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SWOM strategy and influence of its using on developing mathematical thinking skills and on metacognitive thinking among gifted tenth-grade students

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Abstract

Education is important for the advancement of peoples and countries, so it is necessary to take care of the learners by providing them with the skills and experience to face problems systematically based on sound thinking, by following appropriate teaching strategies. Therefore, this study aimed to use the school wide optimum mode (SWOM) strategy to reveal its effect on meta-cognitive thinking, and the effect of its employment in developing the mathematical thinking skills of gifted tenth-grade students. The analytical descriptive approach and the experimental approach were used. 84 gifted male and female students from the tenth grade were randomly selected. The data were analyzed using SPSS and evaluated according to the Rasch model. The study results showed that there were statistically significant differences between the average level of metacognitive thinking among gifted students who learned using SWOM strategy, and the average level of metacognitive thinking among students who learned traditionally, in favor of the students who learned using SWOM strategy. The results of the study also showed that there were statistically significant differences between the average scores of gifted students who learned using SWOM strategy, and the average scores of gifted students who learned traditionally in a mathematical thinking skills test, in favor of the students who learned using SWOM strategy.

Keywords: gifted students, mathematical thinking, SWOM strategy, metacognitive thinking

INTRODUCTION

The present time is characterized by rapid changes and enormous developments in the field of scientific knowledge, so that all areas of education must be developed. Scientific and technological progress in curricula and teaching methods has a significant impact on the educational learning process and the development of pedagogical thinking. Therefore, many goals of education need to be rethought. Education is no longer just the acquisition of information, but has a comprehensive function, helping the learner overcome his weaknesses, forming his personality in all aspects and developing his knowledge and skills (Alneyadi et al., 2023; Jarrah et al., 2022)

This development forced educators to bring the learning process to a level that would allow the student to face these developments, develop self-confidence, positively change his behavior and use his latent abilities (mental and motor) in the implementation of the learning process (Ashour & Subaihawi, 2013). Therefore, efforts must be made to help students gain a deeper understanding of the cognitive domain, exercise creative productivity, develop self-concept, raise achievement levels, develop attitudes toward learning, and develop teaching strategies and methods. As a result, teaching strategies and methods have been developed to integrate thinking skills into the curriculum and to make the student think about the teaching material provided to him (Saieed & Hussain, 2010; Tashtoush et al., 2022).

Modern education confirms that education of good quality must teach all the different life skills, such as thinking skills, because thinking is of great importance in the life of the learner, and because it simplifies things

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Contribution to the literature

- In this study, mathematical thinking is a pattern of thinking that the brain uses to mentally solve mathematical problems, and it is defined by the following five skills: induction, deduction, mathematical proof, logical thinking, and generalization.
- This study aimed to use the SWOM strategy to reveal its effect on meta-cognitive thinking, and the effect of its employment in developing the mathematical thinking skills of gifted tenth-grade students.
- The SWOM strategy should be used in teaching mathematics at different educational stages. Holding training courses and workshops for mathematics teachers on how to use the SWOM strategy in developing meta-cognitive thinking and mathematical thinking skills.

and situations by organizing them (Al-Atoum & Al-Jarrah, 2017; Hamad et al., 2022; Wardat et al., 2022).

Perhaps the most important point to consider in teaching thinking skills in curricula is the need to educate and train students to think well, exercise critical judgment, and think creatively. They also need to be trained to gather, evaluate, and use the information to solve problems and make effective decisions in their work and lives. Teaching thinking skills in school curricula has become a necessity as every student can positively develop their thinking skills (Ashour & Subaihawi, 2013; Gningue et al., 2022).

Many studies have confirmed that the reason for students' poor achievement and thinking is due to the reluctance of most male and female teachers to follow modern teaching methods, which in turn help in raising students' achievement and increasing their thinking (Aloufi et al., 2021; Msaed et al., 2022)

The educational process has developed greatly in the past few years, through the development of many teaching methods and strategies used to achieve the desired goals of teaching and help both the teacher and the student in the educational process as a whole towards a better education. Perhaps the most important of these things is to make the learners the focus of the educational process, to stimulate their thinking and draw conclusions, to actively participate in the completion of their lessons, to stimulate their talents, and to enhance their abilities to innovate in order to benefit from these strategies in the growth of their knowledge, skills and emotional fields (Mohamed, 2017).

Where modern teaching strategies came as a reaction to the negative role that the student was playing in the educational process, so they became in the form of discussions, asking questions, planning a project, raising a problem, preparing a specific situation that calls the student to think and question, trying to discover, imposing hypotheses, comparing, deciding, ..., etc. It is a directed process aimed at organizing and balancing the various factors that enter into the educational process, such as the nature of the student, teaching materials, and the educational situation (Al-Hashemi & Al-Dulaimi, 2008).

Paying attention to modern teaching methods that consider the growth, needs, inclinations, and abilities of learners can contribute to the development of the educational learning process, the mental, physical, spiritual, social, and moral development of learners, and prepare and qualify them for the role expected of them in the future.

The teacher's use of the appropriate teaching method helps him to convey the knowledge, information, and skills contained in the academic content, and translate it in a way that ensures the learner's interaction with the course. In addition, following the appropriate method of teaching helps both the teacher and the learner achieve educational outcomes easily and smoothly (Al-Samarrai, 2017).

The teacher must become acquainted with the different teaching methods, including SWOM strategy, which is an acronym for school wide optimum mode. It is considered one of the strategies that represent the direction of teaching thinking through the school curriculum, focuses on higher-level thinking skills based on integrating thinking skills with academic content, and aims to improve learning and develop the thinking skills of learners (Hussein et al., 2022; Jasim, 2020).

SWOM strategy is one of the metacognitive strategies that focus on using activities and teaching both creative and critical thinking skills to all students. It also aims to create pedagogical effectiveness and make learners thinkers and critics (Dahesh et al., 2022). Teaching strategies that are in line with the skills and abilities that are dependent on student engagement in the learning process (Hussein et al., 2022).

It is also considered one of the important strategies in the success of the educational process through which the interaction between the teacher, the learner, and the educational process is achieved, to prepare a generation of productive learners who are characterized by thinking and continuous self-learning, by integrating them with a set of skills and mental processes in a natural way in teaching various educational subjects through clear and practical procedures, the strategy enables the achievement of many of the desired goals (Dahesh et al., 2022).

SWOM strategy represents a serious contribution to making the student the focus of the educational process, its goal, and purpose. It is based on higher-order thinking skills, and thus it provides a solution to get rid of the negative role that leads the student to the role of mastering the stage of decision-making and mastering information (Ashour & Subaihawi, 2013).

Al-Hashimi and Al-Dulaimi (2008) believe that SWOM model aims to prepare a generation of wise, rational, productive, and thinkers who are characterized by lifelong self-learning, by integrating a set of mental skills, processes, and habits, natural in teaching various educational subjects, and according to clear and practical methods, tools, techniques, and procedures. Where this model can achieve many of the goals that educators of all levels are searching for ways to reach, which are lofty and noble goals and objectives for any educational system (Ghayib, 2012).

The learner in SWOM strategy is at the center of the learning process and its focus, and he is placed in an educational situation that requires him to think. Its importance lies in the transition of the learner from the level of quantitative and numerical education to the level of quality education that aims at learning and qualifying it, which emphasizes mental upbringing, the development of thinking, or providing the student with the means that enable him to interact greatly with information (Al-Hashimi & Al-Dulaimi, 2008; Raji, 2016).

One of the most important principles on which SWOM strategy relies is that thinking, and meditation are essential pillars of learning, integrating cognitive mind skills and productive mind habits in teaching the curriculum, considering the different characteristics of learners such as thinking patterns, learning styles, attention to emotions, feelings and sensations, practical application, and that learning is a lifelong process (Al-Edwan & Daoud, 2018).

The process of thinking allows a deeper understanding of mathematics by empowering students in the mathematics they learn. The process includes the exploration of phenomena, the development of ideas, the construction of mathematical intuitions, and the justification of results. The teacher stimulates the students' natural thinking ability to help them in mathematical thinking. Therefore, attention must be paid to the skills of thinking in all its forms, especially mathematical thinking, that mathematical thinking is the cornerstone of the development of mathematics because through it is the realization of abstract mathematical relations, in mathematical applications, and reaching the highest levels of abstraction. Moreover, that the growth of the mathematical abilities of the students depends on the development of their mathematical thinking skills (Abu Ahmed, 2016).

Mathematical thinking is the way to develop thought in mathematics, as it increases the learner's ability to understand mathematics and acquire sound thinking methods. Numerous studies have emphasized the importance of mathematical thinking, and its importance for the development of students' performance in our schools. (Abu Jazar, 2018; Al-Arini, 2017; AlAli, 2016; Almuqayad, 2016)

After reviewing the literature and previous studies, the results of international mathematics tests, and the practical experience of a group of mathematics teachers, there is a significant decline and weakness in the level of thinking and mathematical thinking skills. Where the analysis of the results of international and local tests of mathematics indicates that there is a difficulty for students in dealing with the type of questions that require mathematical thinking skills, in addition to the lack of interest and seriousness of teachers in developing this aspect.

Therefore, this study attempts to overcome this problem by answering the following questions:

1. What is the effect of using SWOM strategy on the metacognitive thinking of the gifted?
2. What is the effect of using SWOM strategy on the mathematical thinking skills of gifted students?
3. Are there any significant differences the between the mean scores of students of the experimental group and control group in the post-application of the mathematical thinking skills test, and metacognitive thinking scale?

THEORETICAL FRAMEWORK

SWOM strategy is one of the recent trends in teaching thinking skills and integrating them into the educational content, which aims to improve learning and its production, to prepare a conscious generation that thinks comprehensively, critically, and creatively, instead of receiving information and not interacting with it. It is one of the strategies that rely on a set of thinking skills, and it is an educational system and a practical program because it provides a developmental program that includes all aspects of the successful learner. It also has strategies, instructions, rules, and guidelines that ensure a successful learning environment, and a comprehensive organizational plan to manage all parts of the model. One of its advantages is clarity and accuracy in details, with a set of organized ideas and questions that the teacher does when teaching critical and creative thinking skills (Al-Hashemi & Al-Dulaimi, 2008).

The thinking skills of SWOM strategy are defined in two parts, first: is the cognitive mind skills, which include the skills of acquiring and integrating knowledge, deepening knowledge, generating ideas, and building and employing knowledge. Secondly, the productive habits of the mind, are classified into processes represented in self-awareness and control, awareness of thinking, and performance control (Swartz, 2003).

Basic Principles of SWOM Strategy

The strategy was built according to foundations and rules, the most important of which are, as follows (Abu Hantash, 2014; Al-Hashemi & Al-Dulaimi, 2008):

1. The process of thinking and contemplation is a necessary pillar and basis for learning.
2. The integration of productive mental habits and mental and cognitive skills in a clear and specific way in teaching educational courses is the basic structure of the strategy.
3. Considering the strategy for the mental side of the learner, such as thinking patterns, thinking skills, preferred learning methods, aspects of excellence and talent, inclinations and interests, and the area of development closest to the current mental structure is an essential element for successful and effective learning.
4. Learning is a lifelong process that is effective and influences the mind if the appropriate strategy is used.
5. Paying attention to the learner's emotions, feelings, attitudes, beliefs, perceptions, and internal perceptions is half of the learning process.
6. Action, application, performance, and work are the other half of the learning process.

In this study, SWOM strategy is defined as a set of organized steps and interrelated and planned educational activities that depend on the following thinking skills: questioning, comparison, generating possibilities, prediction, problem-solving, and decision-making. SWOM strategy has a set of steps, as follows (Al-Edwan & Daoud, 2018; Jasim, 2020; Raji, 2016):

1. **Questioning:** In this skill, the following questions are raised: What are the small parts that make up the whole? What is the function of each part? How do the parts come together to form and function as a whole?

Questioning is based on asking questions before, during, and after the learning process, in a way that facilitates the learner's understanding and stopping at the important elements of the educational course, thinking about the practical material, and linking the old information with the new. When learners start using questions, they become more responsible and play a more positive role. This also helps the teacher to know what the learner possesses of previous knowledge and to know the extent to which he achieved the desired results.

2. **Comparison:** In this skill, the following questions are raised. What classifications and models do you see in the most prominent similarities and differences?

Comparison is concerned with knowing the similarities and differences between the information given and the information that is being researched and investigated, which helps the learner to organize and store new information in a way that can be retrieved and helps him to develop his knowledge.

3. **Generating probabilities:** In this skill, the following questions are raised: Why do you want to generate probabilities? What possibilities can you think of? What are the other types of possibilities? How do you decide that one of the possibilities is possible?

Generating possibilities is the ability to discover new ways, recreate and organize available information, and generate new solutions. It includes the ability to use prior knowledge to add new information constructively. Learners also try to link new and previous ideas by creating a coherent structure of ideas.

4. **Prediction:** In this skill, the following questions are raised. What might happen in a prediction? What evidence would you get that might indicate that this prediction is correct?

Prediction seeks to achieve a set of educational outcomes, which is represented in the learner being able to anticipate a result, after carrying out a group of different activities and readings, and to imagine a solution to a problem, and this step represents the process of putting forward hypotheses for a problem.

5. **Problem solving:** In this skill, the following questions are raised: What is the problem? What solutions are available to this problem? What is the best solution to this problem?

Problem solving is a process in which the learner uses all his previous knowledge and experience, to remove ambiguity from the problematic situation, through specific steps that help him acquire mental capabilities, develop the value of self-reliance, and develop his thinking abilities, as well as finding appropriate solutions.

6. **Decision-making:** Swartz (2003) believe that there are a set of reasons that motivate the student to decide, namely, there are hosts of complex choices that require us to decide, there are multiple circumstances surrounding the decision-making process that must be understood to improve the decision-making process, and opportunities for making decisions are varied and gradual in terms of ease and difficulty.

Decision-making is the process of consciously selecting among the available alternatives in a given situation and working to select the best alternative. The alternatives are chosen in light of a set of criteria that were monitored by the decision-maker. It is a thinking process aimed at selecting the best suitable alternatives within a given situation, to achieve the desired goal.

Mathematical thinking is a mental activity specific to mathematics, organized and continuous during the educational learning process, that includes a set of aspects or skills, and each of these aspects depends on a set of mathematical abilities and skills (Abu Ahmed, 2016).

In this study, mathematical thinking is a pattern of thinking that the brain uses to mentally solve mathematical problems, and it is defined by the following five skills: induction, deduction, mathematical proof, logical thinking, and generalization:

1. Induction is the method of reaching general judgments by observation and observation. There are two types of induction: complete, which studies all individuals of the phenomenon, and incomplete, which studies specific models of the phenomenon. Induction also leads to new general facts. In this study, induction is defined as a method in which the individual moves from one part to the whole.
2. The deduction is the transition from the general judgment (introduction), which are generalizations, general rules, or theories, to the judgment on particles (special cases) (AlAli, 2016, Hidayat et al., 2022). In this study, the deduction is a way in which the individual moves from the whole to the part and from the general to the particular.
3. Generalization is a fixed relationship between two or more concepts, as it comes at the top of the concept in the hierarchical ladder of learning outcomes, where the student learns the concept, then learns the relationship between that concept and other concepts within a fixed relationship linking the concept with other concepts. In this study, generalization is an individual's ability to extract a general rule or judgment of a set of information and apply it to new situations (AlAli, 2016).
4. Logical thinking is mental ability that allows the individual to move from the known to the unknown, guided by the rules and principles of logic. In addition, it means obtaining evidence to support or substantiate the viewpoint or denies (AlAli, 2016). In this study, Logical thinking a mental ability that enables the individual to move from the known to the unknown, guided by objective rules and principles. Logic is often defined as correct thinking and inference. It helps in understanding logic and its uses, to avoid falling into fallacies, and to increase the skills of analytical thinking.
5. Mathematical proof is one of mathematical thinking aspects, where students produce logical arguments, and make formal proofs that effectively explain their thinking (AlAli, 2016).

LITERATURE REVIEW

The study by Msaed et al. (2022) showed the positive effect of SWOM strategy on developing creative thinking and learning some complex offensive skills in handball. The study by Hussein et al. (2022) showed that SWOM strategy had a positive effect on learning the skill of rolling to stand on the hands. The study of Dahesh et al. (2022) showed that SWOM strategy contributed to the development of some motor abilities, in addition to developing the accuracy of the volleyball-blocking wall. Abu Jazar (2018) in his study showed that there were statistically significant differences in favor of the group that used SWOM model in the mathematical thinking test. Mahdi (2017) in his study showed that there were statistically significant differences in favor of the group that used SWOM model in the critical thinking test and the habits of mind test. The study by Raji (2016) showed the superiority of the group that studied according to SWOM strategy in achievement and high-order thinking. The study by Al-Edwan and Daoud (2018) showed the superiority of the group that studied according to SWOM strategy in achievement and meta-cognitive thinking skills. The study by Jasim (2020) showed the superiority of the group that studied according to SWOM strategy in acquiring mathematical concepts. The study by Abu Hantash (2014) showed that there are differences and influences for students who used SWOM strategy in meta-cognitive thinking, scientific attitudes, and academic achievement. The study of Ashour and Subaihawi (2013) showed the superiority of the group that studied according to SWOM strategy in raising the academic achievement of the physical education teaching methods course. The study by Al-Enezi (2007) confirmed the success of SWOM strategy in developing decision-making skills and the ability to teach thinking and show a high level of understanding and effective thinking in the decision-making process.

Many studies agreed on the effectiveness of many strategies, methods, and educational programs in developing mathematical thinking skills (Almuqayad, 2016; Hazhouzi, 2016; Omer, 2015). The study by AlAli (2016) showed the existence of a relationship and influence of the social perception of mathematics on mathematical thinking.

METHODS

The analytical descriptive approach and the experimental approach were used due to their suitability to the nature of the study objective. The descriptive approach is an accurate and organized description and analytical method of the problem, through a scientific methodology to obtain scientific results and interpret them objectively and impartially to achieve the objectives of the research. While the experimental approach was used because it includes an attempt to control the factors affecting the change of the dependent variables in the experiment.

Population and Sample

The study population consisted of all gifted tenth-grade students in the Al-Ahsa region for the second semester year 2021-2022. The study sample consisted of 42 gifted male and female students from Al-Anjal National School, as well as 42 gifted male and female students from Alkifah Academy Schools. All students are gifted and were selected by the King Abdulaziz and His Companions Foundation for Giftedness and Creativity "Mawhiba" after passing a set of tests related to gifted students. The male section of Al-Anjal School (20 students), and the female section of Al-Kifah School (22 students), were chosen randomly to represent the experimental group. In addition, the female section from Al-Anjal School (22 students), and the male section from Al-Kifah School (20 students), represent the control group. The experimental group studied the geometry unit using SOWM strategy. The control group studied the geometry unit using the usual method.

Study Tools

To achieve the objectives of the study, two tools were prepared: the mathematical thinking test and the metacognitive thinking scale. At first, the content of the study unit was analyzed by a group of teachers and supervisors, which included the goal of the analysis, which is to identify the mathematical thinking skills for this study unit, in addition to the following mathematical thinking skills as categories for analysis: induction, deduction, mathematical proof, logical thinking, and generalization. Teaching plans for each lesson have been prepared and organized in detail, including objectives, means, and assessment methods. It was also presented to experts and modified in light of their opinions.

After reviewing the literature, previous studies, and tests related to mathematical thinking skills in the tenth-grade engineering unit, an objective test of mathematical thinking distributed over six skills was developed. The initial copy consisted of 30 items.

After reviewing the literature, and previous studies related to metacognitive thinking, a scale of metacognitive thinking was developed, which consisted of three skills: planning, monitoring, and assessment. The initial copy consisted of 32 items.

Data Analysis

To answer the study question and verify the construct validity, the data were analyzed using SPSS version 26. In addition, it was analyzed and evaluated according to the Rasch model using Winsteps software version 3.68.2. Rasch model analysis was used to verify the validity and reliability of the instrument. Rasch model is used to reach the highest level of accuracy and objectivity in the measurement to achieve a more accurate relationship between the measuring tool and the underlying attribute of the individual. Rasch Model analysis is a powerful tool for evaluating the construct validity and reliability of the instrument (AlAli, 2020).

Verifying Validity and Reliability of the Instrument

To verify the validity and reliability of the instrument, ten experts from the educational supervisors from the General Administration of Education in Al-Ahsa and faculty members from the University of King Faisal examined both tools. Based on their opinions, some items for the mathematical thinking test were reformulated. In addition, some items of the metacognitive thinking scale were reformulated, and two items were omitted. After that, the tools were applied with a pilot study of 20 students, to ensure validity and reliability, and to determine the appropriate time to answer the test. Rasch model analysis was used because it is a powerful tool for evaluating construct validity.

To find construct validity, first the value of mean square (MNSQ) should be determined. According to Rasch model the values are appropriate for construct validity be-because it lies within $0.5 < x < 1.5$. Second, the item polarity or point measure correlation (PTMEA Corr.) should be detected because its consider the early detection of construct validity. According to Rasch model the values of PTMEA are appropriate for construct validity because it lies within $0.2 < x < 1$. Third, the standardized fit statistic (Zstd) should also be determined. Zstd value is acceptable because it lies within $-2 < Zstd < +2$ (AlAli & Saleh, 2022).

The results of the analysis of students' responses using the Rasch model showed that MNSQ value of infit and outfit and the Zstd value was greater than 1.5 for 5 items of the mathematical thinking test, and three items of the meta-cognitive thinking scale, so these items were omitted. While the dimensionality data results are appropriate to the Rasch model. The data results of item polarity analysis (PTMEA) or consistency of the items is also appropriate to the Rasch model as shown in **Appendix A** and **Appendix B**. The person reliability for both tools was very high, and the item reliability for both tools was very high, which are acceptable. The final copy of metacognitive thinking scale comprised of 27 items as shown in **Appendix C** and **Appendix D**.

After that difficulty index and discriminant index for the mathematical thinking test and meta-cognitive thinking scale were calculated, the difficulty index ranging from 0.29-0.78 and 0.47-0.84, respectively. Therefore, the difficulty of the questions and items is

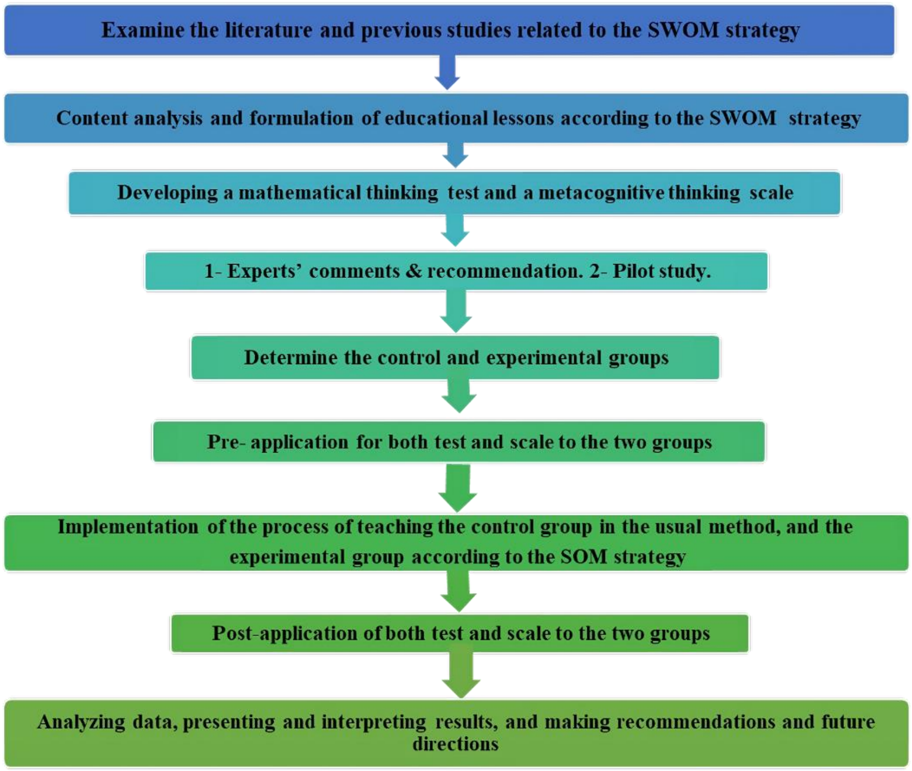

Figure 1. Study procedures (Source: Authors' own elaboration)

Table 1. The means and standard deviation results of the t-test for two groups

Group	n	Mean	Standard deviation	T-value	Sig.
Control	42	3.46	1.15	6.42	0.00*
Experimental	42	4.23	0.67		

Note. *Statistically significant at level 0.05

suitable for the level of students. The discriminant index ranges from 0.26-0.76 and 0.25-0.73, respectively as shown in **Appendix E** and **Appendix F**. Therefore, the questions and items have the appropriate ability to discriminate. Therefore, the final copy of the mathematical thinking test consisted of 25 questions.

Procedures

In order to achieve the objectives of the study, **Figure 1** shows the main steps involved in conducting the study.

Pre-Application for Both Test and Scale to the Two Groups

After the pre-application of the test, the mean and standard deviation for the experimental group was 9.24 and 2.94, respectively, and for the control group was 8.35 and 3.14, respectively. The value of t=1.59 in the comparison between the mean scores of the students of the experimental and control groups indicated that there were no statistically significant difference at the between the mean scores of students of the two groups in the mathematical thinking skills test, where the significant level was more than 0.05. This indicates that the two groups are equivalent.

RESULTS

To answer of the first question: What is the effect of SWOM strategy on the meta-cognitive thinking of gifted students?

Means and standard deviation were calculated. In addition, the t-test was used. **Table 1** shows the means, standard deviation, and results of the t-test for two groups to examine the significance of differences in the meta-cognitive thinking scale according to SWOM strategy.

Table 1 shows that there were statistically significant differences between the average level of metacognitive thinking among students who learned using the SWOM strategy (experimental group) and the average level of metacognitive thinking among students who learned in the usual way (control group), and the difference came in favor of the experimental group.

To find out the effect of the teaching method using SWOM strategy on meta-cognitive thinking, the Eta

Table 2. The values for the effect size levels (Cohen, 1988)

Effect size	Small	Medium	Large	Range
η^2	0.01-0.06	0.06-0.14	≥ 0.14	[0-1]

Table 3. The means and standard deviation results of the t-test for two groups

Group	n	Mean	Standard deviation	T-value	Sig.
Control	42	16.74	8.95	7.02	0.00*
Experimental	42	25.39	6.03		

Note. *Statistically significant at level 0.05

Table 4. The results of the t-test reveal the significance of the differences between the mean scores of the students of the control and experimental groups in the post-test of mathematical thinking skills

Variable	Group	n	Mean	Standard deviation	T-value	Sig.	Statistical significance
Induction	Control	42	5.03	2.16	3.15	0.02	Statistically significant
	Experimental	42	6.24	2.73			
Deduction	Control	42	4.39	1.48	3.67	0.01	Statistically significant
	Experimental	42	5.67	1.39			
Generalization	Control	42	3.65	1.18	2.98	0.02	Statistically significant
	Experimental	42	4.32	1.62			
Mathematical proof	Control	42	4.69	2.01	3.54	0.02	Statistically significant
	Experimental	42	5.91	2.39			
Logical thinking	Control	42	5.19	2.14	5.16	0.01	Statistically significant
	Experimental	42	6.09	2.53			
Overall degree	Control	42	22.95	3.45	5.07	0.02	Statistically significant
	Experimental	42	28.23	3.87			

square (η^2) was used. **Table 2** shows the values for the effect size levels.

The value of η2 was 0.279, which is a large value. This means that the use of SWOM strategy explains 27.9% of the meta-cognitive thinking of gifted students.

To answer of the second question: What is the effect of SWOM strategy on the mathematical thinking skills of gifted students?

Means and standard deviation were calculated. In addition, the t-test was used. **Table 3** shows the means, standard deviation, and results of the t-test for two groups to examine the significance of differences in the mathematical thinking skills test according to SWOM strategy.

Table 3 shows that there were statistically significant differences between the average achievement of students on the mathematical thinking test who learned using SWOM strategy (experimental group) and the average achievement of students on the mathematical thinking test who learned in the usual way (control group), and the difference came in favor of the experimental group.

To find out the effect of the teaching method using SWOM strategy on the achievement of students on the mathematical thinking test, the η^2 was used. The value of η2 was 0.301, which is a large value. This means that the use of SWOM strategy explains 30.1% of the gifted students' performance.

To answer of the third question: Are there any significant differences the between the mean scores of students of the experimental group and control group in the post-application of the mathematical thinking skills test, and metacognitive thinking scale?

The t-test was used to detect the significance of the difference between the average performance in the post-mathematical thinking skills test for both the control group and the experimental group, as shown in **Table 4**.

Table 4 showed that the mean value in the application of the control sample was less than the mean value in the application of the experimental sample of the five dimensions. Where the mean value response of control group to overall mathematical thinking test (22.95) was lower than the mean value response of experimental group (28.23).

To find out the effect of the teaching method using SWOM strategy on the achievement of students on the mathematical thinking test, the η2 was used. The value of η2 was 0.301, which is a large value. This means that the use of SWOM strategy explains 30.1% of the gifted students' performance.

DISCUSSION

The study results showed that there were statistically significant differences between the average level of metacognitive thinking among gifted students who learned using SWOM strategy (experimental group) and the average level of metacognitive thinking among gifted students who learned in the usual way (control group), and the difference came in favor of the experimental group. This can be explained by the fact that SWOM strategy helped develop the ability of gifted students to think, as the thinking maps used helped them reflect and enhance their confidence and competence in thinking skillfully. Students make efforts to acquire knowledge and learning experiences using mental processes and under the guidance of the teacher. This enabled them to focus their mental abilities on realizing the meaning of what they are doing. In addition, the questions and problems posed during learning helped to identify some of the situations they face and to develop and evaluate multiple options and choose the best alternatives, and this led to the development of their meta-cognitive thinking. In addition, SWOM strategy encouraged familiarity, trust, and open-mindedness between the students and the teacher, and this led to interaction between them during their learning. SWOM strategy also provided students with the opportunity to interact with educational tasks, which helped them think through their participation in a reflective activity (meta-cognitive) and various worksheets by asking meditative questions that help them to be aware of the type of thinking they are doing and to know the strategy used during the thinking process and assess its effectiveness. Direct interaction with the scientific material and discussions has an important role in increasing students' understanding of the knowledge they possess. SWOM strategy made students more eager to study, and their awareness of the meaning of what they learned. This helped them to follow up, persist, and turn out to achieve meaningful learning, and acquire meta-cognitive thinking skills. The SWOM strategy also allowed students to plan how to perform some thinking skills in new educational situations. This result is consistent with the study of (Abu Hantash, 2014; Al-Edwan & Daoud, 2018; Al-Ghamdi, 2012; Tok, 2013).

In light of the results, the researcher believes that SWOM strategy has a significant impact on developing mathematical thinking skills and raising the level of achievement of the experimental group students. The superiority of the students of the experimental group who learned according to SWOM strategy may be attributed to the fact that the strategy is new and unfamiliar to the students, so they interacted with it and increased their enthusiasm for it. The researcher attributes these differences to the fact that employing SWOM strategy in developing mathematical thinking skills has a significant impact on teaching more than traditional teaching methods because this strategy is one of the modern trends in teaching that led to students' interaction with lessons and increased their desire and activity in learning. It also works to stimulate students' motivation, attract their attention, and increase their ability to generate new ideas, which contributed to develop mathematical thinking skills. It also allows the student to ask questions about the problems he faces, and works to consolidate the concept of lifelong learning, and thus reach new ideas through previous experiences. SWOM strategy that was followed in teaching increased the concentration of students in lessons through the freedom of discussion and expression of opinions, and thus considered the individual differences among students, which made them the center of the educational process, and this facilitated their acquisition of the required information and skills, and thus their thinking grew, and they realized what surrounded them. SWOM strategy makes the student the focus of the educational process, and thus changes the role of the student from a recipient of knowledge to a creator and developer of knowledge. Moreover, the method of presenting knowledge and information using SWOM strategy was attractive, interesting, and enjoyable, and it answers many questions that revolve around the minds of the students, and the skills included in SWOM strategy satisfy the curiosity of the students and their desire to learn more. Furthermore the nature of presenting the educational material sequentially and coherently helped to develop learning at all levels, and this is consistent with what cognitive psychologists confirmed that the educational process must be analyzed according to strategies designed in an organized manner and in successive and sequential steps that contribute greatly to the development of the teaching process and achieving effectiveness for learners This can only be done through designing the learner's environment to suit his abilities, attitudes, and perceptions. The results of the current study are consistent with the results of previous studies (Abdul Amir, 2016; Abu Jazar, 2018; Hamza, 2014; Mahdi, 2017).

CONCLUSION, LIMITATIONS, AND FUTURE DIRECTIONS

Does the use and employment of the SWOM strategy in teaching as a teaching method affect meta-cognitive thinking and the development of mathematical thinking skills for gifted students? The results of this study showed that there were statistically significant differences between the average level of metacognitive thinking among gifted students who learned using SWOM strategy, and the average level of metacognitive thinking among students who learned traditionally, in favor of the students who learned using SWOM strategy. The results of the study also showed that there were statistically significant differences between the average scores of gifted students who learned using SWOM strategy, and the average scores of gifted students who learned traditionally in a mathematical thinking skills test, in favor of the students who learned using SWOM strategy.

The current study is limited to two concepts: meta-cognitive thinking and mathematical thinking skills. It is also limited to one unit of study from the tenth-grade mathematics book, as well as to gifted students in two schools only.

Considering the findings of the study, it recommends that SWOM strategy should be used in teaching mathematics at different educational stages. Holding training courses and workshops for mathematics teachers on how to use SWOM strategy in developing meta-cognitive thinking and mathematical thinking skills. In addition to designing mathematics curricula for the different stages according to SWOM strategy. The study attempted to highlight SWOM strategy as a teaching method, which motivates researchers to conduct more studies to find out the impact of SWOM strategy on other types of thinking to develop skills at all levels, and in other educational subjects and stages. In addition to conducting studies according to SWOM strategy for other variables such as trends and tendencies towards any curriculum. It is also possible to build an educational program according to SWOM strategy and apply it at different teaching levels.

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Data sharing statement: The authors declare that all other data supporting the findings of this study are available within the article.

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APPENDIX A

Table A. Item fit analysis for mathematical thinking test

Questions	Model SE	Infit		Outfit		Pt-measure CORR
		MNSQ	Zstd	MNSQ	Zstd	
Q23	.06	1.90	1.9	1.92	1.9	.82
Q6	.07	1.90	1.7	1.80	1.1	.72
Q14	.06	1.74	1.5	1.87	1.3	.65
Q21	.08	1.64	1.6	1.70	1.7	.74
Q9	.08	1.45	1.2	1.69	1.0	.74
Q11	.05	1.30	1.3	1.65	1.0	.72
Q19	.08	1.38	1.5	1.58	1.3	.69
Q24	.07	.98	-1.4	1.50	.0	.82
Q16	.05	.83	-1.6	.87	-1.8	.80
Q5	.07	.9	-1.1	.86	-1.9	.77
Q22	.08	.68	-1.9	.75	-1.1	.53
Q13	.06	.64	-1.7	.70	-1.3	.69
Q8	.08	.58	-1.8	.67	-1.8	.80
Q25	.08	.56	-1.8	.57	-1.8	.61
Q1	.13	.49	-1.3	.55	-1.3	.54
Q10	.09	.57	-1.1	.56	-1.7	.74
Q3	.07	.52	-1.7	.46	-1.9	.67
Q20	.11	.48	-1.8	.44	-1.9	.59
Q18	.11	.47	-1.8	.44	-1.9	.67
Q7	.07	.47	-1.8	.43	-1.6	.56
Q17	.11	.45	-1.4	.41	-1.8	.46
Q15	.07	.45	-1.3	.49	-1.9	.80
Q12	.07	.42	-1.2	.49	-1.6	.81
Q4	.07	.42	-.8	.43	-1.1	.56
Q2	.08	.41	-.7	.42	-1.0	.49

APPENDIX B

Table B. Item fit analysis for metacognitive thinking scale

Questions	Model SE	Infit		Outfit		Pt-measure CORR
		MNSQ	Zstd	MNSQ	Zstd	
ME18	.06	1.92	1.8	1.39	1.8	.81
ME11	.05	1.88	1.8	1.52	1.7	.80
ME20	.05	1.80	1.7	1.29	1.6	.79
ME22	.04	1.79	1.6	1.15	1.5	.77
ME9	.04	1.73	1.8	1.37	1.7	.77
ME21	.05	1.66	1.7	1.25	1.4	.76
ME10	.05	1.64	1.3	1.12	1.2	.81
ME14	.04	1.57	1.3	1.24	1.2	.84
ME19	.05	1.57	1.2	1.21	1.3	.81
ME5	.04	1.48	1.2	1.09	1.5	.79
ME24	.05	1.45	-0.9	1.03	0.5	.73
ME1	.04	1.37	1.7	1.19	1.0	.65
ME3	.04	1.13	1.3	1.07	1.3	.71
ME12	.05	1.20	0.1	1.00	0.1	.74
ME23	.05	.97	-0.9	.91	-1.3	.82
ME16	.04	.93	-1.3	.96	-0.6	.77
ME25	.04	.90	1.2	1.10	1.4	.84
ME6	.04	.89	-1.4	1.12	1.1	.76
ME4	.04	.90	-1.5	.91	-1.2	.78
ME7	.05	.88	1.6	.81	-1.1	.79
ME15	.05	.91	-1.4	.82	-1.4	.76
ME2	.04	.66	-1.5	1.37	1.2	.73
ME26	.04	.82	-1.1	.79	-1.2	.77
ME27	.04	.67	1.2	.83	-1.3	.79
ME8	.05	.66	-1.5	.75	-1.6	.70
ME13	.05	.73	1.0	.75	-1.7	.72
ME17	.05	.61	1.3	.68	-1.8	.67

APPENDIX C

Table C. Person separation and reliability for mathematical thinking test

	Score	Count	Measure	Error	Infit		Outfit	
					MNSQ	Zstd	MNSQ	Zstd
Mean	198.3	51.0	.87	.21	1.08	-.1	1.05	-2.0
SD	30.3	.0	1.22	.08	.52	2.5	.49	2.3
Real RMSE	.26							
Adjusted SD	1.19							
Separation	4.53							
Pearson reliability	.87							
Mean	225.7	100.0	.00	.14	1.00	-.2	1.05	.0
SD	13.4	.0	.35	.01	.36	2.3	.52	2.6
Real RMSE	.17							
Adjusted SD	.42							
Separation	2.46							
Item reliability	.83							

APPENDIX D

Table D. Person separation and reliability for metacognitive thinking scale

	Score	Count	Measure	Error	Infit		Outfit	
					MNSQ	Zstd	MNSQ	Zstd
Mean	129.7	51.0	.87	.21	1.08	-.1	1.05	-2.0
SD	21.5	.0	1.22	.08	.52	2.5	.49	2.3
Real RMSE	.27							
Adjusted SD	1.19							
Separation	4.49							
Pearson reliability	.87							
Mean	156.8	100.0	.00	.14	1.00	-.2	1.05	.0
SD	11.2	.0	.35	.01	.36	2.3	.52	2.6
Real RMSE	.16							
Adjusted SD	.30							
Separation	2.35							
Item reliability	.83							

APPENDIX E

Table E. Difficulty index and discriminant index for mathematical thinking test

Item	Difficulty index	Discriminant index
Q1	0.75	0.72
Q2	0.78	0.35
Q3	0.29	0.29
Q4	0.53	0.47
Q5	0.38	0.36
Q6	0.47	0.70
Q7	0.59	0.26
Q8	0.63	0.60
Q9	0.59	0.59
Q10	0.67	0.44
Q11	0.43	0.35
Q12	0.61	0.54
Q13	0.55	0.32
Q14	0.68	0.53
Q15	0.78	0.63
Q16	0.58	0.76
Q17	0.51	0.59
Q18	0.49	0.58
Q19	0.39	0.45
Q20	0.62	0.29
Q21	0.61	0.46
Q22	0.53	0.31
Q23	0.56	0.42
Q24	0.66	0.27
Q25	0.57	0.46

APPENDIX F

Table E. Difficulty index and discriminant index for metacognitive thinking test

Item	Difficulty index	Discriminant index
ME1	0.47	0.27
ME2	0.60	0.43
ME3	0.68	0.44
ME4	0.53	0.39
ME5	0.63	0.52
ME6	0.72	0.63
ME7	0.70	0.33
ME8	0.54	0.32
ME9	0.51	0.52
ME10	0.66	0.35
ME11	0.58	0.25
ME12	0.71	0.53
ME13	0.73	0.55
ME14	0.78	0.47
ME15	0.67	0.35
ME16	0.71	0.68
ME17	0.78	0.64
ME18	0.68	0.71
ME19	0.73	0.49
ME20	0.54	0.36
ME21	0.60	0.48
ME22	0.61	0.43
ME23	0.63	0.63
ME24	0.59	0.44
ME25	0.71	0.33
ME26	0.64	0.73
ME27	0.84	0.53

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