High-ranking Thinking and its Relationship to Engineering Thinking Among Second-grade Intermediate Students

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Abstract. The research aims to answer the following question: Is there a relationship between high-order thinking and its relation to the engineering thinking of second graders? To achieve the aim of this research, the researcher built a high-order thinking scale and an engineering thinking scale. The two scales were applied to a sample of second-grade students who were randomly selected (400) students. The Spearman-Brown equation, the T-test for one sample, the T-test for two independent samples, and the K-square. The research has reached the following results: Second grade students enjoy high level of thinking. The second-grade students enjoy engineering thinking. There is a direct relationship between high-order thinking and geometric thinking, the more high-order thinking increases the geometric thinking.

1. Search problem

Improving students' thinking has become a required goal, because it is one of the mental processes that the student cannot do without, especially when he faces a problem that he cannot solve with his usual methods of behavior. Therefore, educational institutions aimed to instill and develop thinking among individuals, as many scholars and interested people see that the ability Thinking can be learned and taught, and it can be improved and developed through training, and many educators and researchers agree that the teacher has a fundamental role in that, by creating an atmosphere that strengthens the learner’s self-confidence, by raising educational situations that require thinking and creativity, which opens the field for the learner. For high-order thinking and engineering thinking.

High-ranking thinking is one of the educational dimensions that educators have begun to pay attention to in recent years as one of the important keys, to achieve the educational goals of the learning and teaching process, and to ensure effective cognitive development that allows the learner to use the maximum of his mental energies to achieve success and proper adaptation in the field of learning or public life, This type of thinking enables the learner to understand the world around him, and to understand how things happen, the reasons for their occurrence and what makes them happen in different ways. High-ranking thinking is the context in which cognitive skills improve.

Engineering thinking is considered one of the thinking styles that should be developed among learners through engineering, and that the teaching method is an influential factor in the development of engineering thinking, and engineering thinking is the skill of reasoning and the ability to guess among the learners, and it is considered a driver for building the perspective of mental habits, and it contributes to the understanding and awareness of individuals To the world around them, it is through it that they develop a sense of spatial, and perceive the geometric features of shapes and objects in the reality of their daily life.
After examining the researcher about the studies that dealt with these two topics, she found that each of them was addressed separately without addressing these two variables together, so the researcher saw the need to address these two variables together and discuss the relationship between them, and in light of this, the research problem in answering the following question: Is there a relationship between high-ranking thinking and engineering thinking among female students?

2. Research importance

Scientific developments, technological applications, and the contemporary wealth of knowledge have highlighted the effective role that mathematics plays in various walks of life, and it has become in our world today more important and necessary for our contemporary life than it was in the past, hence the development of mathematics education in our schools. Because it “is no longer merely the acquisition of concepts, skills and generalizations, but the process of discovering high art, and the power represented in its many uses in various aspects of life” (Ibrahim, 1997 (18: 18), the need for mathematics has increased in daily and life transactions to overcome the problems facing the individual. , Which is getting more and more complex day by day, and today the need for an individual capable of performing mathematical operations has become.

The process of thinking, reasoning, or contemplation is one that deals with perceptions by contemplating and delving into the light of past experiences and experiences and within the framework of Expectations, goals, and Needs that the behavioral system seeks (Razzouki and Mohamed, 2018: 57).

Loren Resnick (1987) described the features and characteristics of this type of thinking as follows, determined by mathematical relationships, and that the method of work is not fully predetermined, and this thinking tends to be complex, as it includes an analysis of complex situations and situations and the adoption of Mental trials conducted by the individual, and it includes a self-organization of the thinking process, that is, it includes self-evaluation, and often gives multiple solutions instead of giving a unique solution, that is, it avoids simple solutions or formulas, as the single issue often has potential solutions, and the task of the thinker is To create and discover a meaning for the cognitive situation or experience, as it often includes uncertainty, as not everything related to the available task is known, and this leads to the discovery of meanings and ideas, in addition to that it tends to acknowledge the causal or logical relationships that govern the situation at hand, which it may not give Other types of thinking are of great importance (Liebman, 1998: 108-114) (Resnick, 1987: 32).

As for engineering thinking, it is a mental activity related to engineering and depends on a set of mental processes that show the student's ability to perform a set of performances required of him in engineering and measurement.

The mental and behavioral activity that the learner performs when he encounters an engineering problem that he cannot solve easily, which forces him to analyze the problem and study its basic components, define its main features, and realize the relationship between its components, and then his ability to organize previous experiences that he experienced in accordance with the conditions and conditions of the problem, . With the aim of overcoming the obstacle facing it, and reaching sound solutions to engineering problems and issues. (Al-Banna, 1994: 4)

A set of mental processes represented in the student's ability to solve engineering problems and levels of engineering thinking by Van Hail, and it also works to enable the learner to acquire a quantity of engineering facts while developing the mathematical culture of the learner, developing the ability to draw accurate shapes, and introducing the learner to the usefulness of engineering in other areas such as construction industries and others With the development of objective thinking methods of the learner. (Abdelkader, 1997: 27)

The importance of the study appears in the following points:

1- Exposing the relationship between high-ranking thinking and engineering thinking may assist teachers in developing and improving teaching methods and directing them to adopt modern teaching methods, and thus teachers benefit from them in designing geometric shapes during sports activities, focusing on students' understanding and not on memorization and indoctrination.
2- This study shows the importance of high-order thinking in mathematical content and the field of teaching mathematics, and thus helps curriculum developers and encourages them to include mathematics textbooks geometric shapes based on high-order thinking, and taking into account the gradation in levels of engineering thinking when designing mathematics curricula.

3- The educational supervisors may benefit from this study by designing workshops concerned with high-order thinking and its relationship to the engineering content in mathematics.

3. Research goal
The research aims to answer the following question:

Is there a relationship between high-ranking thinking and engineering thinking among second-grade intermediate students?

4. Research assumes
In order to achieve the aim of the study, the following hypotheses were formulated:

1- There is no statistically significant difference \( H_1 = H_0 \) at the level of significance between the theoretical average and the arithmetic mean of the grades of the second intermediate grade female students, the research sample in the high-ranking thinking test.

2- There is no statistically significant difference \( H_1 = H_0 \) at the level of significance between the theoretical average and the arithmetic mean of the grades of the second intermediate grade female students, the research sample in the engineering thinking test.

3- There is no statistically significant correlation at \( (\alpha = 0.05) \) between the second-grade intermediate students in the high-rank thinking test and their scores in the engineering thinking test.

5. Search limits
The current search is limited:

1- A sample of the second intermediate grade female students.
2- The first semester of the academic year (2018-2019).
3- One of the morning schools of the General Directorate of Education in Baghdad / Al-Karkh 3.
4- Mathematics textbook for the second intermediate grade for the academic year (2018-2019).

6. Defining terms
1- High-Rank Thinking: Known by everyone
   (Lipman, 1991) defined high-order thinking as good thinking that combines between its two components critical thinking and creative thinking, meaning that it is equivalent to the merging of both types of thinking where critical thinking includes logical trial, while creative thinking includes creative mental trial, so good thinking consists of a group The critical and creative abilities that help the individual to correct his thinking by himself and think mentally. (Lippmann, 1991: 35)

   High-order thinking can be defined as a thinking pattern that requires special mental effort and patience with doubt, ambiguity, and independence in practicing mental judgment, and it refers to a response to a challenge and is a challenge to other challenges.

2- Geometrical Thinking: Known by everyone
   (Hassan, 2001) that "a form of thinking or a mental activity practiced by the student to solve an engineering problem, whether it is solving an engineering exercise, a theoretical demonstration or an engineering construction, and it depends on a set of mental processes represented in the student's ability to perform a set of performances required to achieve levels Geometric thinking as defined by Van Hill. (Hassan, 2001: 388)

   (Shehata and Zainab, 2003) that it is a form of thinking or mental activity related to engineering, which depends on a set of mental processes represented in the ability of students to carry out a group of activities for each level of the following engineering thinking: (Perception - analysis - non-formal inference - Formal inference - abstraction) (Shehata and Zainab, 2003: 128)
(Ibrahim and Nassour, 2011) is a form of thinking represented in the student's ability to perform a set of activities and mental processes and achieve a certain level of thinking, when confronted with a problem related to engineering. (Ibrahim and Nassour, 2011: 117)

(Jawad, 2011) is a form of thinking, or the mental activity of engineering that depends on a set of mental processes represented in the ability of students to carry out a set of activities for each level of engineering thinking. (Jawad, 2011: 52)

Engineering thinking can be defined procedurally as the mental and behavioral activity that the student performs when she encounters an engineering problem that she cannot easily solve, which forces her to analyze the problem and study its basic components, define its main features, and realize the relationship between its components, then her ability to organize previous experiences that she went through with regard to It fits the circumstances and conditions of the problem, with the aim of overcoming the obstacle before it, and reaching sound solutions to engineering problems and issues, and it is indicated by the score obtained by the student in the test prepared for this purpose.

7. Theoretical framework

First: High-Rank Thinking

High-ranking thinking is one of the educational dimensions that educators have begun to pay attention to in recent years, as one of the important keys to achieving the educational goals of the learning and teaching process and to ensuring effective cognitive development that allows the individual to use his maximum mental energies to achieve success and proper adaptation in the field of learning or public life. (Al-Atoum et al., 2013: 201). Lipman's, 1998 points out that “high-order thinking is the context in which cognitive skills improve (Lipman, 1998: 38).

Characteristics of High Rank Thinking:

High-order thinking is the ability to make widespread use of mental processes, and it occurs when an individual interprets, analyzes and processes information in order to answer a question, or solve a problem that cannot be solved through the routine use of previously learned information, and falls within this pattern of thinking skills of critical, creative and inferential thinking. Contemplative, divergent and others (Al-Atoum et al., 2013: 201-202), as it is thinking that involves a self-organization of the thinking process and involves the imposition of meaning, that is, the creation of a clear cognitive structure in the midst of information chaos, which are higher mental processes (Ady and Shayer 2009: 30). It occurs when the learner implements, analyzes and processes information in order to answer a question or solve a problem that cannot be solved through the routine use of information previously learned. Critical thinking skills fall within this mode of thinking (Bishara, 2003: 29). It also provides learners with skills related to daily life and gives them additional benefit to help them improve their knowledge, low-ranking thinking and self-confidence ((king, et .al, 1999: 8) In addition, it requires a special mental effort and patience with doubt, ambiguity and independence in the practice of mental trial, that is, expanding the boundaries of knowledge of what has been discovered, as it indicates a response to a challenge, and is a challenge to other challenges (Lipman, 1991: 103).

The importance of developing high-ranking thinking:

The development of high-ranking thinking is one of the main goals that those in charge of the educational process seek to develop among the learners. These skills are essential to providing the learner with the tools and means he needs to deal effectively with a rapidly changing world. Teaching and developing such skills is essential for every learner. The individual may face some problems or situations in which he needs to make a decision that requires high thinking skills. (Khalil, 2009: 93)

The importance of developing high-ranking thinking appears in the many benefits it brings to the learner and teacher, as follows:

First: its importance for the learner:

• Helping the learner to look at different issues from the viewpoints of others
• Evaluating the opinions of others in different situations, and judging them with a clear type of accuracy.
• Freeing the learner's mind and thinking from restrictions when answering difficult questions.
• Familiarity with how to learn, and the methods and means that support it.

Second: its importance for the teacher:
• Helping him / her to gain familiarity with the various learning styles, and taking this into account in the educational process
• Increase his motivation, activity and vitality
• Raise the teacher's morale, and increase his self-confidence. (Abd al-Bari, 2012: 361) (Fathallah, 2008: 73-74).

Second: engineering thinking

Engineering is one of the important branches of mathematics and one of its basic components, as it is concerned with the study of geometric shapes and their properties on the plane, and stereoscopes in space, their relationships and their applications in life (Al-Sawai’i, 2004: 12). When the learner deals with it through realistic and natural models and forms. (Moave, 2004: 251), and Hatfield et al. (Hatfield et al.2001) believe that engineering develops the skill of reasoning and the ability to guess among students, as Cuco & Mark (1998) defined the role of engineering in public education in two axes: The first is that engineering helps students to relate to mathematics, and the second is that engineering is a motor for building a mental habits perspective. Engineering is a fertile field for training on how to use different thinking styles, due to the concepts, axioms and theories it contains based on inference. Its development among students through engineering.

Van Hile developed a guiding theory based on a set of the following fundamentals, including the hierarchy of levels: in the sense that the transition from one level to another is only after fulfilling the requirements of the previous level, the language. The student’s transition from one level to another depends on the language used in education, the teacher. The teacher has a fundamental and essential role in moving students from one level to another (Al-Shuwaikh, 2005: 84). He also found that learning is a discontinuous process, as there are jumps in the learning curve, which revealed the existence of separate and different levels of thinking in engineering as well. Note that There are difficulties that face students during their studies of engineering, and they think that one of these difficulties is the teacher himself, by explaining engineering issues in a difficult way, as he speaks at a certain level and the students think of another level. Beverly, 2003: 436), and as a result of these difficulties and belief, Van Hile assumed in his theory a model for learning geometry, in which he describes the various types of thinking practiced by students, from the transition from general perception of geometric shapes to the comprehension of coordinated proofs, and an understanding of the nature of movement between levels And the teacher's role in such a conversion. (Van Hile, 1986: 32)

Van Hile has identified ((Van Hile) in his theory five levels of thinking, representing the development of engineering thinking among learners called the following (perceptual, analytical, ordinal, deductive and abstract) and what follows is a description of each of these five levels.

The first level: perceptual (visualization)

Where the student begins to learn it through non-verbal thinking by judging the shape by its appearance as a whole by its physical appearance and not through its characteristics, that is, it is determined by the ability to see and name geometric shapes and distinguish the shape from among a group of shapes that appear similar without awareness of their properties by learners (Burger) (1986: 31) and Van de Wal, 2001) believes that students at this level deal with geometric shapes. They recognize and notice the shape as an appearance and physical formations, and thinking at this level is to classify objects or shapes that appear to be similar (Van de wall, 2001: 309) and this level is generally determined by the following:
1- Understanding the retention of its image in different situations.
2- Learn engineering vocabulary.
3- Knowing the information on the figure. (Crowley, 1987: 44)

The second level: Analysis

The analysis of engineering concepts begins through observation and experimentation, so that the student begins to perceive the properties of the shape, and begins to visualize the category of the shape through its characteristics so that the student determines the shape, and is also characterized by the
student's ability to observe the properties of shapes and describe them without linking some of them to others, whether on the properties of one shape or the properties of the shapes. The purpose of thinking at this level is to categorize shapes and know their properties. Students will probably be able to give a list of all the properties of squares, rectangles, and parallelograms, but not the partial details between each of these shapes, for example all squares are parallelograms. (Van de Wall, 2001: 310)

This level is determined by the following:
1- Using verbal sentences to describe shapes in light of their characteristics and using that in drawing shapes.
2- Recognizing a shape as part of a larger shape.
3- Realize that shapes can be classified into different types.
4- Describing groups of shapes with one property.
5- Discovering the characteristics of some unknown shapes.
6- Solving some engineering problems using some known information and characteristics.

(Dawood, 1982: 109-110) (Salameh, 1995: 217-220).

The third level: Ordinal Abstraction

The student has the ability to logically arrange shapes, understand the interrelationships between shapes, and know the importance of accurate definitions. The student realizes, for example, that each square is a rectangle, but he is unable to explain that. (Keiser, 2000: 115)

The purpose of this level is for students to be able to think about the properties of geometric shapes, and to explain the relationship between these properties, for example if the four angles are right then the shape must be rectangular, and if the shape is a square then it must be rectangular. (Van de Wall, 2001: 310)

This level includes students doing the following:
1- Coming up with non-problem proofs (like proofs) to prove the correctness of rules or theories (using drawings, engineering tools).
2- Prioritize the properties.
3- Completion of deductive proof of an engineering problem.
4- Giving more than one explanation to prove a specific engineering theory.

(Dawood, 1982: 109-110) (Salameh, 1995: 217-220)

Fourth level: Deduction

At this level, the student's ability to use assumptions and axioms is determined to demonstrate some relationships without realizing the necessity of these assumptions and axioms, and is also distinguished by the ability to conclude by building simple mathematical proofs and understanding the role of the axiom, definition, theory and the ability to reason within the steps of proof. (Hoffer, 1981: 13-15) (Burger, 1986: 31).

The student at this level is able to form proofs, understand the role of axioms and definitions, and know the meaning of the necessary condition and the sufficient condition, meaning that the student at this level is able to find an explanation for the steps of the proof. Van Hile, 1986: 32)

In general, it is determined by the following:
1- Demonstrate the need for identifiers, non-identifiers, and axioms to build an engineering system.
2- Proving theories in the Muslim system or relationships that were identified at the previous level.
3- Establishing relationships between the different theories.
4- Comparison of different proofs for specific theories. (Safety, 1995: 224-225)

Level Five: Defining and Abstraction Rigor

This level is at the top of the levels of engineering thinking, in which students become able to understand the role of indirect proof, prove theories in different engineering axiomatological systems, deduce different engineering axiom systems, prove their properties and compare them, prove engineering theories in an abstract way, create new axioms and then invent methods To solve some engineering problems.

The learner cannot move from one of these five levels until after he is able to the previous levels, and the transition from the level to the next one depends largely on educational experiences and not on
chronological age or the level of genius, as each level has its own language, terminology, relationships
and concepts. The appropriate engineering (Jawad, 2011: 232-234)
Cam (2000: 708-712) believes that the transition from one level to the next takes place through five
stages:
1- Information: Teaching should begin with materials that provide the learner and lead him to
discover specific structures.
2- Direct orientation: The learners should be evaluated for tasks in such a way as to familiarize
them with the related structures.
3- Explanation: The teacher introduces engineering terms and encourages learners to extract them
in their writings and discussions in engineering lessons.
4- Free orientation: The teacher presents tasks that can be completed in different ways, and learners
gain experience in solving requirements on their own, depending on what they previously
studied.
5- Integration: gives learners opportunities to synthesize what they have previously studied, such
as designing their own activities.

8. Previous studies
A study dealing with high-order thinking
Study (Christi & Julie, 1996)
The study was conducted in the United States of America and it aimed to improve high-rank thinking
skills of high school students to teach Spanish as a second language, a program was designed to improve
high-rank thinking skills of high school students to teach Spanish. And that is for four schools, with
(360) male and female students, and the defect in high-ranking thinking was documented through the
teacher’s tests, the student’s oral presentations in Spanish, the teacher's notes record and records to
observe the student’s thinking. The analyzes have demonstrated the students ’lack of knowledge,
application, and mastery of skills. The focus of this study has been on the use of formal organizations,
or mental maps that are presented visually to see the extent of their impact on some key skills such as
arrangement, comparison, knowledge of contradictions and classification. The mock organizations were
chosen for the lesson content and used in teaching and testing that measures high-ranking thinking skills.
The results of the study confirmed that the students developed their mock organizations and used them
in new situations. The development of students ’performance in short exams and written tests has also
been noted. (Christi & Julie, 1996: 1)
A study dealing with engineering thinking
A study (Al-Titi, 2001: 52)
It aimed to identify the degree of students' acquisition of the tenth grade levels of engineering
thinking and its relationship to their abilities to write engineering proofs. His study was applied to a
sample of (264) students from the tenth grade in schools affiliated to the Directorate of Education in
South Hebron, and the researcher reached (6.4%) () Of the sample students did not acquire any of the
Van Hill levels of engineering thinking, 14% were classified in the first level, 46% were classified in
the third level, 15.5% were classified in the fourth level, and the fifth level was the lowest percentage
as it showed a general percentage % 3.4)) The results of the study also showed that there is a relationship
between the student’s achievement in the engineering reasoning test and his achievement in the
engineering proof test. And the existence of differences between males and females in acquiring levels
of engineering thinking in favor of males.
How useful the current study is from previous research and studies:
1- The results of these studies informed the current research, as they were the starting point for the
topic of this research, and a guide for the researcher in preparing her tools and application
procedures, and discussing the results of their application and interpretation.
2- Choosing the appropriate statistical means for the study procedures.
3- Access to resources related to the subject of the study.
9. Research methodology and procedures

It includes identifying the community, selecting a representative sample, preparing two measures with validity and consistency characteristics and procedures for applying them to the research sample, and determining the appropriate statistical means analyzing the data as follows:

First: Research Society:

The research community consists of the female students of the second intermediate grade in secondary and intermediate schools in Baghdad Education / Al-Karkh third and the number of students is (500) students, distributed in four schools.

Second: Research sample:

The randomized progressive method was used in selecting the research sample. Four schools affiliated with Education Baghdad / Al-Karkh / 3 were chosen randomly, and from each school one or two divisions of the second intermediate grade were randomly selected, and from these classes a number of students was chosen in proportion to the required number, and by the method Randomized, 400 female students were selected.

Third: Search Tools:

In order to achieve the objectives of the research, the researcher relied on two tools to measure research variables, one of which is to measure high-ranking thinking, and the other to measure engineering thinking. The following is a presentation of how the research tools are prepared.

Steps to build the High Rank Thinking Scale:

1- The numbers of scale paragraphs: In light of the definition of high-ranking thinking, and the theoretical framework of the current research, the researcher prepared (40) paragraphs in principle.

2- Test validation:

   A- Face Validity:
   In order to ensure the validity of the test for this research, it was presented to a number of experts specialized in measurement, evaluation and psychology to judge the suitability of the test items for the research sample and delete, amend and add what they deem necessary. The test items obtained the approval of more than 90% of the experts.

   B- Construct validity:
   It means the degree to which the test can measure a trait or characteristic that cannot be directly observed, but rather is inferred through a set of associated behaviors such as intelligence, anxiety and other traits, that is, it is related to the psychological and mental traits.

   This kind of validity was achieved by withdrawing (100) questionnaires through statistical analysis using the Pearson correlation coefficient, and it was found that they range between (0.57-.780), and these coefficients are statistically significant, so the correlation coefficients are statistically significant.

   The researcher took some considerations when drafting:
   1- The paragraph should be clear by the respondent and avoid ambiguous words.
   2- That the paragraph contains one concept, and it is not permissible to combine two concepts in the same paragraph.
   3- Avoid negative paragraphs as much as possible (negative).

   Scale Instructions:
   For the purpose of identifying the clarity of the scale's instructions and alternatives, as well as revealing the difficulties that the respondent faces to avoid them and the time it takes to answer the scale, the researcher applied the scale to a sample of (40) students randomly selected from other than the building sample in order to identify the extent of clarity of the scale's paragraphs and instructions where they were It is clear, and the average time spent in answering ranges between (26-28) minutes, ie an average of 27 minutes.

   Scale correction:
   The scale paragraphs have been formulated in both positive and negative formulas. As for the alternatives to respond to the content of the paragraphs, the following are: (It applies to me a lot, it
applies to me often, it applies to me sometimes, does not apply to me, does not apply to me much). Corresponds to the scale of scores (1,2,3,4,5) for the paragraphs with positive content and grades (5,4,3,2,1) for the paragraphs with negative content. In this way, the total score of each respondent was calculated on the scale from the sum of the scores of his response to all the paragraphs.

4- Statistical analysis of the scale paragraphs:
   The aim of these procedures in paragraph analysis is to preserve the distinct paragraphs and deleting the unmarked paragraphs, by calculating the discriminatory power of each paragraph with the aim of excluding the paragraphs that do not distinguish between the respondents and retaining the paragraphs that distinguish between them, if the paragraph possesses distinctive power, this means that that paragraph has the ability to distinguish between respondents with high degrees and respondents Of those with low scores in the concept that the paragraph is measured by, but if the paragraph does not discriminate according to this form, then it is useless, and it must be removed from the final image of the scale.

   This can be investigated as follows:
   The method of the two extremes: Extreme Groups Method

   In this method, two extreme groups of individuals are selected based on the overall scores they obtained in the scale. Each paragraph of the scale is analyzed using the T-test (T.test) for two independent samples to test the significance of the differences between the averages of the upper group and the lower group.

   For the purpose of conducting the analysis in this way, the following steps were followed:
   1- Correct each form and give each paragraph a score according to its type (positive / negative)
   2- Determine the total score for each questionnaire according to the total scores of the paragraphs.
   3- The order of the (400) forms in descending order from the highest degree to the lowest degree
   4- Determination of (27%) of the forms obtaining the highest marks and the adult

   There are (108) questionnaires, and (27%) of the questionnaires obtaining the lowest grades, of which there are (108) forms. Thus, two groups were sorted with the largest size and maximum possible differentiation.

   Then the T-test was applied to two independent samples to test the difference between the mean scores of the upper group and the lower group in each paragraph. The T-value was considered as an indicator to distinguish each paragraph by comparing it to the tabular value of (1.96) at a level of significance (0.05) and all the paragraphs were distinct and thus it became The scale is ready.

   The validity of the scale: There are two types of validity in the tool:
   a. Virtual validity

   Verify the apparent validity of the tool by presenting its paragraphs, alternatives and fields of answer to (10) expert arbitrators to judge its validity.

   The paragraphs of this scale have been presented to a group of experts in the field of education and psychology to express their opinions about the validity of the paragraphs, according to what they see with the deletion, addition and modification of what they see appropriate. In front of each paragraph there are alternatives: (valid, invalid, proposed amendment).

C- Construction validation:

   This honesty is sometimes called the validity of the concept, or (the validity of the hypothetical formation). (Anastasi, 1982) indicates that the validity of the construction requires a gradual accumulation of information from various sources, and that attention has been drawn to the role of psychological theory in constructing the scale and the need to formulate Assumptions that can be proven or described in the verification process.

   This type of honesty (sincerity of construction) has been achieved through the following indicators:
   1- The method of correlating the score of each paragraph with the total score of the scale.
   2- The method of correlating the degree of each paragraph with the field to which it belongs.
   3- Scale stability: (re-apply scale)
The reliability coefficient is calculated in this way through the correlation between the scores of a group of students on the scale after applying it twice and with a time interval between the first and second applications (Odeh, 2005, p. 42).

To find out the consistency in the current study, the researcher applied the scale on a sample of (60) students who were selected, and after (14) days had passed, the application was re-applied to the same sample. After that, the correlation coefficient of the relationship between the first and second applications was calculated, and by using the Pearson correlation coefficient. The stability extracted in this way (81.0) is a good stability coefficient that can be relied upon according to the absolute standard.

10. Second - engineering thinking scale

A- Preparing the initial paragraphs of the scale:

In the drafting of the paragraphs, it was taken into account that they be understandable and capable of one interpretation, do not combine two ideas, and be concise to the extent that the studied problem allows, and does not cause emotional effects on the respondent to give false information, and the objective paragraphs were chosen because they are more comprehensive of the material and for the ease of conducting them, and in light of this, the scale was prepared. In its initial form, it consists of (30) paragraphs.

B- The validity of the paragraphs:

For the purpose of verifying the veracity of the paragraphs and their suitability for the current study, the paragraphs of the scale were presented in their initial form to a group of experts and referees specialized in mathematics for the purpose of ascertaining their apparent authenticity and knowledge of their opinions regarding their validity, formulation and suitability for what was set for it, and in light of the comments of the arbitrators and experts, and based on the discussion of some of them separately, all the scale paragraphs won the approval of the arbitrators at a rate of (100%), with some amendments that included restating some of them and changing some alternatives.

C- Formulating scale instructions:

After the necessary adjustments were made in light of the experts’ opinions, instructions were prepared for the scale that explain to the sample members how to answer its paragraphs, and it was taken into account in preparing the scale instructions that they were suitable for the sample, easy to understand and clear, and the purpose of the scale was clarified, which is to identify the relationship between the quality of teaching performance and engineering thinking for the purposes of scientific research, and they were asked to answer all the scale paragraphs frankly and honestly and not leave any paragraph unanswered, and that the questionnaire is intended for the purpose of the study and not for another purpose.

In order to clarify the duration of the test, the researcher applied it to an exploratory sample consisting of (20) students randomly selected from the community, and that the average time spent in answering ranges between (35-45) minutes, that is, an average of (40) minutes.

D- Statistical analysis of paragraphs:

The researcher applied the scale on (160) students, and the students’ answers were corrected on the scale and the overall score was assigned to each of them. After that, the students’ answers were subjected to statistical analysis of the paragraphs, and the researcher calculated the difficulty factor for the engineering thinking scale, and it ranged between (0.57 -0.66).

1- Paragraph difficulty level:

For the purpose of calculating the discriminatory power, the researcher applied the scale on a sample of (100) students, and after correcting the answer sheets, the grades were calculated, then the grades were arranged in descending order, then (27%) of the higher grades and (27%) of the lower grades were taken.

Using the difficulty equation, it was found that it ranges between (11.0 - 63.0), so the researcher omitted the paragraphs whose difficulty coefficient was less than (20.0), and they are two paragraphs, and thus the paragraphs became good in terms of difficulty / ease, as Bloom asserts. That the scale paragraphs are considered acceptable if the difficulty ratio ranges between (20.0 - 80.0).
2- Item Discrimination Power

The researcher calculated the discriminatory strength of the paragraphs of the engineering thinking scale by classifying the scores of the survey sample members in ascending order, and determining the upper and lower group of scores at a percentage of (27%). Then the distinction of the paragraphs was calculated using the discrimination equation.

He found that the paragraph discrimination coefficient ranges between (15 and 0 - 70 and 0), and (Eble, 1972) in this regard indicates that the discrimination coefficient if it is greater than (20%) is acceptable and thus the paragraphs whose distinction coefficient is less than (20 and 0) was deleted, and the number was (2) Paragraph.

- Psychometric characteristics of the engineering thinking scale:
  1- Honesty:
  For the purpose of verifying the validity of the test, the researcher used the outward validation method:
  - Virtual validity:
    The researcher presented the scale in its initial form to a group of experts specializing in educational and psychological sciences and sports specialists in order to know their views on the validity of the scale paragraphs:
    - The lack of ambiguity of the instructions and questions and their achievement of the goal.
    - Verifying the validity and validity of the scale paragraphs.
    - Judging the rationality of the proposed alternatives.
  The researcher also held individual meetings with some of the judges to discuss the positions and paragraphs in terms of their structure and validity.
  The researcher used the required percentage in analyzing the opinions of the experts. It was noticed that all the paragraphs obtained the approval of all the arbitrators, and with the degree of agreement and by 100%, and accordingly, there was no radical change to the test items except for some simple changes in the language wording of the test items.

2- Reliability
To calculate the stability factor, the researcher used the test half partition method.
Half-segmentation method:
To find the stability of the test in this way, it was calculated from (50) answer sheets from the first application of the test on the members of the exploratory sample that were randomly selected. m-A-Brown) For the purposes of the test length, the reliability factor was (0,92), which is a high reliability coefficient.

Final exam:
After working on the opinions of the experts and the referees in making some adjustments to the test, and through the exploratory application of the test and calculating the level of difficulty of the paragraphs and the strength of their distinction, the unmarked paragraphs of (2) paragraphs were excluded and thus the test in its final form consists of (28) paragraphs in its final form.

View and discuss results
This chapter includes presentation and discussion of search results:
The first goal: To find out the high-ranking level of thinking among the second-grade intermediate students.
To find out the high-ranking level of thinking among the second-grade intermediate students, the analysis of the female students' answers using the T-test for one sample showed that the standard deviation of the female students reached (14.65) and the arithmetic mean was (160.70), which is higher than the theoretical average of its value (120). When calculating the level of significance, it became clear that the difference was statistically significant at the level (0.05), as the calculated T value was (39.26) degrees, which is greater than the tabular T value (1.96) and with a degree of freedom (399). Table (1) shows That.
The results of the research showed that the second-grade intermediate students enjoy high-order thinking.

The second goal: To get acquainted with the engineering thinking of the second intermediate grade female students.

To find out the level of engineering thinking among the second-grade intermediate students, the analysis of the students' answers using the T-test for one sample showed that the standard deviation of the female students reached (16.55) and the arithmetic mean value (218.16) which is higher than the theoretical average whose value is (177 When calculating the level of significance, it became clear that the difference was statistically significant at the level of (0.05), as the calculated T value was (35.16) degrees, which is greater than the tabular T value (1.96) and with a degree of freedom (399). Table (2) illustrates that .

| Sample volume | SMA | standard deviation | Theoretical average | Degree of freedom | The computed T-value | Tabular T-value | Indication level |
|---------------|-----|--------------------|---------------------|------------------|---------------------|----------------|-----------------|
| 200           | 160.70 | 14.65            | 120                | 399              | 39.26               | 1.96            | Function 0.05   |

The results indicate that the second-grade intermediate students enjoy engineering thinking because the arithmetic average of the sample scores is higher than the hypothetical average.

The third goal: the relationship between high-order thinking and engineering thinking.

The results of the statistical analysis of the data showed that there is a direct relationship between high-order thinking and engineering thinking, that is, the more high-order thinking increases, the engineering thinking increases, and for the purpose of knowing that relationship, the Pearson correlation coefficient was used, and Table 3) illustrates that

| the sample as a whole | the number | Correlation coefficient value | The computed T-value | Tabular T-value | The T-value denotes 0.05 |
|-----------------------|------------|-------------------------------|----------------------|----------------|-------------------------|
| The sample as a whole | 400        | 0.52                          | 8.246                | 1.96           | Function                |

11. Interpretation of the results
The study revealed a statistically significant positive relationship between high-ranking thinking and the level of engineering thinking among second-grade intermediate students, and the explanation of this may be due to:

1- The nature of this relationship through the correlation of high-order thinking in mathematics and engineering thinking, as Loren Resnick (1987) described, as high-order thinking is determined by mathematical relations, and that the method of work is not fully predetermined.

2- Both thinking often give multiple solutions instead of giving a unique solution, that is, they avoid simple solutions or formulations, as the one issue often has potential solutions.
3- These two thinking tend to acknowledge the causal or logical relationships that govern the situation at hand, which other types of thinking may not give much importance to.

4- Two forms of thinking are represented in the student's ability to perform a set of activities and mental processes and achieve a certain level of thinking, when confronted with a problem related to mathematics.

Recommendations:
1- Paying attention to providing the educational techniques necessary to prepare the various activities for teaching engineering because most female students cannot absorb the engineering subject without the educational techniques and practical activities that the student undertakes.

2- Development of evaluation systems in engineering so that it moves from measuring the students' ability to memorize the theories and stereotypical proofs to measuring their ability to think engineering in its various dimensions.

The proposals:
1- Conducting a study to reveal the relationship of high-order thinking and engineering thinking with some personal and psychological variables.

2- Conducting studies to uncover the factors affecting high-ranking thinking and engineering thinking among second-grade intermediate students

3- Conducting other studies in which methods are used to develop high-ranking thinking among female students.

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