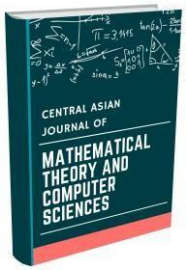

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Article

The Effect of Metacognitive Strategies on Achievement and the Development of Metacognitive Skills in Sixth-Grade Female Students in Mathematics

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Abstract: The current study aimed to explore the impact of metacognitive strategies on achievement and the development of metacognitive skills among sixth-grade elementary students in mathematics. To achieve this goal, the researcher used a quasi-experimental method with partial control by selecting two equivalent groups: one experimental group taught using metacognitive strategies and one control group taught using the regular method, with 27 students in each group. The research tools consisted of an achievement test with 30 multiple-choice items covering the prescribed math topics, and a metacognitive skills test composed of 25 items, the two tests were subjected to validity procedures by being presented to a group of specialized experts. The researcher applied the two tools on a pilot sample to ensure the clarity of the items and to extract the difficulty and discrimination indices, as well as the effectiveness of the wrong alternatives for each item. She also extracted the reliability of the two tests using the Kuder-Richardson KR-20 formula. To test the research hypotheses, the researcher used the t-test for two independent samples. The results showed that the students in the experimental group outperformed in both the achievement test and the metacognition test, indicating the effectiveness of metacognitive strategies in improving academic achievement and developing metacognitive skills among sixth-grade students in mathematics, which supports improving math teaching methods and enhancing learning outcomes.

Keywords: Metacognition Strategies, Academic Achievement, Metacognitive Skills, Mathematics, Sixth Grade Elementary.

1. Introduction

The world today is witnessing rapid developments in various fields of knowledge, which has forced educational systems to review their goals, curricula, and teaching methods to align with the requirements of the twenty-first century. The aim of the educational process is no longer limited to transferring information to learners; it now focuses on developing their mental and cognitive abilities, enabling them to think critically, solve problems, and make appropriate decisions, as well as developing self-learning skills that allow learners to continue learning throughout their lives [1].

Mathematics is considered one of the subjects that most contributes to building mathematical concepts and developing skills in analysis, reasoning, and interpretation, in addition to its role in preparing learners to deal with various life situations. For this reason, modern educational trends have focused on developing mathematics teaching methods to

achieve more effective learning and make learners active participants in constructing knowledge instead of merely relying on memorization and rote learning [2]

Flavell, who is considered the first to lay the theoretical foundations for the concept of metacognition, pointed out that a learner who possesses metacognitive skills is better able to organize their learning, choose appropriate strategies, and effectively tackle educational problems.

According to the above, metacognitive strategies have emerged as one of the most important modern trends in learning and teaching, due to their role in developing the learner's awareness of their thinking processes, enabling them to plan their learning, monitor their performance while carrying out educational tasks, and continuously evaluate their results. Since learning mathematics requires engaging in multiple mental processes such as analyzing data, choosing the appropriate strategy for solving problems, monitoring the steps of execution, and evaluating final results and all of these processes are closely linked to metacognitive strategies using these strategies in teaching helps students move from rote learning to learning based on deep understanding [3].

The results of many studies have pointed to a positive relationship between using metacognitive strategies and improving academic achievement and developing cognitive skills across different educational stages. These strategies have helped increase understanding, enhance problem-solving abilities, and improve self-regulation in learning, in addition to boosting self-confidence . Modern educational literature also emphasizes that developing cognitive skills is no longer just a secondary goal; it has become a key indicator of education quality and the effectiveness of teaching methods, especially in science subjects that rely on thinking and reasoning, with mathematics being at the forefront [4].

Despite the progress in methods of teaching mathematics, and what studies have shown about the effectiveness of metacognitive strategies, the educational field still points to a gap in academic achievement levels and a weakness in students' mastery of the metacognitive skills needed to deal with different math situations. This is what makes the current research necessary to explore the impact of metacognitive strategies on achievement and the development of metacognitive skills in sixth-grade students in mathematics.

Previous studies have consistently shown that metacognitive strategies positively influence students' academic achievement, problem-solving ability, and self-regulated learning. Flavell laid the theoretical foundation of metacognition, while subsequent studies confirmed that planning, self-monitoring, and self-evaluation enhance learners' mathematical understanding and cognitive awareness. Recent research has also reported that incorporating metacognitive strategies into mathematics instruction improves conceptual understanding and long-term learning outcomes. However, despite this growing body of evidence, limited studies have simultaneously examined the effect of metacognitive strategies on both academic achievement and metacognitive skills among sixth-grade elementary students in the Iraqi educational context. Therefore, the present study seeks to address this gap by investigating these two outcomes within a single experimental framework. Chapter One: Introduction to the Research. Mathematics is considered one of the subjects that plays a key role in developing scientific and logical thinking, as it contributes to building the learner's personality and enhancing their ability to analyze, reason, solve problems, and make appropriate decisions. To achieve this, relying solely on traditional teaching methods based on lecturing and memorization is no longer sufficient. It has become necessary to adopt modern teaching strategies that place the learner at the center of the educational process and help them organize their learning and manage their thinking consciously [5]. One of the most prominent of these strategies is metacognitive strategies, as they allow learners to plan their learning, monitor their performance while carrying out educational tasks, and evaluate the results of their

learning, which helps them acquire knowledge more deeply and effectively. Despite the attention given by the Ministry of Education to developing math curricula and adopting modern teaching methods, the educational reality still shows differences in academic achievement levels among students. Additionally, many students lack metacognitive skills that enable them to understand mathematical concepts and apply them in various learning situations. This is often due to continued reliance on teaching methods that focus on memorizing information and the limited use of strategies that promote conscious thinking and self-regulated learning. Based on the above, the problem of the current study is defined by attempting to answer the following main question: What is the effect of metacognitive strategies on achievement and the development of metacognitive skills among sixth-grade students in mathematics?

The world today is witnessing rapid developments in various fields of knowledge, which has forced educational institutions to take on the responsibility of developing teaching methods that align with the demands of modern education and achieve comprehensive development of the learner's personality, especially in cognitive and mental aspects. The success of the educational process is no longer measured by the amount of information a learner acquires, but by their ability to use that information in thinking, analyzing situations, solving problems, and making appropriate decisions. This requires adopting modern teaching strategies that shift the learner from a passive role to an active role in building knowledge [6].

The National Council of Teachers of Mathematics points out the special place of mathematics among school subjects, given its role in developing logical thinking, mathematical reasoning, and the ability to analyze and interpret, as well as its contribution to preparing learners to face various life situations. Therefore, improving math learning is a main goal that educational systems aim for by adopting modern teaching strategies that promote a deep understanding of mathematical concepts, rather than just memorizing rules and procedures. Metacognitive strategies are considered one of the most prominent contemporary trends in educational psychology, as they help learners plan their learning, monitor their performance, and continuously evaluate their results. This contributes to increasing their awareness of their thinking processes and improving their academic performance. A learner who possesses metacognitive skills is more capable of choosing the right strategy for a learning situation, identifying mistakes, and correcting them independently, which leads to deeper and more lasting learning [7], [8], [9]. The importance of the current research lies in the fact that it deals with two important variables: achievement and metacognitive skills, in light of metacognitive strategies, among a sample of sixth-grade elementary students. This stage is transitional before middle school and requires students to have mental and cognitive skills that enable them to continue learning efficiently.

2. Materials and Methods

Research Objectives: The current research aims to identify:

1. The effect of metacognitive strategies on academic achievement among sixth-grade students in mathematics.
2. The effect of metacognitive strategies on developing metacognitive skills among sixth-grade students in mathematics.

Research Hypotheses: To achieve the research objectives, the following two null hypotheses were formulated:

1. There is no statistically significant difference at the 0.05 significance level between the average scores of the female students in the experimental group who study mathematics using metacognitive strategies and the scores of the female students in the

control group who study the same subject in the usual way in the post-achievement test**.**

2. There is no statistically significant difference at the 0.05 significance level between the average scores of the female students in the experimental group who study mathematics using metacognitive strategies and the scores of the female students in the control group who study the same subject in the usual way in the post-test of metacognitive skills.

Research Scope: The current research is limited to the following:

1. The first semester of the academic year 2025-2026
2. Sixth-grade female students at Martyr Salem Al-Zubaidi Primary School under the Directorate of Education of Maysan Governorate.
3. Topics of the mathematics subject for sixth-grade students, represented by the first four chapters (whole numbers - algebraic expressions and equations - operations on common fractions - operations on decimal fractions).

Defining Terms:

1. **Effect:** It was defined by as "the amount of change that occurs in a learner's behavior or performance level as a result of exposure to a certain variable or educational experience"**.**
   Operational definition: The amount of change those metacognitive strategies cause in the scores of sixth-grade female students on the achievement test and metacognitive skills test compared to the usual method.
2. **Metacognitive strategies were defined** by Schunk and Greene as 'the actions that a learner consciously uses to organize their learning and manage their cognitive processes while performing educational tasks'**.**
   Operational definition: A set of teaching procedures adopted by the researcher in teaching mathematics to sixth-grade female students, focusing on training them in planning, self-monitoring, and self-assessment during learning, aiming to improve achievement levels and develop metacognitive skills.
3. **Achievement is defined by** as the amount of knowledge and skills a learner acquires as a result of going through an educational experience, which can be measured using achievement tests. The operational definition: the total score that sixth-grade students obtain on the achievement test prepared by the researcher to measure their performance in the assigned math topics.
4. **Metacognitive skills:** defined by Anderson et al. as 'the mental processes that an individual uses to acquire knowledge, organize it, understand it, analyze it, and apply it in different learning situations.' According to OECD, they are 'a set of mental abilities that enable the learner to think, reason, analyze information, solve problems, and make decisions effectively.' **Operational definition:** the mental abilities that sixth-grade female students possess, measured by the score they obtain on the metacognitive skills test prepared by the researcher for this purpose.
5. **Sixth grade of primary school**

The Ministry of Education defined it as: 'the last grade of the primary stage in the Iraqi educational system, which comes before the middle stage, and includes students who study the curricula set by the Ministry of Education during the academic year in which the research is applied.'

Metacognitive Strategies: Metacognitive strategies are considered one of the most prominent concepts that emerged in cognitive psychology and modern education. They represent a qualitative shift in the way learning is viewed, from being merely a process of acquiring information to a conscious process where the learner can organize their thinking and manage their learning independently. This concept has received increasing attention since the 1970s due to its role in improving academic achievement, developing thinking skills, problem-solving abilities, and decision-making in various educational situations.

Recent studies also indicate that integrating metacognitive strategies into math teaching enhances conceptual understanding, learning autonomy, and problem-solving skills compared to traditional teaching methods.

Learning based on metacognitive strategies involves making the learner aware of how they learn. Their role isn't just to receive information; they become an active participant in organizing their learning, choosing the right strategies, and addressing mistakes that may come up during the learning process. Metacognitive strategies are especially important in mathematics, because learning math requires practicing a sequence of mental processes that start with understanding the problem, then analyzing the data, choosing an appropriate plan to solve it, following through with its execution, and finally checking the results. These processes can't be done effectively unless the learner has the prior skills, which are the main components of metacognition. John H. Flavell was the first to use the term metacognition scientifically, referring to an individual's awareness of their cognitive processes, understanding the nature of their thinking, and their ability to monitor, organize, and evaluate these processes to achieve learning goals.

Schraw and Moshman believe that metacognition refers to an individual's knowledge about their ways of thinking and their ability to organize these ways through planning, monitoring, and evaluation, which helps improve their learning. Modern educational literature points out that metacognitive strategies are one of the most important components of self-regulated learning, as they help the learner become more aware of the thinking processes they use and better able to control them to achieve deep and lasting learning, rather than just rote memorization. From the above, it can be said that metacognitive strategies represent a set of organized mental processes that the learner consciously practices (planning, self-monitoring, and evaluation) in order to organize learning, improve performance, and develop cognitive abilities.

The Emergence and Development of the Concept of Metacognition

The concept of metacognition is considered relatively modern in the field of cognitive psychology. Most researchers trace the origin of the concept to the work of American psychologist John H. Flavell, who clearly presented this concept in the 1970s and regarded it as a new area in cognitive psychology. Flavell explained that metacognition involves an individual's knowledge of their cognitive processes, as well as their ability to monitor, organize, and control them while performing various tasks, which he called cognitive monitoring. This is considered the foundation for effective learning and problem-solving.

In the 1980s, the concept of metacognition expanded further. Brown introduced an idea that distinguishes between two main aspects: knowledge of cognitive processes and the regulation of those processes. He emphasized that a learner's success doesn't just depend on having knowledge, but also on their ability to use and manage it effectively during learning .

In the 1990s, Schraw and Moshman proposed a more comprehensive model, dividing metacognition into two main components: knowledge about knowledge, which includes an individual's awareness of their abilities, strategies, and the demands of the learning task, and knowledge regulation, which involves planning, self-monitoring, and evaluation—processes that learners rely on to organize their learning and improve their academic performance.

In recent years, interest in studying metacognition in mathematics education has increased, as researchers have confirmed that using metacognitive strategies helps improve math achievement, develop problem-solving abilities, and enhance mathematical thinking among learners at different educational stages. This reflects the growing global interest in applying metacognitive strategies in teaching mathematics and improving its outcomes .

From the above, it is clear that the concept of metacognition has gone through multiple stages of development. It started as a theoretical concept explaining an individual's awareness of their thinking processes, then evolved into a practical framework for organizing learning, and became one of the main approaches used in developing modern teaching methods, especially in mathematics, due to its role in improving academic achievement and developing cognitive skills. This makes applying it at the elementary level essential for preparing learners capable of organized thinking and independent learning.

Metacognitive Strategies

These are a set of organized mental actions and processes that learners consciously use before, during, and after learning, aiming to organize their learning, monitor their performance, and evaluate their results, which contributes to more effective and deeper learning. These strategies are not limited to just having knowledge but also extend to how it is used in different learning situations, making the learner more capable of handling educational problems and making appropriate decisions during learning.

Al-Ghurriri pointed out that metacognitive strategies serve as a link between thinking and knowledge, as they help the learner manage their mental processes in an organized way, make them more aware of their abilities and potential, and more capable of choosing the right strategy for the learning task and adjusting it when needed. The literature confirms that employing these strategies in the classroom contributes to improving learning, increasing learners' motivation, and developing reflective thinking and independence in learning **.**

In the researcher's view, since the nature of mathematics requires the learner to think through the steps of a solution, constantly review their procedures, and verify the accuracy of the results they reach, metacognitive strategies are considered some of the most suitable strategies for teaching mathematics. Success in mathematics doesn't just depend on the learner's knowledge of mathematical rules, but also on their ability to plan the solution, monitor their steps, and assess the correctness of the final answer, all of which are processes that form the core of metacognition. These are among these strategies.

1. Planning Strategy: Before starting a learning task, the learner sets their goals, analyzes the task requirements, chooses the appropriate strategy, and determines the expected time to complete it. They also recall previous experiences related to the new task. This step emphasizes that effective learning starts even before diving into the task, as the quality of planning directly impacts the quality of later performance.
2. Self-Monitoring Strategy: This involves the learner keeping track of their performance while carrying out the learning task, observing how well they stick to the plan, and spotting and correcting mistakes as they go. This type of monitoring gives the learner a chance to adjust their strategy if it turns out it's not achieving the desired goal, which improves learning efficiency and reduces the chances of repeating mistakes.
   The researcher believes that while solving math problems, a student practices self-monitoring when they review calculations, check the correctness of moving from one step to another, and compare interim results with the information they have. This helps them catch errors before reaching the final answer.
3. Self-Evaluation Strategy: This involves the learner evaluating their own performance after completing a learning task, analyzing the reasons for their success or failure, assessing how suitable the strategy they used was, and then applying this experience to future learning situations.

The researcher believes that self-evaluation in math happens when a student rechecks their solution, ensures it aligns with the given information, uses another method to verify the answer, or logically explains the result they reached. Self-evaluation is considered one of the key indicators of mature thinking because it enables the learner to learn from their mistakes and continuously improve their performance.

The Importance of Metacognitive Strategies

Metacognitive strategies have received wide attention in modern educational literature because of their active role in improving students' learning, developing their mental abilities, and enhancing their independence in learning. This interest is due to the fact that these strategies focus on how the learner thinks during learning and how capable they are of organizing and managing their mental processes consciously, which positively reflects on their academic achievement**.**

Attia points out that metacognitive strategies represent one of the most important modern approaches in teaching because they develop the learner's ability to think about their own thinking, help them discover and correct errors independently, and contribute to the development of independent learning and responsibility. These goals have become central in contemporary education. Al-Ghariri emphasizes that a learner who possesses metacognitive skills is more capable of planning their learning, more aware of the strategies they use, and more successful in facing educational problems compared to learners who rely on memorization and rote learning.

The researcher believes that metacognitive strategies are important in teaching mathematics because math is a subject that relies on logical thinking, reasoning, and analysis. It requires learners to follow organized steps to reach the correct solution in a way that helps them gain a deeper understanding of mathematical concepts and increases their ability to apply mathematical knowledge in new situations, rather than just memorizing. These strategies not only improve immediate learning outcomes but also prepare learners to manage their own learning independently, make appropriate decisions, and address educational challenges efficiently. This makes them particularly suitable for teaching mathematics in primary school, especially for sixth-grade students, who are at the last stage of primary education and preparing to move on to an educational level that demands higher levels of thinking and organization.

Second: Academic Achievement :

Academic achievement is considered one of the variables that has received the most attention from researchers in the fields of education and psychology because it represents one of the most important indicators through which the success of the educational process and its achievement of goals can be judged. It is the final outcome of the learning process, reflecting how much the learner has gained in terms of knowledge, skills, and attitudes as a result of going through organized learning experiences. It is usually measured through achievement tests that have adequate levels of validity and reliability.

The Ministry of Education has clearly focused on improving achievement across all subjects by developing curricula, introducing modern teaching strategies that emphasize active learning, developing thinking skills, and involving students in building knowledge, rather than just relying on traditional methods based on lecturing and rote learning. Regarding mathematics, it is an important indicator of how well students grasp mathematical concepts and skills and apply them in different educational and real-life situations. It doesn’t focus on memorizing formulas and theorems but includes understanding mathematical relationships, the ability to reason, logical analysis, choosing appropriate solution methods, and verifying results—all of which require higher-level cognitive skills beyond mere memorization.

Third: Metacognitive Skills

Metacognitive skills are the mental processes that learners use to acquire, organize, understand, and apply knowledge in different learning situations. Interest in developing these skills has increased with the shift towards thinking-based learning, which focuses on building learners who can analyze, infer, and solve problems, rather than just memorizing and recalling information. Therefore, developing these skills has become one of the main goals of modern curricula, especially in science subjects, including mathematics**.**

Attia believes that developing metacognitive skills should be a goal in all teaching practices because it helps prepare learners who can think properly, analyze problems, and come up with logical solutions. Zaitoun also points out that when learners have these skills, it helps them understand the relationships between concepts and use them correctly in new situations, which leads to better academic performance.

The researcher believes that metacognitive skills are particularly important in mathematics because learning math relies on a series of sequential mental processes. It starts with understanding the mathematical problem, then analyzing its data, choosing the appropriate strategy to solve it, carrying out the solution steps, and finally evaluating the results and verifying their accuracy. Therefore, a student's success in mathematics is largely linked to having skills that allow them to handle these processes efficiently and accurately. In the current study, metacognitive skills represent the set of mental abilities that sixth-grade students have in math, which include understanding mathematical concepts, analyzing data, choosing appropriate solution methods, applying them, and evaluating the results. These skills are measured by the score the student receives on a test prepared by the researcher for this purpose.

Previous Studies:

1. **Al-Hiti's Study:** It aimed to identify the effectiveness of using the metacognitive strategy (K.W.L) in achievement and systemic thinking among fourth-grade science students in mathematics. The study used an experimental method, with a sample consisting of 60 students, divided equally into two groups: an experimental group that studied using the (K.W.L) strategy, and a control group that studied using the traditional method. The results showed statistically significant differences at the 0.05 significance level between the average scores of the two groups in both the achievement test and the systemic thinking test, in favor of the experimental group. The researcher benefited from this study in building the theoretical framework for metacognitive strategies, utilizing the procedures of experimental design, the method of constructing the achievement test, as well as benefiting from its results when interpreting the results of the current research.
2. Sheikh's study aimed to identify the effectiveness of metacognitive strategies in developing some system thinking skills among fourth-grade students in mathematics. The study used an experimental method, with a sample of 60 students, randomly divided into two groups: an experimental group of 30 students who were taught using metacognitive strategies, and a control group of 30 students who were taught using the traditional method. To achieve the study’s objectives, the researcher prepared a list of system thinking skills. The results showed statistically significant differences at the 0.05 level between the average scores of the experimental group and the control group in the system thinking skills test, in favor of the experimental group [19]. The researcher benefited from this study in supporting the theoretical framework related to metacognitive strategies, applying its steps in the classroom, as well as benefiting from its results when discussing the findings of the current research.
3. **Fyfe et al. study:** The study aimed to identify the effect of integrating metacognitive-based questions in teaching mathematical equivalence, arithmetic, and place value among sixth-grade students. The study used an experimental approach, with a sample of 100 sixth-grade students who were randomly divided into an experimental group, which was taught through lessons that included metacognitive questions, and a control group, which was taught the same lessons without these questions. The researchers used a pre-test, a post-test, and a retention test after two weeks to measure the effect of the intervention. The results showed a statistically significant improvement in the performance of the experimental group in understanding mathematical equivalence, arithmetic, and place value, as well as an improvement in their metacognitive monitoring compared to the control group. This effect also persisted in the retention

test, highlighting the importance of integrating metacognitive strategies in teaching mathematics at the elementary level.

Research Gap: Through reviewing some of the literature, the researcher points out that there are several aspects that still need further investigation. Most studies have focused on variables like academic achievement, systems thinking, or creative thinking, while foreign studies have more extensively addressed metacognitive awareness, self-regulation, and solving math problems. The current research differs from previous studies in several ways, the most important of which are **:**

1. Considering two dependent variables, namely academic achievement and metacognitive skills, within a single study**.**
2. Targeting sixth-grade elementary students, which is a crucial stage before moving on to middle school**.**
3. Applying the research in the Iraqi educational environment, contributing to enriching local studies related to teaching mathematics using metacognitive strategies.

Thus, the current research seeks to fill this scientific gap by uncovering the effect of metacognitive strategies on academic achievement and developing metacognitive skills among sixth-grade students in mathematics, adding new scientific evidence to the educational literature in this field.

Chapter Three: Research Methodology and Procedures

Research Method

This study used a quasi-experimental method, as it is the most suitable for the nature and objectives of the research. The researcher chose a partially controlled experimental design with two equivalent groups: one experimental group that is taught using metacognitive strategies, and one control group that is taught in the usual way. Two post-tests were applied to both research groups: an achievement test and a metacognition test.

Research Population and Sample: The research population consists of all primary schools under the Misan Governorate Directorate. The researcher selected Al-Shaheed Salem Al-Zubaidi School for Girls using a purposive method due to the school's administration being willing to cooperate with the researcher and having more than one sixth-grade class. Two classes were randomly chosen, with one representing the experimental group studied using metacognitive strategies, while the other represented the control group studied using the traditional method. The total number of students in the research groups was 54 students, with 27 in each group.

Equivalence of the research groups: Before starting the experiment, the researcher ensured that the research groups were equivalent in a number of variables that could affect the research results, in order to minimize the impact of confounding variables and ensure that any differences observed after the experiment could be attributed to the independent variable, which is the metacognitive strategies. The research groups were matched on the following variables:

1. **Chronological age calculated in months:** The researcher relied on school records to calculate it. The arithmetic means and standard deviation for each group were extracted, and an independent samples t-test was used to check the significance of the difference between the two means. The results showed that the calculated t-value was 0.31, which is less than the tabular t-value of 2.00 at a significance level of 0.05 and 52 degrees of freedom, indicating that there is no statistically significant difference between the two research groups in chronological age. Thus, the two groups are considered equivalent in this variable.
2. **Intelligence:** The researcher used the Raven's Progressive Matrices test because it is a common test for measuring general mental ability and is suitable for the age group of sixth-grade students. After administering the test to the participants of both research groups and scoring their responses, the researcher calculated the mean and standard

deviation of each group's scores and used the t-test for two independent samples to check if there was a significant difference between the means. The results showed that the calculated t-value was 0.47, which is less than the critical t-value of 2.00 at a significance level of 0.05 and 52 degrees of freedom, indicating that there is no statistically significant difference between the two research groups in terms of intelligence. Thus, the two groups are considered equivalent on this variable.

Controlling Extraneous Variables: The researcher made sure to limit the impact of extraneous variables that could affect the research results, aiming to increase the internal validity of the experiment for the following variables**:**

1. Subject matter: Both research groups studied the same topics from the sixth grade mathematics textbook, covering the first four chapters**.**
2. Experiment duration: The experiment started at the beginning of the school year on 9/21/2025**.**
3. Subject teacher: The school's subject teacher taught the students the assigned topics according to the teaching plans prepared by the researcher, which served as a guide for teaching the experimental group using metacognitive strategies, ensuring a standardized teaching method, with the only difference between the two groups being the teaching method.
4. Accompanying incidents: During the period of implementing the experiment, there were no exceptional events or circumstances that could affect its course or the performance of the participants in my research groups, which helped in maintaining the integrity of the experiment's procedures **.**
5. Measurement tool: The same two tools were used with both research groups: the achievement test, which consisted of 30 multiple-choice items, and the metacognition test, which consisted of 25 items. They were applied under uniform conditions regarding time, instructions, and correction method**.**
6. Confidentiality and accuracy of scoring: The researcher made sure to correct the students' responses according to a standardized answer key, while keeping the results confidential and only revealing them to the students after all research procedures were completed, ensuring objectivity and accuracy.

3. Results and Discussion

Research tools :

First: The achievement test: It aimed to measure the level of sixth-grade students' achievement in mathematics after completing the topics of the first four chapters of the prescribed textbook, and to identify the effect of using metacognitive strategies on their academic achievement. This was done by comparing the performance of the female students in the experimental group with that of the female students in the control group in the post-application of the test [10]. Content analysis is considered one of the basic steps in building achievement tests. To do this, the researcher analyzed the content of the first four chapters of the prescribed sixth-grade mathematics textbook, which are: (integers, algebraic expressions and equations, operations on common fractions and mixed numbers, operations on decimal fractions). The researcher relied on the results of the content analysis in formulating 120 behavioral objectives distributed across Bloom's cognitive levels. These were presented to a group of specialists in mathematics teaching methods, measurement, and evaluation to ensure the soundness of their formulation, their coverage of the study content, and their appropriateness for the academic level of sixth-grade students [11], [12].

Preparing the Test Blueprint (Specification Table): The researcher prepared a test blueprint (specification table) to ensure the content validity of the test and to achieve a balance between the subjects of the curriculum and the cognitive domain levels. The 30 items of the achievement test were distributed across the content topics and cognitive

domain levels in a way that ensures proper representation of all parts of the curriculum [13], [14]. The test blueprint helped in creating a test with a high level of content validity and balanced coverage of the curriculum topics and behavioral objectives, ensuring accurate measurement of academic achievement for sixth-grade students.

Preparing the Achievement Test Items: The researcher prepared a test consisting of 30 multiple-choice items, each with four options, one of which is the correct answer, while the other three options are incorrect. The items cover all the topics from the first four chapters, according to Bloom's cognitive levels.

Test Correction: The researcher relied on a unified key to correct the achievement test, giving one point for a correct answer and zero for a wrong or skipped answer. This made the total test score 30 points, with the minimum score being zero [15].

Test Validity: The researcher used face validity and content validity by presenting the test to a group of specialists in mathematics teaching methods. The agreement rate among the reviewers on the validity of the items was 80% or more, which is considered acceptable in educational studies .

Pilot Test Application: The researcher applied the test to a pilot sample of 100 sixth-grade female students selected from schools not included in the main experiment. This was done to check the clarity of the items and instructions, determine the time needed for answering, and to obtain the necessary data for statistical analysis of the test items [16], [17].

Statistical analysis of the test items: After applying the achievement test to the pilot sample, the researcher corrected the answers and arranged the total scores in descending order from highest to lowest. The researcher adopted a 27% ratio to determine the two extreme groups in order to analyze the items in terms of difficulty, discrimination, and the effectiveness of incorrect options for each of the 30 test items .

Difficulty coefficient of the test items: The difficulty coefficients of the achievement test items ranged between 0.56 and 0.69, which is within the educationally acceptable limits.

Discrimination coefficient of the test items: The discrimination coefficients of the items ranged between 0.41 and 0.59, and an item is considered to have good discrimination if its coefficient is 0.20 or higher [18].

Effectiveness of Incorrect Alternatives: The analysis results showed that all the incorrect alternatives were effective, as their values were negative, indicating their ability to attract lower-group individuals more than upper-group individuals .

Test Reliability: The researcher used the Kuder-Richardson formula (KR-20) because the test items were multiple-choice, giving one point for a correct answer and zero for an incorrect or unanswered one [19]. The reliability coefficient reached (0.87), which is considered acceptable in educational research, indicating that the test has a good level of reliability and is suitable for application to the main sample .

Metacognition Test Preparation: To achieve the second research goal, the researcher prepared a test to measure the level of metacognition. The test consisted of 25 multiple-choice questions .

Goal of the Metacognition Test: The test aimed to measure the sixth-grade female students' level of metacognitive skills in mathematics and to uncover the effect of using metacognitive strategies on developing these skills in the experimental group compared to the control group [20], [21].

Defining Metacognition Test Areas: The researcher relied on three main areas when building the metacognition test, which are: (Planning - Self-Monitoring - Evaluation). The 25 test items were distributed across these areas as shown in the following table:

Table 1. Distribution of Metacognition Test Items across Its Areas.

Field	Number of paragraphs	Percentage
Planning	8	32%
Self-monitoring	9	36%
Self-evaluation	8	32%
Total	25	100%

Metacognition Test Scoring: The researcher assigned one point for a correct answer and zero for a wrong or skipped answer, making the total score of the test 25 points, while the minimum score was zero.

Metacognition Test Validity: The researcher relied on face validity by presenting the test to a group of experts specialized in mathematics teaching methods, measurement, and evaluation. The items received an agreement rate of 80% or more, making the test valid for use [22].

Pilot Application of the Metacognition Test: The researcher applied the metacognition test to a pilot sample of 100 sixth-grade female students, outside of the main sample, to check the clarity of the items and instructions, determine the time needed to answer, and obtain the data needed for statistical analysis of the items [23], [24].

Statistical Analysis of the Metacognition Test Items

After correcting the responses of the pilot sample, their scores were arranged in descending order, then the top 27% and the bottom 27% of the scores were selected. The responses of these two groups were used to calculate the difficulty and discrimination indices for the test items.

Difficulty Indices: The difficulty indices ranged between 0.57 and 0.67, which are within the acceptable limits as indicated by educational literature, showing that the test items are appropriate.

Discrimination Indices: The discrimination indices ranged between 0.41 and 0.59, which are good indices, indicating the items' ability to differentiate between high- and low-performing students.

Reliability of the Metacognition Test: The researcher used the Kuder–Richardson formula (KR-20), and the reliability coefficient reached 0.84, which is an acceptable value according to educational literature [25].

Final Version of the Metacognition Test: After verifying the test's validity, statistically analyzing its items, and calculating its difficulty, discrimination, and reliability indices, the test became ready to be applied to the main research sample.

Applying My Research Tools: After finishing the preparation of my research tools, verifying their validity and reliability, and extracting the psychometric properties of each, and after the experiment period ended, I administered the achievement test on Sunday, 21/12/2025, and the metacognition test on Tuesday, 23/12/2025, to the participants of both the experimental and control groups. After completing the tests, I graded the answers according to the pre-prepared answer keys and recorded the scores in special forms in preparation for performing the necessary statistical treatments to test the research hypotheses.

Statistical Methods: I used a number of appropriate statistical methods to achieve the research objectives, test its hypotheses, and extract the psychometric properties of the research tools, as follows: the independent samples t-test, item difficulty coefficient, item discrimination coefficient, effectiveness of wrong alternatives, and the Kuder–Richardson formula 20 (KR-20).

Chapter Four: Presentation and Interpretation of Results

First: Presentation and Interpretation of the First Hypothesis Results: which states that "There is no statistically significant difference at the 0.05 level of significance between the average scores of the experimental group students who studied using metacognitive strategies and the scores of the control group students who studied using the traditional method in the achievement test"**.**

The researcher used the independent samples t-test to compare the average scores of the two research groups in the achievement test, as shown in the following table:

Table 2. Results of the T-test for the scores of the members of my research groups in the achievement test.

Level of significance	tabulated T-value	Calculated T-value	standard deviation	arithmetic mean	No.	Group
significance	2,01	4,27	2,84	24,78	27	Experimental.
			3,76	20,89	27	Controlled.

It's clear from Table (2) that the calculated t-value (4.27) is higher than the tabular t-value (2.01) at a significance level of 0.05 and with 52 degrees of freedom, which indicates a statistically significant difference between the two groups. Therefore, the first null hypothesis is rejected, and it can be concluded that using metacognitive strategies had a positive effect on improving the math achievement of sixth-grade elementary students [26].

Explanation of the result: The researcher attributes this result to the fact that metacognitive strategies provided a learning environment that made the students more aware of their thinking processes. These strategies helped them plan solutions, monitor their steps, and continuously evaluate their performance, which contributed to a better understanding of mathematical concepts and improved problem-solving skills.

These strategies also encouraged active participation in class, motivated the students to think systematically, review their answers, and correct their mistakes on their own. This led to higher academic achievement compared to their peers who learned using the traditional method. This result aligns with several previous studies that confirmed the effectiveness of metacognitive strategies in improving academic achievement in mathematics [27], [28].

Second: Presenting and interpreting the results of the second hypothesis, which states that: 'There is no statistically significant difference at the 0.05 significance level between the mean scores of the experimental group students who studied with metacognitive strategies and the control group students who studied in the usual way in the metacognition test.' The researcher used the independent samples t-test to compare the mean scores of the two research groups in the metacognition test, as shown in the following table:

Table 3. Results of the paired test for the scores of the members of my research groups in the metacognition test.

Level of significance	tabulated T-value	Calculated T-value	standard deviation	arithmetic mean	No.	Group
significance	2,01	5,38	2,15	21,63	27	Experimental.
			3,08	17,74	27	Controlled.

It is clear from Table (3) that the calculated t-value reached (5.38), which is higher than the tabular value of (2.01) at a significance level of (0.05) and degrees of freedom (52), indicating that there is a statistically significant difference between the two groups. Therefore, the second null hypothesis is rejected, and it can be concluded that using metacognitive strategies contributed to developing metacognitive skills among sixth-grade elementary students [29].

Result Interpretation: The researcher attributes this result to the fact that metacognitive strategies made the students more capable of organizing their learning, planning to solve math problems, monitoring their steps during execution, and evaluating their performance after completing the solution. They also helped develop their awareness of cognitive processes, which positively reflected on their scores in the metacognition test. This result aligns with previous studies that confirmed that metacognitive strategies play an active role in developing structured thinking, increasing awareness of cognitive processes, and improving learners' performance in various educational situations.

4. Conclusion

In light of the results reached by the research, the researcher concluded the following:

Metacognitive strategies contributed to improving the academic achievement of sixth-grade students in mathematics. Metacognitive strategies had a positive impact on developing metacognitive skills among the experimental group members. Recommendations: In light of the results reached by the researcher, she recommends the following: Adopting metacognitive strategies in teaching sixth-grade mathematics, as they have a positive impact on improving academic achievement and developing students' metacognitive skills. Encouraging math teachers to use metacognitive strategies during lessons and to involve students in planning, thinking, following solution steps, and evaluating them. Suggestions: The researcher suggests the following: Conduct a similar study to measure the impact of metacognitive strategies on other variables, such as mathematical thinking, critical thinking, and solving mathematical problems. Conduct a similar study at other educational stages, such as middle or preparatory school, to verify the effectiveness of metacognitive strategies at those stages.

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