undersanding	remember		
87	4	5	6	18	18	36	Coordinate Engineering	fourth
67	6	8	10	12	8	23	Measurement Engineering	Fifth
154	10	13	16	30	26	59	total	

Preparation of Teaching Plans

Within the content of the scientific material for the fourth and fifth semesters, 40 teaching plans were prepared (20 for each group), distributed between the two chapters (10) for the fourth semester (coordinate engineering) and 10 for the fifth semester (engineering).

Research Tools

To verify the research objectives and hypotheses, two tools have been built to measure the dependent variables: Analytical engineering and thinking skills.

Building the Analytical Engineering Achievement Test

One of the requirements of this research is to build an analytical engineering achievement test for the chapters involved in the research experiment. This was done by determining the objective of the test, which is to measure the level of achievement of analytical engineering for female students in the content of the research. A set of 154 behavioural objectives, 20 test items, 15 thematic items of multiple-choice type and 5 paragraphs of the frying type were formulated. The following specification table (test map) has been prepared based on this content. Scientific material and behavioural purposes are shown in Table (4).

Table 4: Table of specifications for the achievement of analytical engineering in mathematics as scheduled for chapters IV and V. Specification table for analytical engineering achievement test table 4:

Number of paragraphs	**Cognitive domain levels**						**The relative weight of the class**	**Number of quotas**	**Title chapter**	**chapter**
	evaluation %6.5	**installation %8.5**	**analysis %10**	**Implementation %20**	**%17 understanding**	**remember %38**				
10	**1**	**1**	**1**	**2**	**1**	**4**	**50%**	**10**	Coordinate Engineering	**forth**
10	**1**	**1**	**1**	**2**	**1**	**4**	**50%**	**10**	Measurement Engineering	**fifth**
20	**2**	**2**	**2**	**4**	**2**	**8**	**100%**	**20**	**total**	

After preparing the table of specifications (test map) of the content of the scientific article, 20 test items were drafted according to these specifications, as well as a page for the test instructions.

The Test is Verified

This refers to testing for the possibility of the test to measure what it was developed to measure, and ensuring it does not measure anything else instead. (Seliti et al., 2009)

The validity of the test was verified using some types of honesty following the research, namely:

Virtual Validity

The test paragraphs were presented to several arbitrators with competence in mathematics and methods of teaching them to clarify their opinions regarding the validity of the test paragraphs in measuring what was set for them and the accuracy of their formulation, and observations were taken.

Believe Content

The use of the specification table in the construction of the analytical engineering achievement test is also an indication of the validity of the test content. Thus, the test is valid in terms of its representation of the content of the scientific material and the behavioural purposes it measures.

Sample Information

The test was applied to a sample of 43 female students of the third intermediate grade on Thursday, 11/4/2019 in the pathway of the certificate of the Directorate of Education in Rusafa III. The observations of the students about the paragraphs that were used were noted and their inquiries were followed-up. The test took about 40 minutes to complete.

Statistical Analysis Sample

The test was applied to a second reconnaissance sample of 120 female students of the third intermediate grade in the intermediate path of the certificate of the Directorate General of Education Baghdad Rusafa III, on Sunday 22/4/2019, after making sure that the students completed the study of the two chapters covered by the research.

Statistical Analysis of Analytical Engineering Achievement Test Clauses:
After correcting the students' answer sheets and finding the final score for each student, the scores were arranged in descending order and a higher percentage (27%) and a lower (27%) score were set for the two groups, 32 in the upper and 32 in the lower.

Coefficient of difficulty for test items:
According to the special difficulty coefficient equation, it was found that the coefficients ranged from (0.72 to 0.31). Also, the difficulty coefficient was calculated for each of the test paragraphs, which were (5) items according to the equation of their difficulty coefficient. (-0.49). It is also noted that the difficulty coefficient of test paragraphs as a whole varied within the test period (0.80-0.20), which is the period of acceptance of the paragraphs. (Dulaimi and Adnan, 2002)

التمييز *Discriminatory power of test items*:
The discriminatory coefficient equation was applied to calculate the discriminatory power for each objective test item. It was found to range from (0.55-0.31). This is considered a good indicator of acceptance of all paragraphs, as Ebel (1972) indicated that the paragraph is good and acceptable if the ratio of the discriminatory force coefficient is between (0.80-0.20). (Ebel, 1972)

Effectiveness of wrong alternatives:
The efficacy of the most attractive camouflage for lower-grade female students was calculated for each of the multiple-choice subjective test items according to their equation for the effectiveness of their faulty alternatives, and was found to range from ([0.08-] - [0.06-]), indicating their effectiveness, and thus the decision was made to keep the alternatives as they are.

Test stability:
The stability coefficient was calculated to test the achievement of analytical geometry according to the equation (Elva - Kronbach), as one of the equations that can be applied in the test, which consists of article paragraphs and objective (Essawi, 1985). As for the article paragraphs, 60 papers were drawn randomly and then one of the teaching staff corrected the papers and after a week, he corrected again using the Cooper equation. This reached a (0.95) rate of agreement. Using the same equation to determine corrected papers from before the research, the rate of agreement was (0.97), showing that both ratios express a high coefficient of stability, as indicated by Majid and Yassin (2012).

Building the Engineering Thinking Test

The following engineering thinking test was built:

1) Determine the purpose of the test:
The purpose of the test was determined as being to measure the engineering thinking of third-grade students.

2) Review the previous literature and studies:
Previous studies of engineering thinking were examined, including Shara (1999) and Amal Abdullah Khasawneh (2007). These studies have benefited from the division of thinking indicators and the formulation of paragraphs.

3) Identify areas of engineering thinking:
Through reference to the literature and the translation of some definitions of this variable, and after consulting several specialists in the field of teaching methods of mathematics and psychology, four areas were identified (cognition, analysis, arrangement, conclusion) as suitable for the competencies and capabilities of students at this stage (Al-Yasiri, 2016).

4) Formulation of test items in the light of specific areas:
Several test items were formulated for each field to be consistent with the theoretical definition of each. The test consisted of 20 items, with 5 items for each field.

5. Presenting the fields with the paragraphs to the arbitrators:
After determining the areas of engineering thinking and formulating the test paragraphs in light of the areas identified in the initial form, independent arbitrators were presented with the paragraphs, consisting of 20 paragraphs to several arbitrators, to know their opinions and observations on the consistency of the paragraphs with the specific areas addressed in the test and the validity and validity of the paragraphs to measure. The engineering thinking of the third-grade students in the light of their views was then modified, and the agreement rate for these paragraphs (87%) has been retained and distributed, as in table (5).

Table 5: Distribute the paragraphs of the engineering thinking test to their fields
Distribute the paragraphs of the engineering think test to their fields table:

conclusion	**ranking**	**analysis**	**perception**	**skill**
8,14,15,16,19	6,7,9,11,13	3,5,17,10,20	1,2,4,12,18	**Distribute paragraphs to areas**

5) Answer and Correction Instructions:
A page was provided at the front of the test containing instructions for the test, as well as for instructions for correction, where one grade is allocated for the correct answer for the paragraph and zero for the wrong answer or where it has been left unanswered.

6) Believe the test:
The validity of the test was verified using two types of validity:

الظاهري virtual honesty:
Virtual honesty was achieved by presenting the test to several specialists in the methods of teaching mathematics and psychology.

Construction Validity:

The internal consistency of the test was verified by finding the correlation between:
1) Grades of each paragraph with the grades of its field:

The correlation coefficient between the scores of each of the test items and the scores of the field to which they belong was extracted using the Pearson Correlation Coefficient. The results showed that all test paragraphs were statistically significant. The correlation coefficient values ranged between 0.66-0.30 which is a good indicator of the construct validity of the test.

2) Total test scores:
The correlation coefficient between the scores of each field and the total test scores was extracted using the Pearson Correlation Coefficient. The results showed that all test items are statistically significant. The correlation coefficient values ranged between 0.69 - 0.46, which is a good indicator of the validity of the test.

7) Sample information and statistical analysis sample for engineering thinking test:
Sample information:

To ensure the clarity of the test clauses and instructions, and determine that the time required is enough for the students to answer all the test clauses, the test was applied to a sample of 40 students, and the time taken in the response ranged between 35-45 minutes, with the average time calculated to be 40minutes as an average time for students to answer all paragraphs of this test.
Statistical Analysis Sample:
After applying the engineering thinking test to the information sample and making the appropriate adjustments, the test was ready to be applied again to conduct statistical analyses of the test items.

Statistical Analysis of Test Items

After correcting the students' answer sheets and finding the final score for each student, the scores were arranged in descending order and a higher percentage (27%) and a lower (27%) score were set for the two groups, the highest (32) and the lowest (32) degrees.

Coefficient of difficulty of test items:
According to the special difficulty coefficient equation, the coefficients were found to be between (0.73 - 0.40).

التمييز *Discriminatory power of test items*:
The discriminatory power was calculated for each test item. This was found to be between (0.61-0.32).

Effectiveness of wrong alternatives:
The effectiveness of the alternatives was calculated for each of the test items. Their value ranged from ([0.08-] - [0.05-]), indicating their effectiveness.

Test stability:
The coefficient of stability of the geometric reasoning test was calculated according to the equation (K-R20), which depends on the application of the test at once and can be used to

verify the homogeneity of all test items that measure a single attribute or attribute and are binary (0.1) (Alam, 2006).

The coefficient of stability of the test is 0.81, which is considered a good value.

Statistical Methods

The following statistical methods were used after using the statistical program (SPSS) version 22:

Equivalence of vertebral difficulty, equation of differential force of vertebrae, equation of efficacy of wrong alternatives, equation of effect size, Cooper equation, Alpha-Kronbach equation, Koder-Richardson equation (K-R20), Pearson equation, and Levin test for two samples, which was used to determine the homogeneity between the two groups (experimental and control) about the variables included in the comparison. T-tests were also used to check the equivalence between the two groups (experimental and control) in the variables included in the comparison. As well as to know the significance of the statistical difference between Mt Average grades two students in the analysis of the results.

Results

Axis I: Presentation of the results of the analytical engineering achievement test
- Results related to the first zero hypotheses:

To validate the first zero hypotheses which states that:

There is no statistically significant difference at the significance level of 0.05 between the mean scores of the experimental group students (who study mathematics prescribed using the proposed strategy) and the scores of the control group students (who study the same subject using the usual method in the test of the achievement of analytical engineering)

H0: There is no association among the proposed teaching strategy and achievement of analytical engineering and engineering thinking among third-grade students.
H1: There is an association among the proposed teaching strategy and achievement of analytical engineering and engineering thinking among third-grade students.

After applying the analytical engineering achievement test and correcting the answers of the students, the statistical portfolio program (SPSS version 22) was used to obtain the statistical description of the raw data of the experimental and control groups in the analytical engineering achievement test. Table (6) shows this description of the two groups (experimental and control) that were involved in the variable of analytical engineering achievement.

Table 6: A Statistical Description of the Experimental and Control Groups concerning (test ANALYTICAL ENGINEERING)

95% Confidence Interval of the Difference		Arithmetic mean error	Standard deviation	Average calculation	Order number	Division	The group
Lower	Upper						
6.23	**1.8**	**0.63**	**2.02**	**74**	**40**	**A**	Experimenta
6.54	**1.6**	**0.71**	**2.06**	**61**	**41**	**B**	Contro

We note from Table (6) that the average scores of the experimental group were 74 with a standard deviation of 2.02, while the average score of students of the control group was 61 with a standard deviation of 2.06, using the application of (Test Levene) for two independent samples. To find out the significance of the difference between the different degrees of students of the experimental and control groups, Levin statistics (F) 4.28 at the significance level (0.069), which is greater than the level of significance (0.05), which means that the two groups are homogeneous in this variable.

By applying a t-test to two independent samples, to determine the significance of the difference between the mean scores of the experimental and control groups, the t value was 2.45 at the probability level of 0.003, which is smaller than the level of significance (0.05) and the degree of freedom (79. Table (7) shows these outcomes for the students of the experimental group who studied according to the proposed strategy and the students of the control group who studied according to the usual method of testing the achievement of analytical engineering.

Table 7: value f and t the group experiment and control concerning (test Analytical Engineering

Statistical significance at (0.05)	**df**	t-test for Equality of Means		Levene's Test for Equality of Variances		**Order number**	**The group**
		Sig. (2-tailed)	**t**	**sign**	**F**		
sign	**79**	**0.003**	**2.45**	**0.069**	**4.28**	**40**	Experimental
						41	Control

Thus, the first zero hypotheses were rejected, and the alternative hypothesis, based on the Analytical Engineering Achievement Test was accepted for the experimental group.

To determine the magnitude of the effect of the independent variable on the dependent variable, it is possible to use (t-test when converting (t to d) directly.

Table 8: Reference table to determine the size of the effect.

size of the effect			The level
large	**average**	**small**	
0.8	**0.5**	**0.2**	**Number value**

Using the equation (d of the magnitude of the effect), the value was 0.84, which is large effect size, i.e., this strategy appears to have had a significant impact on the dependent variable.

Axis II: Presentation of the results of engineering thinking:

Results Related to the Second Zero Hypothesis

To validate the second null hypothesis which states that:

There is no statistically significant difference at the significance level of 0.05 between the mean scores of the experimental group students (who study mathematics prescribed using the proposed strategy) and the scores of the control group students (who study the same subject using the usual method in the engineering thinking test).

H0: There is no association among the average scores of the experimental group students and the scores of the students of the control group.
H1: There is an association among the average scores of the experimental group students and the scores of the students of the control group.

After applying the engineering thinking test and correcting the answers of the students, the statistical analysis program (SPSS ver. 22) was used to obtain the statistical description of the raw data of the experimental and control groups in the engineering thinking test. Table (9) shows this description:

Table (9) Statistical description of the two groups (experimental and control) about the variable of engineering thinking

Table 9: A Statistical Description of the Experimental and Control Groups concerning (engineering thinking)

95% Confidence Interval of the Difference		Arithmetic mean error	Standard deviation	Average calculation	Order number	Davison	The group
Lower	Upper						
7.23	**1.11**	**0.87**	**8.17**	**17.67**	**40**	**-h**	Experimental
7.24	**1.12**	**0.76**	**7.98**	**14.99**	**41**	**d**	Control

We note from Table (9) that the mean scores of the experimental group students were 17.67 with a standard deviation of 8.17, while the average scores of students of the control group were 14.99 with a standard deviation of 7.98 and the application of (Test Levene) for two independent samples. To find out the significance of the difference between the different scores of the experimental and control groups, Levin (F) (1.34) returned a level of (0.16) which is greater than the level of significance (0.05). This means that the two groups are homogeneous about this variable.

By applying a t-test of two independent samples to determine the significance of the difference between the mean scores of the experimental and control groups, the t value reached 4.15 at the level of 0.001, which is smaller than the level of significance (0.05) and the degree of freedom (79). Findings relating to these analyses for the students of the experimental group (who studied according to the proposed strategy) and the students of the control group (who studied according to the usual method of test thinking) are shown in table (10).

Table (10) value of (F) and (t) for the experimental and control groups in the variable (engineering thinking)

Table 10: value f and t group Experimental and Control concerning (engineering thinking)

Statistical significance at (0.05)	**df**	t-test for Equality of Means		Levene's Test for Equality of Variances		**Order number**	**The group**
		Sig. (2-tailed)	**t**	**sign**	**F**		
sign	**79**	**0.001**	**4.15**	**0.16**	**1.34**	**40**	Experimental
						41	Control

Thus, the first zero hypotheses was rejected, and the alternative hypothesis was accepted, which states that:

There is a statistically significant difference at the level of significance (0.05) between the average scores of the experimental group students studied according to the proposed strategy and the average scores of the control group students studied according to the usual method in the test of engineering thinking, in favour of the experimental group.

To determine the magnitude of the effect of the independent variable on the dependent variable, it is possible to use (t-test when converting (t to d) directly. Using the equation (d for the magnitude of the effect), the value is 0.71, which is the average size. The function (geometric thinking) appears to have had a medium effect on the test scores of these students.

Interpretation of results

Results Related to the First Hypothesis

The superiority of the experimental group in the variable of the achievement of analytical geometry and the magnitude of a large impact is in line with the literature and with the researchers' logical explanation. This strategy has contributed to the learner's ability to understand the scientific material, and has made an effective contribution to the search for information and attain a high assessment outcome for what these students learned in each step, which led to attention and continued communication and follow-up of what was learned from the lesson material. and thus formed structured knowledge Learning in other situations invested

Results Related to the Second Hypothesis

The excellence in the test of engineering thinking among the experimental group students may be attributed to the use of the proposed strategy in teaching, as contributing to the development and promotion of many variables among the learner, including engineering thinking in its different types. The new addition to the obvious role that emerges as a result of the use of this strategy of increasing interaction in the classroom between learners themselves on the one hand and between them and the scientific material on the other hand in addition to the possibility of the learner in the use of what he learned in positions New Other.

Research Recommendations

1. Review the content of the mathematics curriculum for the intermediate stage so that the subjects included in the textbook contribute to the development of engineering thinking among learners.

2. Suggest a need to contain the curricula of mathematics for the intermediate stage on the different types of engineering thinking skills in a balanced manner and commensurate with the developmental characteristics of learners in that study.
3. Raise the level of the learner through attention to the process of learning ("how"), and focus on the development of understanding and engineering thinking, as opposed to mere memorisation and indoctrination.
4. Preparing special programs and training courses to increase the awareness of teachers in the areas of engineering thinking and the importance of giving them to learners.

Search Suggestions:
In light of these findings, the researchers propose the following:
1. Standardise a test that measures the cognitive load of all levels of study, and develop teaching strategies that take into account the level of cognitive load for each grade.
2. Conduct similar studies involving the use of other strategies and different stages of study in mathematics.

REFERENCES

Abu Jadu M.S (2003): Teaching theoretical thinking and application, i 3, Dar Al-Masirah for Publishing and Distribution, Amman. 2 No (34) , pp 145 – 154

Abu Rayash M.H (2007): cognitive learning: I 1, Al-Masirah Publishing House, Amman. 5 No (24) ,pp 204 - 214

Zeina A.K.F (1996): Curriculum and Teaching of School Mathematics, Al-Falah Library, Kuwait. 4 No (56) , pp 175 – 184

Al-Harbi, A., (2005): Engaging in learning in light of the different source of cognitive load, the level of learning disability and the level of cognitive control among secondary school students, Journal of Educational Sciences, College of Education, King Saud University, 37 No (3), pp 461-488.

Hamadneh, M.M & Khalid H.M (2012): concepts of teaching in the modern era, methods ... methods .... Strategies, the world of modern books, Irbid. 3 No (47) , pp 165 - 164

Homsi, A (1996): Experimental Psychology, Damascus University Publications, Faculty of Education, Damascus. 7 No (87) , pp 205 - 214

Al-Hailah, M.M (2001): Teaching Methods and Strategies, University Book House, Al Ain. 8 No (57) ,pp 132 - 143

Khouzam, N.A & Isan, S.A (2017): The strategy of science and recall among university students, Journal of Studies of the Humanities, Jordan. 2 No (53), pp 222- 234,

Khasawneh, A.A. (2007): Thinking about Space Engineering among Grade 10 Students, Jordan Journal of Educational Sciences, 3, No. 1,pp 254 - 260 March.

Al-Dulaimi, I.A & Adnan M.M(2002): Measurement and Evaluation, Ministry of Higher Education and Scientific Research, Iraq. 5 No (34) , pp 123 - 135

Thiab, S.R (2000):: Teaching thinking and mathematical thinking skills for upper primary students, Gaza and Dar Al-Manara. 8 No (59) , pp 154 - 164

Al-Surour, N.H. (2002) An Introduction to Creativity, i1, Wael Publishing House, Cairo. 1 No (22) , pp 78 - 90

Salama, H.A (2005): Recent trends in the teaching of mathematics, I 1, Dar Al-Fajr for publication and distribution, Cairo. 3 No (12) , pp 53 - 62

Al-Siliti, F (2008): Learning and Teaching Strategies, 1st floor, Dar Al-Kutub Al-Hadit for Publishing and Distribution, and Dar Al-Jadara for World Book, Irbid, Amman. 8 No (45), pp 161-175

Shara, R.F (1999): Measuring Thinking Levels for Students of General Education Stages in Engineering, Unpublished Master Thesis, College of Education, Ibn Al-Haytham, Baghdad. 9 No (88) , pp 168-176

Abidi, K. (2006): What is Engineering, available at: http://khalid-alubaidy.com/news.php?i=86

Attia, M.A (2008): Modern Strategies in Effective Teaching, Dar Safaa, Amman, Jordan. 4 No. (23) , pp 169- 172

Allam, S.M (2006): Educational and psychological tests and standards, Dar Al Uloom for printing and publishing. 7 No (64) , pp 236 - 247

Odeh, A.S (2014): Measurement and Evaluation in the Educational Process, 1st Floor, Wael Publishing House, Amman. 5 No (32) , pp 273 - 284

Al-Kinani**,** H.K.R (2009): Using Computer-Aided Structural Theory Strategies and Their Effect on Achievement and Developing Numerical Sense Skills among Middle School Students in Mathematics, Unpublished PhD Thesis, University of Baghdad. 12 No (66) , pp 128 – 134

Al-Yasiri, S.J.D (2016): The use of three teaching strategies and their impact on achievement and mathematical thinking among students of the middle stage, unpublished doctoral thesis, University of Baghdad. 6 No (54) , pp 215 - 223

Cooper, G (1988) Research into cognitive load theory and instructional design at Unsw; University of New South, Australia, Unsw 9 No (68) , pp 226 - 257

Sweller, J. (2003): Evolution of human congnitive architecture, The psychology of learning and motivation, 2 No (43), pp 21, 266.

Shara, (2000): Cognitive load theory and aging effect of worked examples on learning efficiency. Learning and instruction, 8 No (98),pp 902-913.