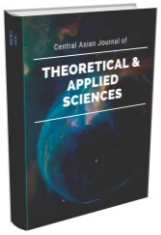

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*Article*

# Skills of Mathematical Reflective Thinking Among Secondary School Students

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**Abstract:** This paper aims to patently identify the skills of reflective thinking among preparatory school students and investigate the differences based on gender. Several hypotheses were formulated to achieve the research goal. The sample included 300 students from the Directorate of Education in Al-Karkh First. A research tool was developed in the form of a test consisting of 20 items distributed across five skills: reflection and observation skills, detecting fallacies, drawing conclusions, providing convincing explanations, and proposing solutions. After conducting statistical analyses, the findings showed that the research sample had limited reflective thinking skills in mathematics, and male students exhibited better reflective thinking skills compared to female students. Based on these findings, the research suggested the following recommendations: introducing reflective thinking skills in mathematics to students by mathematics teachers and using models, images, and educational tools to develop reflective thinking among students. Additionally, the research proposed conducting a study that links reflective thinking skills in mathematics to other variables and conducting a similar study to investigate reflective thinking skills among students in other educational stages.

**Keywords:** Reflective thinking skills

## Research Problem

After reviewing multiple studies, the researchers observed that several numerical studies have addressed the topic of reflective thinking and its associated skills. These include the studies by Sura and Ghassan (2023), Ali (2023), Nidal (2022), and Hussein (2018), which highlighted students' weak reflective thinking skills and the need for schools and teachers to train students in this type of thinking. Similarly, studies by Tariq (2016), Ibrahim (2012), Al-Jadba (2012), Ubaid (2011), and Saadi and Al-Taie (2011) indicated a clear deficiency in students' ability to employ operations on numbers and understand how and when to use them. These studies also pointed out that teachers do not utilize teaching aids and instead focus solely on delivering large amounts of information, encouraging memorization, and relying on rigid methods without paying attention to intellectual engagement and reflective thinking. This approach leads students to

memorize and retrieve information only when needed, as dictated by the prescribed mathematics textbooks. All these studies have demonstrated the weakness in reflective thinking skills and the need to adopt methods and strategies to equip students with such skills. Therefore, the significance of investigating students' levels and abilities in reflective thinking becomes evident. Accordingly, the problem is framed in the below question:

- What are the mathematic skills of reflective thinking of high schoolboys?

## Research Importance

### Theoretical Aspect

1. There is a scarcity of local studies that have addressed mathematic reflective thinking skills among high schoolboys.
2. It is crucial for high schoolboys to acquire mathematic reflective thinking skills.

### Applied Aspect

This research provides a test to assess mathematic skills of reflective thinking among high schoolboys. It examines mathematic reflective thinking skills among high schoolboys based on gender (male and female).

### Research Objectives

The current paper aims to identify the mathematic reflective thinking skills of high schoolboys.

### Research Hypotheses

1. There is no statistically significant difference at the 0.05 significance level among the actual and expected mean performance of high school students in the mathematical reflective thinking skills test.
2. There is no statistically significant difference at the 0.05 significance level among the mean scores of high schoolboys in the mathematic reflective thinking skills test based on gender (male and female).

### Research Limits

1. High school students (Scientific Fourth Grade) in morning schools under the General Directorate of Education, Baghdad/Al-Karkh First, for the academic year 2024-2025.
2. The 1st semester of the year 2024-2025.
3. Reflective thinking skills, which include observation and reflection skill, detecting fallacies skill, drawing conclusions skill, providing convincing explanations skill, and proposing solutions skill.

### Definition of Terms

*Reflective Thinking*

Atoum (2012) defines it as the thinking process in which an individual reflects on a situation, analyzing it into its components, and develops tactics to grasp it in order to reach the necessary

conclusions and evaluate the results of the proposed plans (Atoum, 2012). Al-Zuhairi (2017) defines it as the thinking process in which the learner reflects on a situation, analyzing it into its components, and develops the required plans for understanding it and reach the required conclusions, then evaluates the results based on the developed plans (Al-Zuhairi, 2017).

*Skills of Reflective Thinking*

Abdel Salam (2009) describes these skills as the ability to evaluate and interpret evidence, modify opinions, and make objective judgments, emphasizing their presence in all subjects (Abdel Salam, 2009). On the other hand, Wilson (2003) sees these skills as a set of cognitive processes that an individual performs to gather information, store it in their mind through analysis, planning, and evaluation, and reach conclusions for decision-making.

Reflective thinking includes five skills mentioned by Othman (2017) and Afaneh & Al-Lulu (2002):

1. **Observation and Reflection Skill:** Involves using visual aids to illustrate the relationships between their components, providing an accurate description of concepts, clarifying their elements, and visually discovering existing relationships.
2. **Detecting Fallacies Skill:** Refers to the ability to detect gaps in various topics by identifying incorrect or illogical relationships. This skill helps verify the accuracy of information, recognize misconceptions, and determine the properties belonging to a geometric shape.
3. **Drawing Conclusions Skill:** Utilizes prior experiences to draw conclusions and establish logical relationships by analyzing the essence of a problem. It enables students to arrive at appropriate results by carefully examining similarities within the educational context and identifying relationships between different geometric shapes.
4. **Providing Convincing Explanations Skill:** The capability to indicate logical sense to results or interconnected relationships, which might be centered on prior knowledge or the nature and attributes of a given problem. This skill helps uncover facts, includes explanations of geometric shape properties, and interprets images presented in mathematical contexts.
5. **Proposing Solutions Skill:** Encourages prediction, imagination, and problem-solving by applying prior theories. It involves formulating logical steps to solve a given problem, relying on expected mental representations of the issue. It also includes questions that help anticipate outcomes and generate new ideas and solutions. (Othman, 2017; Afaneh & Al-Lulu, 2002)

It has been concluded that skills of reflective thinking are a set of skills that assist both learners and teachers in achieving desired objectives by observing presented figures, identifying gaps and fallacies, drawing conclusions, providing logical and accurate explanations, and proposing rational solutions to the given problem. The study adopts Al-Harithi's (2011) definition as a theoretical reference.

*Procedural Definition*

Reflective thinking skills refer to a set of abilities possessed by high school students (the study sample), including observation and reflection skill, detecting fallacies skill, drawing conclusions skill, providing convincing explanations skill, proposing solutions skill. These skills are measured using a test specifically designed for this purpose.

*Theoretical Background*

The primary goal of teaching mathematics today is to transform the learner's role from merely being a machine that performs calculations into an active thinker who considers mathematical

operations, estimates approximate results before solving problems, and attempts mental solutions. Additionally, students should grasp mathematical concepts and acquire skills that enhance their overall mathematical development. In any country, the fundamental goal of the educational process is to build critical thinkers and develop students' cognitive abilities. *(*Al-Heela*,* 2001*)*

The first scholar to discuss reflective thinking was John Dewey in his book “How We Think”. He defined reflective thinking as “a sort of thinking that involves considering a specific problem and seriously evaluating it in the mind.” (Tican & Taspinar, 2015). The teacher plays a crucial role in developing students’ thinking abilities by encouraging discussion, participation, active learning, and listening to their ideas while valuing and respecting their thoughts. Teachers should also provide students with time to think, build their self-confidence, and offer positive feedback. (Al-Sharif, 2013).

Effectively incorporating reflective thinking skills in teaching mathematics is not a difficult task, but it requires the teacher’s commitment to using diverse teaching methods. These methods should provide students with opportunities for reflection and thinking, rather than just delivering instructional content. Mathematics, in particular, demands reflective thinking skills because it is an abstract and structured subject. (Abu Zeina, 2010). Additionally, Al-Harithi (2011) emphasized that reflective thinking skills can be perceived and understood through observation, direct visualization of diagrams and illustrations, detecting fallacies, providing convincing explanations, and formulating logical steps and proposed solutions to solve problems. These skills help in discovering facts, drawing conclusions, and establishing logical and accurate relationships regarding a subject.

**Characteristics of Reflective Thinking**

1. It focuses on real-life problems.
2. Reduces impulsivity in learners and enables better thinking during problem-solving processes.
3. Encourages curiosity, investigation, and persistence in solving unclear problems.
4. Develops a sense of confidence to handle academic and life challenges.
5. Enhances prior knowledge and connects it to new situations.
6. Promotes awareness and thoughtful consideration of events. (Abdulwahab, 2005; Karwan, 2012; Kirk, 2000)

**Barriers to Reflective Thinking**

1. Many teachers are not adequately trained in teaching strategies before entering the profession, and large classroom sizes hinder effective teaching.
2. The lack of visual or interactive materials in classrooms limits students' ability to engage in reflection.
3. Students' thoughts and solutions are often disregarded, especially when they are incorrect, discouraging further participation.
4. The excessive information in curricula leaves little room for reflection and observation. (Jabr, 2004; Othman, 2017)

**Stages of Reflective Thinking**

1. **Problem Identification**
   - Understanding the problem and identifying its components.

- Recognizing potential causes.

2. **Problem Analysis**
   - Formulating hypotheses regarding relationships between problem components.
   - Analyzing the hypotheses to verify their validity.
3. **Finding Solutions**
   - Exploring possible solutions based on analysis.
   - Testing solutions against available data.
4. **Solution Implementation**
   - Selecting the best solution based on evidence.
   - Implementing the solution and monitoring its outcomes.
5. **Evaluation of Results**
   - Examining the effectiveness of the solutions.
   - Making improvements or modifications if necessary.

**Levels of Reflective Thinking**

1. **Basic (Everyday) Reflective Thinking**
   - Occurs spontaneously in daily life.
   - Does not require individual solitude.
   - Involves surface-level reflection without deep analysis.
2. **Deliberate Reflective Thinking**
   - Requires self-review and analyzing past experiences.
   - Occurs in educational or professional environments.
   - Involves evaluating teaching methods or decision-making strategies.
3. **Systematic Reflective Thinking**
   - Happens through structured reviews and development programs.
   - Relies on research and future planning.
   - Used in fields such as project management and strategic decision-making.

| No | Researcher | Objective | Methodology | Stage | Sample | Tools | Statistical means | Result |
|---|---|---|---|---|---|---|---|---|
| 1 | Mr. Mohamed Fathi Mahmoud Abu Bakr (2024) / Jenin Governorate | The study aims to identify the degree of proficiency of basic stage science teachers in managing reflective thinking skills in mathematics teaching from the perspective of their supervisors in public schools. | The qualitative approach in data collection using interview tools. | | A purposive sample of supervisors for the basic stage in the scientific branch. | The interview consists of five questions designed by experts in the field. | | The results indicated a noticeable variation among the teachers regarding the management of reflective thinking skills in teaching mathematics. There are statistically |

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| | | | | | | | | significant differences at the 0.01 level between the mean scores of the experimental group students and their peers in the control group in the post-test of reflective thinking, in favor of the experimental group. There are statistically significant differences at the 0.01 level among the mean scores of the experimental group students and their peers in the control group in the post-test of mathematical communication, in favor of the experimental group. There are statistically significant differences at the 0.05 level among the mean scores of |

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| | | | | | | | | the students in the experimental group, who were taught using metacognitive strategies, and the mean scores of the control group students, who were taught using the traditional method, in the post-test of reflective thinking, in favor of the experimental group. There are statistically significant differences at the 0.05 level among the mean scores of the students in the experimental group, who were taught using metacognitive strategies, in the pre-test and post-test of reflective thinking, in favor of the post-test. |

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|---|---|---|---|---|---|---|---|---|
| 2 | Tarek Omar Nasser Al-Atrash (2016) June / Gaza | The study aims to examine the effectiveness of a proposed program centered on multiple intelligences in developing reflective thinking skills and mathematical communication among ninth-grade students in Gaza. | The experimental method involves designing a test for both the experimental and control groups. | | Ninth-grade students in Gaza. | A test was conducted on the experimental and control groups. | T-test for Independent Samples and Eta-squared and Cohen's d values to determine the effect size of the difference resulting from the T-test. | The results indicated a noticeable variation among the teachers regarding the management of reflective thinking skills in teaching mathematics. There are statistically significant differences at the 0.01 level between the mean scores of the experimental group students and their peers in the control group in the post-test of reflective thinking, in favor of the experimental group. There are statistically significant differences at the 0.01 level between the mean scores of the experimental group students and their peers in the control group in |

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| | | | | | | | | the post-test of mathematical communication, in favor of the experimental group. There are statistically significant differences at the 0.05 level between the mean scores of the students in the experimental group, who were taught using metacognitive strategies, and the mean scores of the control group students, who were taught using the traditional method, in the post-test of reflective thinking, in favor of the experimental group. There are statistically significant differences at the 0.05 level between the mean scores of |

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| | | | | | | | | the students in the experimental group, who were taught using metacognitive strategies, in the pre-test and post-test of reflective thinking, in favor of the post-test. |
| 3 | Asmaa Atef Abu Bashir (2012) / Al-Azhar University in Gaza | The study aims to explore the impact of employing metacognitive strategies in developing reflective thinking skills in technology curricula for ninth-grade students in the Central Governorate. | The experimental method involves designing a test for both the experimental and control groups. | 9th | The sample for the ninth grade consisted of 104 male and female students. | The researcher developed a list of reflective thinking skills. | Guttman's Formula, Kuder-Richardson Formula-21, T-test, effect size using Eta-squared, Pearson correlation. | The results indicated a noticeable variation among the teachers regarding the management of reflective thinking skills in teaching mathematics. There are statistically significant differences at the 0.01 level among the mean scores of the experimental group students and their peers in the control group in the post-test of reflective thinking, in favor of the experim |

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| | | | | | | | | ental group. There are statistically significant differences at the 0.01 level among the mean scores of the experimental group students and their peers in the control group in the post-test of mathematical communication, in favor of the experimental group. There are statistically significant differences at the 0.05 level among the mean scores of the students in the experimental group, who were taught using metacognitive strategies, and the mean scores of the control group students, who were taught using the traditional |

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| | | | | | | | | method, in the post-test of reflective thinking, in favor of the experimental group. There are statistically significant differences at the 0.05 level among the mean scores of the students in the experimental group, who were taught using metacognitive strategies, in the pre-test and post-test of reflective thinking, in favor of the post-test. |

## Benefits of Previous Studies

Previous studies help in defining the research problem and formulating hypotheses as well as determining the research population and sample size. Moreover, it helps in assisting in the development of the research tool, reviewing statistical methods used in similar research, and enriching the current study with relevant sources.

## RESEARCH METHODOLOGY

**1. Research Method:**

The descriptive research method was used as it aligns with the study's objectives.

**2. Research Community:**

The research population includes all high school students (male and female) in daytime schools under the Directorate of Education in Baghdad/Karkh First for the year 2024-2025.

3. **Research Sample**: The sample included several secondary schoolboys. The exploratory sample included 30 he/she-students, while the statistical sample consisted of 80 students (40

male and 40 female). The main sample included 300 students (145 male and 155 female). The sample was selected using a random sampling method.

4- **Research Tool**: Mathematical Reflective Thinking Skills Test:

**Determining the Purpose of the Test**: The objective behind preparing the test was to do measuring the mathematical skills of reflective thinking of secondary schoolboys.

**Determining the Areas of the Test**

After reviewing previous studies, the areas of mathematical reflective thinking skills were identified as five areas: (1) Observation and reflection skill, (2) skill of detecting fallacies, (3) skill of drawing conclusions, (4) skill of providing convincing explanations, (5) and skill of proposing solutions.

**Validity of Test Items**: After determining the areas of the test, the test items were made, including 25 items. The test was meticulously presented to a professional group of experts in the domain of teaching methods in mathematics.

**Instructions for Answering the Test**: A set of specific instructions was provided, which included information about the students and instructions on how to respond to the items.

**Grading Instructions**: A grading criterion was used, assigning (1) point for every single correct answer and (0) for incorrect one, resulting in a total score range for the test from 0 to 20 points.

**Test Validity**: The following methods were used to measure the test's validity:

**Face Validity**: After presenting the items related to the test to a group of experts in teaching techniques in mathematics, their feedback was considered. Items that achieved an 80% agreement rate were retained, while some items were removed, merged, or modified, resulting in a final set of 20 items for the test.

**Internal Consistency Validity**: **Item-Total Correlation**: Pearson correlation coefficients were calculated among the score for each item in each area and the overall score for the test. The values ranged from (**0.412–**0.595), indicating that all these items were statistically significant, as shown in Table (1).

Table (1) **Item-Total Correlation**:

| Item | Coefficient of correlation | Item | Coefficient of correlation | Item | Coefficient of correlation | Item | Coefficient of correlation |
|---|---|---|---|---|---|---|---|
| 1 | 0.495** | 6 | 0.564** | 11 | 0.412** | 16 | 0.490** |
| 2 | 0.466** | 7 | 0.490** | 12 | 0.447** | 17 | 0.509** |
| 3 | 0.422** | 8 | 0.412** | 13 | 0.411** | 18 | 0.532** |
| 4 | 0.523** | 9 | 0.428** | 14 | 0.432** | 19 | 0.460** |
| 5 | 0.409** | 10 | 0.595** | 15 | 0.453** | 20 | 0.506** |

Correlation is significant at the 0.01 level (2-tailed).

**Item-Skill Correlation:**

To determine the relationship between each test item and its corresponding skill, Pearson's correlation coefficient was adopted. The correlation values ranged between 0.417 and 0.692, indicating statistical significance. The details are presented in Table (2): Item-Skill Correlation.

| Skills | Coefficient of correlation |
|---|---|
| 1 | 0.563** |
| 2 | 0.417** |

| | |
|---|---|
| **3** | 0.465** |
| **4** | 0.544** |
| **5** | 0.692** |

** correlation is significant at 0.01 level (2-tailed)

**Skill-Total Score Correlation:**

Pearson's correlation coefficient was adopted to determine the relationship among each skill and the total test score. The correlation values ranged between 0.405 and 0.694, indicating statistical significance. The specifics are presented in Table (3):

**Table (3)**: **Skill-Total Score Correlation**

| **Skill1** | | **Skill2** | | **Skill3** | | **Skill4** | | **Skill5** | |
|---|---|---|---|---|---|---|---|---|---|
| **Item** | **Coefficient of correlation** | **Item** | **Coefficient of correlation** | **Item** | **Coefficient of correlation** | **Item** | **Coefficient of correlation** | **Item** | **Coefficient of correlation** |
| 1 | 0.422** | 5 | 0.514** | 9 | 0.506** | 13 | 0.501** | 17 | 0.460** |
| 2 | 0.466** | 6 | 0.493** | 10 | 0.584** | 14 | 0.477** | 18 | **0.405 |
| 3 | 0.643** | 7 | 0.601** | 11 | 0.684** | 15 | 0.694** | 19 | 0.432** |
| 4 | 0.426** | 8 | 0.479** | 12 | 0.477** | 16 | 0.441** | 20 | 0.433** |

**Application of the Test on the Exploratory Sample:**

**Statistical Analysis:** After correcting the test papers for the exploratory sample based on the correct answer keys and arranging the answers in descending order, 50% of the students with the highest scores were designated as the upper group, and 50% with the lowest scores were designated as the lower group. Statistical analyses were then conducted on both groups.

**Difficulty Index:** The difficulty index for every single item was calculated by employing the difficulty index formula, and it was found to range between (0.25 – 0.55). Therefore, the test items are considered acceptable, and all items were retained.

**Discrimination Index:** The discrimination power for each item was calculated using the discrimination index formula, and it was found to range between (0.26 – 0.50). Therefore, the test items are considered acceptable.

**Effectiveness of Incorrect Alternates:** The effectiveness of the incorrect alternates was calculated using the specific formula, and it was found that all values were negative, indicating that all incorrect alternatives were effective.

**Test Reliability:** To calculate the reliability of the Reflective Thinking Skills Test, the Kuder-Richardson 20 formula was used, and the reliability coefficient was 0.800, that is considered a good reliability coefficient (Hassan, 2006, 10).

**Statistical Tools:** The SPSS statistical software, version 25, was used to verify the results of the following statistical tools:

1. **Kuder-Richardson 20 Formula:** This formula was employed to calculate the reliability of the Reflective Thinking Skills Test.
2. **One-Sample t-Test:** calculating the significance of the difference among the hypothetical mean and the actual mean for the Reflective Thinking Skills Test.

3. **Independent Two-Sample t-Test:** Used to calculate the significance of the statistical differences among the mean scores of male and female students in the Reflective Thinking Skills Test.

4. **Pearson Correlation Coefficient:** Used for calculating the internal consistency validity of the Reflective Thinking Skills Test.

**Presentation of Results:**

First Hypothesis: To verify this hypothesis, a one-sample t-test was meticulously adopted to compare the actual mean (6) with the hypothesized mean (10). It was found that the actual mean is smaller than the hypothesized mean, and the calculated t-value (-32.702) is smaller than the table t-value (1.96) at a level of sig (0.000) with 299 degrees of freedom, as shown in Table (4). Therefore, the null hypothesis is accepted, meaning that there is no statistically significant difference at the (0.05) significance level among the actual and hypothesized means. These results indicate that the research sample has a low level of reflective mathematical thinking skills.

**Table (4): Significance of the Difference among the Hypothetical and Actual Means for the Reflective Mathematical Thinking Skills Test**

| Sample | Arithmetic mean | Hypothetical mean | Standard deviation | Standard error | Calculated T value | Tabular T value |
|---|---|---|---|---|---|---|
| 300 | 6 | 10 | 2.05682 | 0.11875 | -32.702 | 1.96 |

**Second Hypothesis:** Verifying this hypothesis, the arithmetic means for students were calculated. The mean for males was (6.3548) with a standard deviation of (2.09434), while the mean for females was (5.8621) with a standard deviation of (1.99172). A t-test for independent samples was artfully employed to determine the significance of the statistical differences between male and female students. The calculated t-value was (2.085), which is higher than the table t-value of (1.96), and the significance level was (0.038), which is smaller than the significance level of (0.05), with 398 degrees of freedom, as in Table (5). Therefore, there is a statistically significant difference among the mean scores of male and female students, in favor of male students. Thus, the null hypothesis was refuted and the alternative hypothesis was supported, meaning that male students excel in possessing reflective mathematical thinking skills over female students.

Table (5): Statistical Significance of the Difference among the Mean Scores of Intermediate Students on th

## Results Interpretation

The findings of the first null hypothesis showed that intermediate-level students (the research sample) exhibit a lack of reflective mathematical thinking skills. The results of the 2nd hypothesis indicated that there are differences among students in terms of possessing reflective thinking skills, with male students outperforming female students. This may be attributed to the limited use of educational tools and activities designed for reflective mathematical thinking. Additionally, mathematics teachers may not participate in specialized training courses focused on reflective mathematical thinking skills to introduce these skills to their students, and they may still rely on traditional teaching methods. Despite the overall low level of reflective mathematical thinking skills in the research sample, male students demonstrated better possession of these skills than female students, possibly due to environmental and educational factors that differ between males and females.

CONCLUSIONS

1. The research sample shows a lack of reflective mathematical thinking skills.
2. Male students possess reflective thinking skills more effectively than female students.

## Recommendations

1. Mathematics teachers should introduce students to reflective mathematical thinking skills.
2. Use models, images, and educational tools to enhance reflective thinking among students.

## Suggestions

1. Conduct a survey that examines the relationship among reflective mathematical thinking skills and other variables.
2. Carry out a similar study to explore reflective thinking skills among students at other educational levels.

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