



Effectiveness of Using the IMPROVE Program on the Achievements of Preliminary Students

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The study aimed to investigate the effectiveness of the seven-stop IMPROVE program (Introducing new concepts, Metacognitive questioning, Practicing, Reviewing and reducing difficulties, Obtaining mastery, Verification, and Enrichment) on the achievement of preliminary students at Taif University, Saudi Arabia, at the first three levels of the Bloom's taxonomy (Knowledge, Comprehension, Application). The researcher used the experimental design to achieve the objective of the study. In order to achieve the purpose of the study, the sample was chosen in a deliberate manner from groups that were taught using cooperative learning in mathematics classes. The experimental group (32 students) who studied using the IMPROVE program was compared with the second group (32 students) who were taught in the traditional lecture style. The results of the study showed the effectiveness of using the IMPROVE program in mathematics teaching at the knowledge, comprehension and application levels. This study recommends the use of this metacognitive strategy in mathematics teaching for other stages of education. It also recommends expanding awareness in educational institutions of the concept of metacognition and its importance in improving the learners' awareness to deal with mathematics problems.

Keywords: metacognition, mathematics, IMPROVE program, cooperative learning, achievement

INTRODUCTION

National Transformation Program (NTP) was introduced in Saudi Arabia to develop a curriculum with focus on high literacy and numeracy standards. NTP aims to build an education system that meets the modern market requirements and contributes towards construction of a successful economy (Vision, 2030). In this regard, Al-Maimooni, (2016) notices a gap between what the skills Saudi students develop in educational setting and the skills required at the workplace. Such gaps are a matter of concern when it comes to considering a variety of benefits of education for fast-changing global market and economy. It is essential to restructure education system to meet the goals of Vision 2030 by understating the way in which education contributes to the Saudi economy (Alzahrani, 2017). Mathematics forms the foundation for scientific and

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technological advancement. Thus, economic and social development bears a close relation with mathematical sciences (Kuku, 2012). A good mathematics education produces better technicians and technologists who in turn contribute to the development and growth of a society.

The education sector faces challenges. One of such challenges is the low academic achievement in mathematics. Although, necessary efforts are taken to improve the students' performance in mathematics, the expected results are not achieved. To address this concern, the researcher have tried to come up with possible solutions that could increase mathematics achievement of learners. One well-known idea in Mathematics Education which is believed as one of the most reliable predictors of students attainment in mathematics. This is called as Metacognition: *thinking about one''s thinking*.

The I.M.P.R.O.V.E. model is employed for instructional purpose as a metacognitive intervention tool in mathematics. The acronym of I.M.P.R.O.V.E. represents all the essential steps of teaching that constitute the method: In terms of the IMPROVE program, it is an acronym for the instruction steps that comprise the method: Introducing new concepts, Metacognitive questioning, Practicing, Reviewing and reducing difficulties, Obtaining mastery, Verification, and Enrichment. The program was first presented by Mevarech and Kramarski (1997). It encompasses three interrelated components (Mevarech & Kramarski, 1997, p. 369) : (a) Facilitating both strategy acquisition and metacognitive processes; (b) Learning in cooperative team[s], so four students with different prior knowledge; and (c) Provision of feedback – corrective – enrichment that focuses on lower and higher cognitive processes. Mevarech, Z. & Kramarski B. developed this instructional approach in 1997 to facilitate learners involve in metacognitive conversations to construct mathematical meaning. The ultimate goal of this approach is to enhance learners' mathematical reasoning. The IMPROVE method is reported to have a positive effect on mathematical attainment (Cetin, Sendurur, & Sendurur, 2014).

Keeping in view the contextual realities, the research chose to employ IMPROVE program not without valid justification. The researcher thinks that mathematics teaching is not a rote process, which involves reasoning and metacognitive process. To teach mathematics in a better way, it is very important for a teacher to activate metacognitive process of learners so that they may build meaningful relationships between the new knowledge they receive and the knowledge they have already acquired. This happens through a process of constructing and reconstructing instead of rote learning and the process of memorization. The approach advocates socio-cultural perspective of knowledge and promotes cooperative learning to understand the tacit connection of metacognition and mathematics. It is important to assert that the IMPROVE program was carried out in order to enable the formulation of a clearer and more complete picture of the nature of the relationship between metacognitive teaching and students' academic achievement in mathematics classrooms, in Saudi Arabia in particular, and in other countries in general.

Review of Literature

Definition and the Concept of Metacognition

The concept of metacognition was first described by the American scientist Flavell, and then later by Brown and Kluwe. In order to shed light on this concept, it is helpful to refer to these three scientists who experienced the emergence of this term in its infancy. Flavell (1979, p. 1232) describes the term 'metacognition' to be one's knowledge concerning one's own cognitive processes or anything related to them, along with monitoring and regulation of these processes for some concrete goal or objective. In a similar way, Brown (1987) reemphasized the same concept to refer to one's knowledge and control of one's own cognitive processes. Kluwe (1982, p. 202) asserts that there are general attributes of these activities that require the individual's knowledge about their own thinking as well as monitoring and regulating the course of their own thinking.

Given these perspectives, the concept of metacognition can be based on two key domains. The first domain is knowledge of one's own cognition, while the second, referred to as executive processes by Kluwe (1982), is monitoring and regulating this cognition. In further analyzing the first element, metacognition can be described as the knowledge or beliefs that an individual possesses about their own or other's cognition, the knowledge of information processing systems (Brown, 1987), and the apprehension of metacognitive knowledge variables, namely, person, task and strategy variables (Flavell, 1979).

In regard to cognitive monitoring and regulation, Flavell (1979) described the executive process achieved through monitoring one's cognition as metacognitive strategy. Brown (1987) agreed that both monitoring and regulating one's cognitive activity are metacognitive skills, aiming directly at gaining knowledge about one's cognitive processes. Furthermore, Kluwe (1982) stated that the executive process denotes four skills involved during executive monitoring: identification, checking, evaluation, and prediction. Brown (1987) identified the second component of metacognition with regulatory skills such as planning, monitoring and evaluation. Prior to learning, planning involves setting goals, selecting and allocating resources, planning strategies, etc. Monitoring activities, carried out during the learning process, require testing, modifying, and revising plans and strategies. Finally, after learning, evaluation is carried out to assess, analyze and verify strategy efficiency and effectiveness.

However, even though all these introductions are taken into account, providing a definition of metacognition does not mean that there is agreement or consensus on the limits of this term. This is because the concept has grown over time and its extent has expanded; it is also because it is essentially multifaceted (Buratti & Allwood, 2015). There is therefore a need for a more specific theoretical clarification that includes a definition and description of the components of this concept (Azevedo & Aleven, 2013). It can be concluded that the concept of metacognition, from an educational perspective, is one's knowledge of, and the monitoring and control of, one's own systematic cognitive activity, which requires certain metacognitive skills such as planning and evaluation. In the context of this discussion, however, it is important to emphasize the

importance of the concept of self-monitoring and control in the context of the concept of metacognition, no matter how multifaceted it is, or what Kluwe (1982, p. 202) explained: “The subject of metacognition is regulation of one’s own information processing.”

Metacognition and Mathematics

There are several dimensions related to the nature of the relationship between metacognition and mathematics. The nature of relation has been differently reported by the academicians and researchers. Although a vast majority of the researchers show a positive relation between metacognition and mathematics teaching, there are some who still show reservations about the use of metacognitive strategies in mathematics teaching and learning. The current section explores both the views: negative as well as positive correlation between metacognition and mathematics.

Reservations for using metacognitive techniques in mathematics teaching

Some studies demonstrate empirical evidences that simultaneous elucidations of metacognitive involvements/experiences can negatively impact performance, at minimum when “intuitive” feelings are a result of direct experiences. In a couple of studies by Schooler et al. (1993, 1997), they notice the negative impact of verbalization on cognitive performance in accomplishing the tasks (see also Yamada, 2009). Verbal overshadowing is defined in view of incongruity amid verbal labels and features of the conceptual experience- that indicates a shift from global to local processing, and a criterion change to more traditional replying (Chin and Schooler, 2008). Another line of thoughts suggests that conscious attention to metacognitive experiences doesn’t always result in benefits, the evidences come from research and studies conducted on mindlessness (Neal et al., 2011). Mindlessness is simply defined as the absence or opposite of mindfulness. According to Langer (1992), mindlessness is defined as lack of presence or attention, resulting in by automated application and employment of possessed knowledge. Thus, main characteristic of mindlessness is cognitive inflexibility. According to Di Nucci (2013), mindlessness which is characterized by an unconscious or automated process is associated with “System 1” thinking, i.e., fast, automatic/uncontrollable, associative, effortless, implicit (Kahneman, 2003). Whereas Langer (1992) regards mindlessness as a state of mind which must be avoided others maintain that that it may at times be beneficial (Di Nucci, 2013; Kashdan and Biswas-Diener, 2014). Overconfidence is a third factor. Studies by Kruger and Dunning (1999) show that performance of those falling within the lesser quartile on numerous laboratory and real-life tasks, have a tendency to overrate their performance compared to people who achieve better. This is referred to as a “double curse” (Dunning, 2011) as it seems that the identical inadequacies accountable for low performance also stops low-performing persons from identifying that they are committing errors.

Positive impact of using metacognitive techniques in mathematics teaching

However, the vast majority of the research as mentioned earlier show the benefits of using metacognition skills in teaching and learning mathematics. Critical thinking skills are crucial serve as basis for life skills that learners must develop, particularly for

enhancing reasoning, improving communication, and problem-solving encountered by students' daily lives. Critical thinking skills in learning of mathematics are founded on cognitive processes. Such skills are utilized for solving problems and influencing attitudes to mathematics (Paul, 2007 cited in Harjo, Kartowagiran & Mahmud, 2019). One of the main findings of the literature shows that the students' perception of the difficulty of mathematics and solving mathematical problems was because they neglected a wide range of thinking processes or metacognition (Cardelle-Elawar, 1992; Grizzle-Martin, 2014; Tok, 2013; Wolf, Brush, & Saye, 2003). This is in agreement with the findings concluded by Coles (2013) whose study proved that learners suffer from a lack of basic metacognitive skills. Several studies confirm that student performance in mathematics is positively influenced by the application of metacognitive strategies (Bernard & Bachu, 2015; Desoete, 2007; Gillies & Richard Bailey, 1995; Goos, 1993; Grant, 2014; Sahin & Kendir, 2013; Schoenfeld, 1987). Thus, metacognition, as a concept, plays a crucial role in learning processes, which ultimately impacts the academic performance of students in general and their mathematical performance in particular, as confirmed by several studies, including: Almeqdad, 2008; Grizzle-Martin, 2014; Panaoura & Philippou, 2005; and Schoenfeld, 1992. A study to analyze self-efficacy reinforcement and motivation of students in learning mathematics while adopting the cooperative learning model using the Teams Games Tournament type was conducted by In'am & Sutrisno (2021). In the light of the findings, the cooperative learning model with the Teams Games Tournament significantly enabled the self-efficacy and learning motivation. A correlation in positive direction observed between their self-efficacy and learners' motivation in mathematics learning suggests teachers in using the cooperative learning model. These studies, which indicate the importance of focusing on teaching according to the concept of metacognition, all recommended further research to study the impact of adopting these strategies on students' academic achievement.

In this context, students' inability to perform the required monitoring, control and regulating of their learning processes is an important factor behind their poor performance in mathematics, rather than being weakness in their knowledge or mathematical information (Grant, 2014; Tok, 2013; Yimer, 2004). Thus, the effectiveness of learners' problem-solving will be enhanced when they are capable of monitoring and controlling their learning processes. (Grant, 2014; Sahin & Kendir, 2013; Schoenfeld, 1987) Many other studies have also confirmed that students can be trained to improve their mathematical performance through metacognitive skills such as monitoring, control or regulation (Grant, 2014; La Barra et al., 1998; Sahin & Kendir, 2013). According to metacognition, teachers need to deliberately aim to enhance students' monitoring and control of their thinking processes so that they have self-directed skill in their performance. This has been confirmed by a series of studies, for instance Desoete, 2007, 2009; Grizzle-Martin, 2014; Raoofi, Chan, Mukundan, & Rashid, 2013; Schoenfeld, 1987.

It is also important for teachers themselves to first ensure that the concept of metacognition is reflected in their teaching methods so that they can enhance the skills of this concept among learners. Therefore, whenever teachers represent this theory in

themselves and with a real conviction that it is important in learning, it will help to bring about change in others, as Larkin (2000) stated. This confirms the need for good training for teachers. In their study, Sahin and Kendir (2013) confirmed that teachers would not be able to conduct this performance unless they are sufficiently trained in this field. In this context, a study by Coles (2013) indicated that there is a lack of studies concerned with the requirements of metacognition-based teaching that assists teachers with promoting such skills among the learners.

Based on these important introductions, utilizing metacognition in the teaching of mathematics and in the context of the reality of mathematics teaching and learning in Saudi Arabia, this study seeks to examine the impact of using a method based on the theory of metacognition on the achievement of preparatory year students at Taif University in Saudi Arabia, and to discover whether the theory of metacognition plays a positive role in learning mathematics. The study hopes to add scientific results to the research literature in the field of mathematics teaching, along with contributing to employing the theory of metacognition in the teaching of mathematics. Thus, educational stakeholders, through the findings of this study, can find information to support the adoption of this concept in teaching mathematics at all educational stages

There has been no study to assess the impact of using the IMPROVE seven-step instruction program (Introducing new concepts, Metacognitive questioning, Practicing, Reviewing and reducing difficulties, obtaining mastery, Verification, and Enrichment) in mathematics teaching to enhance the metacognitive skills of students in general at any level of education in Saudi Arabia, not even university students. Consequently, this study was conducted to achieve this aim with math students in the preparatory year at the University of Taif, Saudi Arabia at the first three levels of the Bloom's taxonomy (Knowledge, Comprehension, Application). Based on the many different dimensions regarding the nature of the relationship between metacognition and mathematics, and in light of the status quo of mathematics learning and teaching in Saudi Arabia, this important study stems its significance from its exploration of adopting the IMPROVE program in this context. The target audience or population of such a method is classes arranged into groups of four students, each comprising students with different abilities, learning in a cooperative self-discovery environment, rather than by the traditional (lecture) method. The study aimed to identify the effectiveness of the IMPROVE program in mathematics teaching on the achievement of students at Taif University in Saudi Arabia at the first three levels of the Bloom's taxonomy (Knowledge, Comprehension, Application). Thus, the study was concerned with testing the following hypotheses:

1. There are no statistically significant differences at the level of (0.05) in the means of scores in mathematics achievement of students of the preliminary year between the experimental group, which studied using the IMPROVE program, and the control group, which studied in the traditional way, in the post-testing of overall achievement test.
2. There are no statistically significant differences at the level of (0.05) in the means of scores in mathematics achievement of students of the preliminary year between the

experimental group, which studied using the IMPROVE program, and the control group, which studied in the traditional way, at the level of knowledge.

3. There are no statistically significant differences at the level of (0.05) in the means of scores in mathematics achievement of students of the preliminary year between the experimental group, which studied using the IMPROVE program, and the control group, which studied in the traditional way, at the level of comprehension.

4. There are no statistically significant differences at the level of (0.05) in the means of scores in mathematics achievement of students of the preliminary year between the experimental group, which studied using the IMPROVE program, and the control group, which studied in the traditional way, at the application level.

METHOD

The researcher employed the experimental design. Two groups were formed: experimental and control. Experimental group learned in a cooperative self-discovery environment where as control was taught in a traditional way for a month in the 1st semester of the year 2018/2019. Measures were taken to ensure the experimental and control groups were identical in nature and with regard to their academic background before introducing intervention. At the end of the study, an achievement test composed of objective multiple-choice questions was conducted to test the research hypothesis and find if there was any relation found between IMPROVE program and achievements of preliminary students.

Sampling

The study population was restricted to students in the preliminary year at Taif University, KSA. I employed an intentional strategy to choose two groups, the experimental group and the control group which might be a more suitable environment to fulfil the following requirement criteria: the number of students in the class should not exceed 30 students, and teacher found who was cooperative and enthusiastic to implement the idea of metacognitive teaching. In addition, there should be a pre-existing practice of cooperative mathematics learning among students and teacher. Considering these criteria to find a suitable environment might help me to focus on the main subject of the study, particularly the IMPROVE programme based on cooperative learning. All the participating students were Males and they were 18 years old and lived in the same area of the city.

Instrument and procedures for teaching the experimental group

An achievement test composed of objective multiple-choice questions was the instrument employed in this study. The test aimed to cover the three cognitive levels of the Bloom's taxonomy, (knowledge, comprehension and application). The module vocabulary was used to compose the test items.

Construction of the achievement test

The researcher prepared a test that measures the students' achievement in the unit assigned to the preparatory year students at the university. The researcher followed the following steps

1. Determining the objective of the test: The researcher intended to measure the achievement of the preparatory year students, including the cognitive aspects of the study unit for the experimental and control groups, to compare between them and to identify the significance of the differences in achievement between the two groups.
2. Determining the learning outcomes of the subjects.
3. Analysis of the content of mathematical topics and the stability and validity of the analysis were confirmed.
4. Determining the importance and relative weight of the test items according to the steps followed in that, which are:
 - a. Determine the number of pages for each topic of the unit.
 - b. The number of lessons allocated for teaching each of these topics
 - c. Determine the number of learning outcomes for each lesson of the unit.
5. Preparation of the test specifications table based on the table of importance and the relative weight of the course subjects so that the percentage of the number of questions in any lesson of the course is proportional to the average percentage corresponding to that topic in the table of importance and relative weight, and the researcher determined (25 a question) to measured learning outcomes based on the test specification table.
 - a. Determining the subjects of the study in which the student's achievement is to be measured.
 - b. Determine the number of lessons needed to teach each subject.
 - c. Determining the relative weight of the subjects of the study, and this can be created from the following equation.
 - d. The relative weight of the topic's importance = $\frac{\text{the number of lessons needed to teach the topic}}{\text{The number of lessons needed to teach the subject}} \times 100$
 - e. Determining the relative weight of the learning outcomes at their three different levels, the following equation can be used:
 - f. Relative weight of learning outcomes at a certain level = $\frac{\text{Number of learning outcomes at that level}}{\text{The sum of all learning outcomes}} \times 100$
 - g. Determining the total number of test questions in light of the time available to answer, the type of questions, the age of the student, and other influential variables.

- h. Determining the number of questions in each topic for each level of objectives, and it is possible to benefit from the equation: the number of topic questions = the total number of questions x the relative weight of the topic's importance x the relative weight of the topic's learning outcomes.

6. Formulation of test items: Based on the test specification table, the researcher formulated the test items, which amounted to 25 items, in a multiple-choice method. The test was distributed to the lowest levels of cognitive goals for each subject, namely knowledge (remembering), understanding and application. The percentage of the number of knowledge questions for the total questions represents 20%, the percentage of the comprehension questions for the total questions represents 48%, and finally, the percentage of the application questions for the total questions represents 32%.

Research procedure

At the beginning of each session, the teacher presented the class with a brief 10-minute overview of the new concepts through a question-answer approach. After this introduction, students started working in small teams. Utilizing and building upon the material presented to them, students worked on asking and answering three metacognitive questions: a) Comprehension question: what is the problem at hand? b) Connection question: what similarities and differences can one notice between the current problem and previous problems? c) Strategic question: what is the appropriate strategy to solve the current problem? When students did not agree with one another, they were encouraged to continue discussions until a consensus was reached. As the problem was being discussed and conceptualized, it was tackled from different standpoints, perspectives were compared to one another, and the best choice deemed - at that time - was used to find an answer. Unknowingly, students benefited from the heterogeneity in their previous knowledge levels and this constituted a driving factor in self-regulating their learning. When all team members reached a solution, they wrote it down on their answer sheets. Students' answers included the final solution as well as explanations and metacognitive questions such as: this problem is about ..., the difference between this problem and a previous problem is....., the best mathematical strategy for solving this problem is.....etc. At the end of class, the teacher explained how metacognitive questions can be used to solve problems and explained each step needed to reach the solution.

Data Analysis

The researcher used SPSS (version 21) in order to find correlation coefficients in order to check the validity and reliability of the test and to test the hypothesis, the researcher calculated (t) value to compare the means of scores between the two groups: experimental and control.

Validity and reliability of the Test

To ensure the external validity of the test, it was reviewed by a group of jury members in order to judge it in terms of the following: Clearness of test instructions, Appropriateness of its linguistic integrity, Suitability of items for measuring

mathematical achievement and addition, deletion, or modification according to the judgment of jury members. The researcher made the appropriate modifications taking into consideration the judgment of jury members. Hence, the achievement test is valid regarding content. To ensure the internal validity of the achievement test: The achievement test was administered to a pilot study, and the internal validity was confirmed by calculating the coefficient of correlation between the dimensions to the total degree of the achievement test obtained from the sample. The researcher used SPSS (version 21) in order to find correlation coefficients, and the results came as the following:

Table 1

The correlation matrix between the dimensions of the achievement test to the total score of the achievement test

Dimension	Total factor correlation coefficient
Knowledge	0.63**
Comprehension	0.87**
Application	0.82**

The sign (**) indicates that the dimension is significant at 0.01

It is clear from the previous table that the coefficients of internal validity of the test dimensions to the total score of the achievement test ranged from (0.92) to (0.97). All of which are statistically significant correlation coefficients at 0.01, which are acceptable, indicating that the achievement test can be viewed in terms of its dimensions as a total unit with the ability to deal with its overall degree. That is, the achievement test is characterized by good internal validity.

To ensure the external reliability of the test, the achievement test was administered in a pilot study to a random sample of students. The researcher used the Kuder-Richardson Coefficient 21 (KR21) to test the reliability of the test. The following table shows the results (where the final score of the test is 25):

Table 2

Achievement test reliability factor

Final test score (N)	Means of scores (M)	Standard deviation (S)	Grade variation (P2)	Stability factor (R1.1)
25	16.19	4.21	17.72	0.92

By applying the previous formula to the test results, the test reliability factor was found to be (0.71), which indicates that the test is stable and could be administered to the study sample. Moreover, the reliability factor obtained in this way gives the minimum degree of the reliability factor. Thus, the minimum degree of the reliability factor is (0.71), which means that the test is stable, valid and reliable.

Equivalence between the experimental group and the control group in the pre administration of the achievement test:

Table 3

(t) Value and statistical significance of the difference between the means of scores of the experimental group and the control group in the pre administration of the achievement test

Dimension	Group	Number	Mean	Standard deviation	(t) Value	Significance
Knowledge	Experimental	32	1.28	1.11	0.76	Non significant
	Control	32	1.09	0.86		
Comprehension	Experimental	32	2.78	1.43	0.54	Non significant
	Control	32	2.56	1.81		
Application	Experimental	32	1.72	1.35	0.92	Non significant
	Control	32	1.44	1.08		
Total	Experimental	32	5.78	2.50	1.10	Non significant
	Control	32	5.09	2.52		

It is clear from the previous table that the calculated (t) value is lower than the tabulated (t) value at each level of the dimensions and the total sum. This indicates that there is no statistically significant difference between the means of scores of the experimental group and the control group in the pre administration of the achievement test at each level of the dimensions and the total sum, confirming the equivalence of the two groups.

FINDINGS

First: Testing the first hypothesis

The hypothesis states that there are no statistically significant differences at the level of (0.05) in the means of scores in the mathematics achievement of students of the preliminary year between the experimental group, which studied using the IMPROVE program, and the control group, which studied in the traditional way, in the post-testing of the overall achievement test. In order to test the hypothesis, the researcher calculated (t) value to compare the means of scores between the two groups in the post-testing of the overall achievement test, and the result was as follows:

Table 4

(t) Value and its statistical difference of the means of scores between the experimental and control groups in the post-testing of overall achievement test

Statistical data Group	Number (N)	Mean (M)	Standard deviation (S)	Df.	tabulated (t) value		Calculate (t) value	Sig.	Effect size (η^2)
					0.05	0.01			
Experimental	32	19.31	2.66	62	2.00	2.66	8.89	0.01	0.56
Control	32	13.06	2.96						

The table above illustrates that the calculated (t) value is (8.89), while the tabulated (t) value is (2.00) at the level of (0.05), and equals (2.66) at the level of (0.01) with (62) degrees of freedom. Hence, the effect size is also shown to be large as it is greater than (0.14) and equals (0.56). From the above, it is clear that the calculated (t) value is greater than the tabulated (t) value, which indicates a statistically significant difference in favor of the experimental group. Thus, the first hypothesis was rejected and the

alternative hypothesis was accepted, which states: ‘There are statistically significant differences at the level of (0.05) in the means of scores in mathematics achievements of students of the preliminary year between the experimental group, which studied using the IMPROVE program, and the control group, which studied in the traditional way in the post-testing of the overall achievement test, in favor of the experimental group.

Second: Testing the second hypothesis

The hypothesis states that there are no statistically significant differences at the level of (0.05) in the means of scores in the mathematics achievements of students of the preliminary year between the experimental group, which studied using the IMPROVE program, and the control group, which studied in the traditional way, at the level of knowledge. To test the hypothesis, the researcher calculated (t) value to compare the means of scores between the two groups in the post-testing of the achievement test at the level of knowledge and the result was as follows:

Table 5

(t) Value and its statistical difference of the means of scores between the experimental and control groups in the post-testing of the achievement test at the level of knowledge

Statistical data Group	Number (N)	Mean (M)	Standard deviation (S)	Df.	tabulated (t) value		Calculate (t) value	Sig.	Effect size (η^2)
					0.05	0.01			
Experimental	32	3.97	0.86	62	2.00	2.66	4.32	0.01	0.23
Control	32	2.84	1.19						

From the table above, it is clear that the calculated (t) value is (4.32), while the tabulated (t) value is (2.00) at the level of (0.05), and equals (2.66) at the level of (0.01) with (62) degrees of freedom. Hence, the effect size is also shown to be large, as it is greater than (0.14) and equals (0.23). Results state that the calculated (t) value is greater than the tabulated (t) value, which indicates a statistically significant difference in favor of the experimental group. Thus, the second hypothesis was rejected and the alternative hypothesis was accepted, which states: ‘There are statistically significant differences at the level of (0.05) in the means of scores in mathematics achievements of students of the preliminary year between the experimental group, which studied using the IMPROVE program, and the control group, which studied in the traditional way, in the post-testing of the achievement test at the knowledge level in favor of the experimental group.

Third: Testing the third hypothesis

The third hypothesis states that there are no statistically significant differences at the level of (0.05) in the means of scores in mathematics achievement of students of the preliminary year between the experimental group, which studied using the IMPROVE program, and the control group, which studied in the traditional way, at the level of comprehension. For testing the hypothesis, the researcher calculated (t) value to compare the means of scores between the two groups in the post-testing of the achievement test at the level of comprehension and the result was as follows:

Table 6

(t) Value and its statistical difference of the means of scores between the experimental and control groups in the post-testing of the achievement test at the level of comprehension

Statistical data Group	Number (N)	Mean (M)	Standard deviation (S)	Df.	tabulated value	(t) value	Calculate (t) value	Sig.	Effect size (η^2)
Experimental	32	8.69	1.75	62	2.00	2.66	5.83	0.01	0.35
Control	32	5.94	2.02						

Results in the table above yield the calculated (t) value with (5.83), while the tabulated (t) value is (2.00) at the level of (0.05), and equals (2.66) at the level of (0.01) with (62) degrees of freedom. Hence, the effect size is also shown to be large, as it is greater than (0.14) and equals (0.35). From the above, it is clear that the calculated (t) value is greater than the tabulated (t) value, which indicates a statistically significant difference in favor of the experimental group. Thus, the third hypothesis was rejected and the alternative hypothesis was accepted, which states: 'There are statistically significant differences at the level of (0.05) in the means of scores in mathematics achievement of students of the preliminary year between the experimental group, which studied using IMPROVE program, and the control group, which studied in the traditional way in the post testing of the achievement test at the comprehension level in favor of the experimental group.

Fourth: Testing the fourth hypothesis

This hypothesis states that there are no statistically significant differences at the level of (0.05) in the means of scores in mathematics achievements of students of the preliminary year between the experimental group, which studied using IMPROVE program, and the control group, which studied in the traditional way, at the level of application. To test the hypothesis, the researcher calculated (t) value to compare the means of scores between the two groups in the post testing of the achievement test at the level of application, and the result was as follows:

Table 7

(t) Value and its statistical difference of the means of scores between the experimental and control groups in the post-testing of the achievement test at the level of application

Statistical data Group	Number (N)	Mean (M)	Standard deviation (S)	Df.	tabulated value	(t) value	Calculate (t) value	Sig.	Effect size (η^2)
Experimental	32	6.66	1.15	62	2.00	2.66	7.28	0.01	0.46
Control	32	4.28	1.44						

From the above table, it is clear that the calculated (t) value is (7.28), while the tabulated (t) value is (2.00) at the level of (0.05), and equals (2.66) at the level of (0.01) with (62) degrees of freedom. Hence, the effect size is also shown to be large as it is greater than (0.14) and equals (0.46). Results confirm that the calculated (t) value is greater than the tabulated (t) value, which indicates a statistically significant difference in favor of the

experimental group. Hence, the fourth hypothesis was rejected, and the alternative hypothesis was accepted, and it states: ‘There are statistically significant differences at the level of (0.05) in the means of scores in mathematics achievement of students of the preliminary year between the experimental group, which studied using IMPROVE program, and the control group, which studied in the traditional way in the post testing of the achievement test at the application level in favor of the experimental group.

DISCUSSION

Based on the Results, it was found that the following hypothesis was refuted: ‘There are no statistically significant differences at the level of (0.05) in the means of scores in mathematics achievement of students of the preliminary year between the experimental group, which studied using the IMPROVE program, and the control group, which studied in the traditional way, at the level of (knowledge, comprehension and application). Regarding the previously mentioned hypotheses, the results showed that there are statistically significant differences in favor of the experimental group for both the levels of knowledge, comprehension and application. The findings prove the efficacy of teaching mathematics based on metacognition. The findings agree with the literature of Giladi (2009), Ismail (2014), Gidalevich and Kramarski (2019), Shilo and Kramarski (2019). The main objective of the current study was to explore the efficacy of practicing the concept of metacognition in the teaching and learning of mathematics. For this objective, the IMPROVE program was chosen and conducted. Therefore, there was a difference between traditional teaching and teaching based on metacognition. This would be tackled and addressed through reviewing the past studies. The theory of metacognition-based teaching made contributions to developing the students' mathematical concepts by creating links between them and other mathematical concepts. It is important to make mathematical comparisons that assist with making the learner able to reflect and observe the mechanisms they adopt while addressing mathematical problems. Results from Artzt and Armour-Thomas's (1992) study agree with this as it links the learner's weakness in addressing the mathematical problem with lacking the skills of monitoring and controlling. Furthermore, the theory of metacognition-based teaching improves the skills of the learner's monitoring and control, and style of thinking when tackling these mistakes, instead of reviewing the learner's errors where the learner becomes disinterested in improving metacognitive skills. Artzt and Armour-Thomas's (1998) study affirmed that there was a shortage in the skills of monitoring and controlling skills in the educational setting. Similarly, Truelove (2013) concluded that during the process of handling mathematical problems, that there was a lack of focus on employing metacognitive skills during the phases of the problem-solving process. Added to this, Schudmak's (2014) study illustrates that improving metacognitive skills when addressing mathematical problems during students' everyday study did not cause any concern. Therefore, students are willing to follow the shortest cut to find the solution to the problem without giving heed to comprehending the mechanism to solve the problems, as stated by the Sahin and Kendir's (2013) study.

Theory of Metacognition-based teaching focuses on helping the students address and employ different and various ways when discussing or handling mathematical problems.

This is to develop the skills of monitoring and controlling, along with the student's mechanism of thinking. Schoenfeld (1985) highlighted four areas of knowledge and practices that take place when handling mathematical problems: mathematical awareness, the approach to handle a mathematical problem, observe or control the way of thinking, and eventually the conceptualization of the trend. Therefore, it can be stated that the traditional method of teaching focuses only on the first two areas; it does not give any attention to the weaknesses of learners. Schoenfeld (1985) points out that a student can enjoy a mathematical awareness but be unable to utilize it because they lack monitoring and control skills with respect to their way of thinking about mathematical problems. Adopting the traditional way in teaching mathematics can make the teacher's role an obstacle to the learning and teaching process when dealing with metacognition. This agrees with the Larkin's (2006) and Hurme, Järvelä, Merenluoto, and Salonen (2015) studies, which conclude that learners were not given opportunities to work collaboratively to enhance metacognitive skills while receiving their lessons in the traditional way. Thus, the teacher-learner's relationship was characterized by being non-participatory and not having a structural trait. On the other hand, it just places focus on checking mistakes as a dominant method. Therefore, the teacher's role was found to be central. As for the learning process, it just focused on conveying information, which led to the hindrance of metacognition-based teaching.

IMPROVE is the acronym that represents all the steps that comprise this instructional method: Introducing new concepts, Metacognitive self-directed questioning, Practicing, Reviewing and reducing difficulties, Obtaining mastery, Verification, and Enrichment. While implementing IMPROVE in mathematics, there seemed to be an overlap between teaching mathematics and the steps of IMPROVE. This might be due to certain steps that students use while solving mathematical problems such as using metacognitive questions. Furthermore, overlap might arise as teachers try to help students achieve metacognitive learning, such as reducing difficulties and introducing new concepts. Metacognitive questions can be used to comprehend the problem, find connection problems and solution strategies. These questions represent some of the most important discussion topics that must take place between team members. By capitalizing on such questions, students across variable academic levels can grasp advanced mathematical concepts by elucidating initial thoughts needed to deal with advanced mathematics. It is crucial that students engage in metacognitive self-directed learning in a clear manner while implementing IMPROVE. Meanwhile, to identify and reduce difficulties, the teacher can survey obstacles that student teams faced while dealing with mathematical problems. This is followed by a discussion of different factors that might help resolve such obstacles. This emphasizes the importance of establishing the role that teachers play in reducing difficulties.

This study puts forth the steps needed by teachers to implement the IMPROVE programme in the Saudi educational system. To start, the teacher introduces the students with new mathematical concepts. As the teacher supervises student teamwork, he/she should note difficulties faced by students in dealing with mathematics problems. This is important so that these difficulties be discussed later with the students to help them overcome them. Afterwards, conducting corrective evaluation can help students' thought

processes when dealing with mathematic problems. This study also presents steps for implementing student teamwork, including metacognitive questions that will be used by the teams to understand, link and categorize problems. Furthermore, students' finding a strategy to solve the problem and justifying each step are the steps to discovering a strategy to solve and confirming the validity of the solution. Students will then compare strategies and solutions with others to find areas of similarities and differences.

CONCLUSION

The current study stresses the significance and efficacy of teaching mathematics based on metacognition, when contrasted with the traditional method, with respect to knowledge, comprehension and application levels of Bloom's taxonomy. Therefore, it provides the following set of and implications. First, Adoption of the metacognition strategy in teaching mathematics in the various educational stages and grades that have not been addressed by previous research endeavors. Second, Training programs to be conducted for mathematics teachers with the aim of adopting teaching methods based on metacognition, to enhance control skills and follow up the mechanisms the learner use while handling mathematical problems. Third, Educational programs taught at universities and other colleges to be improved, in order to make metacognition an integral part of teaching mathematics so as to actively and effectively contribute to developing the adoption of metacognition in educational settings. Forth, Expand the university's awareness of the metacognition theory and its importance to empower learners' thinking methodology to address mathematical problems.

REFERENCES

- Alghamdi, F. (2012). The effectiveness of teaching, according to the Social Constructive Theory, on developing some learning processes, the metacognitive thinking skills as well as achievement of the second grade- secondary stage female students in Biology in Al-Baha District (Ph.D), Princess Noura Bint Abdul Rahman University Riyadh.
- Al-Maimooni, M. (2016). A one trillion-riyal non-oil revenue approaching: Deputy crown prince reveals 13 national initiatives for Kingdom's future Vision 2030. *Al-Yaum Newspaper*. Retrieved from <http://www.alyaum.com/article/4133366>
- Almeqdad, Q. I. (2008). Self-explanation and explanation in children with learning difficulties. University of Cambridge.
- Alzahrani, A. (2017). Markets and language policy in Saudi Arabia: how the English language can contribute to the success of the Saudi vision 2030. *International Journal of English Language and Linguistics Research*, 5(6), 1-12.
- Artz, A. F., & Armour-Thomas, E. (1992). Development of a cognitive-metacognitive framework for protocol analysis of mathematical problem solving in small groups. *Cognition and instruction*, 9(2), 137-175.
- Artzt, A. F., & Armour-Thomas, E. (1998). Mathematics teaching as problem solving: A framework for studying teacher metacognition underlying instructional practice in mathematics. *Instructional Science*, 26(1-2), 5-25.

- Azevedo, R., & Aleven, V. (2013). Metacognition and learning technologies: An overview of current interdisciplinary research. *International handbook of metacognition and learning technologies*, 1-16.
- Berlin, Heidelberg.Kramarski, B., & Mevarech, Z. R. (2003). Enhancing mathematical reasoning in the classroom: The effects of cooperative learning and metacognitive training. *American Educational Research Journal*, 40(1), 281-310.
- Brown, A. (1987). Metacognition, Executive Control, Self Regulation and Mysterious Mechanisms. In R. K. Franz E. Weinert (Ed.), *Metacognition, Motivation and Understanding* (3 ed., pp. 65-117). The University of Michigan: L. Erlbaum Associates.
- Buratti, S., & Allwood, C. M. (2015). Regulating metacognitive processes—support for a meta-metacognitive ability. In *Metacognition: Fundamentals, applications, and trends* (pp. 17-38). Springer, Cham.
- Cardelle-Elawar, M. (1992). Effects of teaching metacognitive skills to students with low mathematics ability. *Teaching and Teacher Education*, 8(2), 109-121.
- Cetin, I., Sendurur, E., & Sendurur, P. (2014). Assessing the impact of meta-cognitive training on students' understanding of introductory programming concepts. *Journal of Educational Computing Research*, 50(4), 507-524.
- Chin, J. M., & Schooler, J. W. (2008). Why do words hurt? Content, process, and criterion shift accounts of verbal overshadowing. *European Journal of Cognitive Psychology*, 20(3), 396-413.
- Coles, A. (2013). *Being alongside: for the teaching and learning of mathematics*: Springer Science & Business Media.
- Desoete, A. (2007). Evaluating and improving the mathematics teaching-learning process through metacognition. *Electronic Journal of Research in Educational Psychology*, 5(3), 705-730.
- Di Nucci, E. (2014). *Mindlessness*. Cambridge Scholars Publishing.
- Dunning, D. (1999). A newer look: Motivated social cognition and the schematic representation of social concepts. *Psychological Inquiry*, 10(1), 1-11.
- Dunning, D. (2011). The Dunning–Kruger effect: On being ignorant of one's own ignorance. In *Advances in experimental social psychology* (Vol. 44, pp. 247-296). Academic Press.
- Flavell, J. H. (1976). Metacognitive aspects of problem solving. *The nature of intelligence*, 12, 231-235.
- Flavell, J. H. (1979). Metacognition and cognitive monitoring. *American Psychologist*, 34(10), 906-911.
- Gidalevich, S., & Kramarski, B. (2019). The value of fixed versus faded self-regulatory scaffolds on fourth graders' mathematical problem solving. *Instructional Science*, 47(1), 39-68.

- Gillies, R. W., & Richard Bailey, M. (1995). The effects of Metacognitive Strategy and Attributional Interventions on the ability of students' to solve mathematical word problems. Paper presented at the AARE Conference, Hobart, Tasmania.
- Goos, M. (1993). Metacognitive decisions and their influence on problem solving outcomes. Paper presented at the The Sixteenth Annual Conference of the Mathematics Education Research Group of Australasia (MERGA), Brisbane.
- Grant, G. (2014). *A metacognitive-based tutoring program to improve mathematical abilities of rural high school students: An action research study* (Doctoral dissertation, Capella University).
- Grizzle-Martin, T. (2014). *The effect of cognitive-and metacognitive-based instruction on problem solving by elementary students with mathematical learning difficulties* (Doctoral dissertation, Walden University).
- Harjo, B., Kartowagiran, B., & Mahmudi, A. (2019). Development of Critical Thinking Skill Instruments on Mathematical Learning High School. *International Journal of Instruction*, 12(4), 149-166
- Hurme, T. R., Järvelä, S., Merenluoto, K., & Salonen, P. (2015). What Makes Metacognition as Socially Shared in Mathematical Problem Solving?. In *Metacognition: Fundamentals, applications, and trends* (pp. 259-276). Springer, C
- ham.In'am, A., & Sutrisno, E. S. (2021). Strengthening Students' Self-Efficacy and Motivation in Learning Mathematics through the Cooperative Learning Model. *International Journal of Instruction*, 14(1), 395-410.
- Ismail, N. M. (2014). Effectiveness of a Metacognitive Reading Strategies Program for Improving Low Achieving EFL Readers. *International Education Studies*, 8(1), p71.
- Kluwe, R. H. (1982). Cognitive knowledge and executive control: Metacognition. In *Animal mind—human mind* (pp. 201-224). Springer,
- Kramarski, B., & Michalsky, T. (2013). Student and teacher perspectives on IMPROVE self-regulation prompts in web-based learning *International handbook of metacognition and learning technologies* (pp. 35-51): Springer.
- Kuku, A. O. (2012). *Mathematics as a time-tested resource for scientific, technological, socioeconomic and intellectual development*. Distinguished Mathematics Lecture delivered at the University of Ibadan. Ibadan: Ibadan University Pres
- De La Barra, M. L., De La Barra, G. L., Urbina, A. M., & De La Barra, B. L. (1998, November). Towards a global improvement of Engineering Maths Teaching. In *FIE'98. 28th Annual Frontiers in Education Conference. Moving from 'Teacher-Centered' to 'Learner-Centered' Education. Conference Proceedings (Cat. No. 98CH36214)* (Vol. 3, pp. 1327-1331). IEEE.
- Langer, E. J. (1992). Matters of mind: Mindfulness/mindlessness in perspective. *Consciousness and cognition*, 1(3), 289-305.

- Neal, D. T., Wood, W., Wu, M., & Kurlander, D. (2011). The pull of the past: When do habits persist despite conflict with motives?. *Personality and Social Psychology Bulletin*, 37(11), 1428-1437.
- Larkin, S. (2000). How can we discern metacognition in year one children from interactions between students and teacher. Paper presented at the ESRC Teaching and Learning Research Programme Conference.
- Larkin, S. (2006). Collaborative group work and individual development of metacognition in the early years. *Research in Science Education*, 36(1-2), 7-27.
- Merriam, S. B. (1998). *Qualitative Research and Case Study Applications in Education: Revised and Expanded from Case Study Research in Education*. San Francisco: Jossey Bass Wiley.
- Mevarech, Z., & Fridkin, S. (2006). The effects of IMPROVE on mathematical knowledge, mathematical reasoning and meta-cognition. *Metacognition and Learning*, 1(1), 85-97.
- Mevarech, Z., & Kramarski, B. (1997). IMPROVE: A multidimensional method for teaching mathematics in heterogeneous classrooms. *American Educational Research Journal*, 34(2), 365-394.
- Mevarech, Z. R. (1999). Effects of metacognitive training embedded in cooperative settings on mathematical problem solving. *The Journal of Educational Research*, 92(4), 195-205.
- Mevarech, Z. R., & Amrany, C. (2008). Immediate and delayed effects of meta-cognitive instruction on regulation of cognition and mathematics achievement. *Metacognition and Learning*, 3(2), 147-157.
- Mokhtari, K., & Reichard, C. A. (2002). Assessing students' metacognitive awareness of reading strategies. *Journal of Educational Psychology*, 94(2), 249-259.
- Panaoura, A., & Philippou, G. (2005). The measurement of young pupils' metacognitive ability in mathematics: The case of self-representation and self-evaluation. Paper presented at the Proceedings of CERME.
- Raofi, S., Chan, S. H., Mukundan, J., & Rashid, S. M. (2013). Metacognition and Second/Foreign Language Learning. *English Language Teaching*, 7(1), p36.
- Sahin, S. M., & Kendir, F. (2013). The effect of using metacognitive strategies for solving geometry problems on students' achievement and attitude. *Educational Research and Reviews*, 8(19), 1777-1792.
- Schoenfeld, A. H. (1985). *Mathematical problem solving*: New York: Academic Press.
- Schoenfeld, A. H. (1987). What's All the Fuss About Metacognition. In A. H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (Vol. 189-215). Hillsdale, NJ: Lawrence Erlbaum Associates.

- Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. *Handbook of research on mathematics teaching and learning*, 334-370.
- Schraw, G., & Gutierrez, A. P. (2015). Metacognitive strategy instruction that highlights the role of monitoring and control processes. In *Metacognition: Fundamentals, applications, and trends* (pp. 3-16). Springer, Cham.
- Schudmak, W. (2014). *Metacognitive strategies employed during mathematical problem solving: a comparative case study of fifth graders who are gifted and have ADHD* (Doctoral dissertation, George Mason University).
- Schooler, C., Neumann, E., Caplan, L. J., & Roberts, B. R. (1997). Stroop theory, memory, and prefrontal cortical functioning: Reply to Cohen et al. (1997).
- Shilo, A., & Kramarski, B. (2019). Mathematical-metacognitive discourse: how can it be developed among teachers and their students? Empirical evidence from a videotaped lesson and two case studies. *ZDM*, 51(4), 625-640.
- Tobias, S., & Everson, H. T. (1996). Assessing metacognitive knowledge monitoring. In G. S. and J. C. Impara (Eds.), *Issues in the measurement of metacognition* (pp. 147-222). Lincoln NE: Buros Institute of Mental Measurements.
- Tok, Ş. (2013). Effects of the know-want-learn strategy on students' mathematics achievement, anxiety and metacognitive skills. *Metacognition and Learning*, 8(2), 193-212.
- Truelove, H. (2013). *Examining Evidence of Metacognition by Preservice Secondary Mathematics Teachers While Solving Tasks Situated in the Secondary Curriculum*. (Ph.D), The University of Alabama Tuscaloosa.
- Ukeje, B. O. (2002). Production and retention of mathematical sciences teachers for Nigerian educational system. 2005), *Reflective and Intellectual Position papers on mathematics Education Issues*, 80-102.
- Wolf, S. E., Brush, T., & Saye, J. (2003). Using an information problem-solving model as a metacognitive scaffold for multimedia-supported information-based problems. *Journal of Research on Technology in Education*, 35(3), 321-341.
- Yamada, A. (2009). Appreciating art verbally: Verbalization can make a work of art be both undeservedly loved and unjustly maligned. *Journal of Experimental Social Psychology*, 45(5), 1140-1143.
- Yimer, A. (2004). *Metacognitive and cognitive functioning of college students during mathematical problem solving*. Illinois State University.