International Journal of Multidisciplinary and Current Educational Research (IJMCER)
ISSN: 2581-7027 ||Volume|| 6 ||Issue|| 6 ||Pages 34-44 ||2024||

The effectiveness of teaching strategies in developing the mathematical thinking skills of 10th grade students in Jordan

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ABSTRACT: This study explored the impact of three teaching strategies—Multiple Intelligences, Problem Solving, and the Six Hats—on the development of mathematical thinking skills among tenth-grade students in Jordan. A total of 374 students, both male and female, were divided into six groups: three for males and three for females. Each group was taught using one of the strategies, and a test measuring mathematical thinking across five domains was administered. The findings revealed that students taught using the Six Hats strategy achieved significantly higher scores compared to those using the Multiple Intelligences and Problem-Solving strategies. Additionally, there were significant differences in performance based on gender, with females outperforming males in all areas of mathematical thinking. However, no significant differences were found regarding the interaction between teaching strategy and overall scientific thinking skills.

KEYWORDS: Teaching strategies, multiple intelligences, the six hats, problem solving, mathematical thinking.

I. INTRODUCTION:

Thinking is the right way towards creativity in various fields of knowledge and science. Therefore, educational programs directed to the various stages of education must focus on thinking abilities according to the path of the scientific methodology, and the old view that depends on the presentation of concepts and the use of traditional teaching methods must be changed to a modern view. The modern methods that guarantee the development of student's thinking skills, show him/ her how to deal with the mechanisms of scientific thinking with its scientific methodology and methods of implementation (Wilson, 2000). In contemporary education, fostering critical thinking and problem-solving skills has become paramount. This paradigm shift reflects a departure from traditional teaching methods towards innovative strategies designed to unlock students' cognitive potential and enhance their readiness for the challenges of the 21st century. As highlighted by Wilson (2000), modern educational programs must prioritize the development of thinking abilities, steering away from rote memorization towards a dynamic approach grounded in scientific methodology. The significance of teaching strategies cannot be overstated, considering their pivotal role in advancing students' cognitive capacities and preparing them for a rapidly evolving world. The theory of multiple intelligences, the six hats, and problem-solving strategies stand out as methodologies geared towards nurturing thinking skills, as evidenced by previous studies (Al-Khatib, 2018; DeBono, 2001; Batchelor, 2000; Gardner, 1983).

In light of the exponential growth in scientific and technological advancements, the traditional emphasis on memorization-centric mathematics curricula is no longer sufficient. Birbeck (2010) underscores the urgent need to align educational objectives with the demands of a knowledge-driven society, emphasizing the cultivation of research skills, critical thinking, and adaptability among students. Mathematics education, in particular, plays a pivotal role in nurturing cognitive development and problem-solving abilities. Recognizing this, educational institutions worldwide have reevaluated their mathematics curricula to foster a deeper understanding of mathematical concepts and structures (Al-Ghamdi, 2014). Central to this transformation is the recognition of mathematics as not merely a subject but a mode of thinking. Al-Asmar (2016) asserts that mathematics serves as a cornerstone for logical reasoning and analytical precision, equipping individuals with invaluable problem-solving skills essential for success in various domains. In response to the evolving educational landscape, educators have embraced innovative methodologies such as the Six Thinking Hats strategy. Developed by Edward DeBono (2001), this approach offers a structured framework for cultivating diverse thinking modes, fostering creativity, and enhancing problem-solving abilities (Al-Omari, 2014). Similarly, the theory of multiple intelligences has revolutionized teaching practices by recognizing the diverse cognitive capabilities of students. Gardner's theory empowers educators to tailor instruction to individual learning styles, promoting self-discovery, motivation, and positive thinking among students. As educational systems continue to evolve, the integration of dynamic teaching methodologies remains imperative.

By embracing innovative strategies grounded in scientific inquiry and cognitive development, educators can empower students to thrive in an ever-changing world characterized by complexity and uncertainty.

The Study Problem and Research Questions : Given the pivotal role of mathematics as a cornerstone in basic education curricula and its significance in current and future contexts, it stands as a fertile ground for nurturing students' sound thinking methods and equipping them with skills to solve real-life problems throughout their educational journey. This significance is particularly pronounced during the intermediate stage of education, which plays a foundational role in preparing students for further learning and personal development. This stage is characterized by relative stability and continuity in students' educational experiences. Despite the considerable attention given to teaching and learning mathematics, coupled with efforts to enhance curricula and teaching strategies, a persistent problem arises in the form of consistently low student achievement levels across various educational stages. This issue has been substantiated by numerous studies, including those conducted by Al-Jabri (2007), and it has received international attention through reports like the Trends in International Mathematics and Science Study (TIMSS) in 2015. TIMSS results indicated a clear decline in students' mathematical thinking skills.

The educational literature suggests that the decline in mathematical thinking skills can be attributed to ineffective teaching methods and the limited use of modern teaching approaches in mathematics education. Such methods are essential for preparing students for the demands of the twenty-first century. The ramifications of this issue extend to students, parents, and teachers alike, especially considering the cumulative nature of mathematical learning. Weakness in one aspect of mathematics can have cascading effects on a student's overall proficiency in related subjects (Al Ali, 2016 and Badr, (2007). In Jordan's educational landscape, a similar concern emerges in the realm of science education. Despite substantial efforts, students often exhibit low academic achievement levels in mathematics. Studies such as the one conducted by Afaneh and Al-Khazindar (2005) reveal that many students tend to memorize and regurgitate information without grasping its meanings, leading to a lack of understanding, comprehension, and the ability to apply analytical or problem-solving skills.

Recent global educational trends underscore the importance of adopting modern teaching strategies and methods, including digital learning tools, which have demonstrated their effectiveness in mathematics education (Munira Al-Harbi, 2013; Joifel and Amna Al-Amarin, 2013; Amal Al-Qahtani, 2013; Hanan Khalil, 2012). The development of mathematics curricula and teaching methods remains a central focus in seminars and conferences worldwide, emphasizing the need to keep pace with advancements and experiment with innovative approaches (Center for Research Excellence in the Development of Science and Mathematics Education, 2011).

To fulfill the new vision for mathematics education and learning development in line with modern trends and technological advancements, educators must embrace contemporary methods. Mathematics teachers, in particular, should be well-versed in the latest strategies and trends to create engaging learning experiences (Saleh, 2012). While some studies, like those conducted by Al-Mohammadi (2013) and Al-Mughni (2015), highlight the underutilization of modern technologies in mathematics education, others, such as the study by Al-Qahtani (2013), emphasize the significance of incorporating modern techniques and strategies to enhance mathematics education. Modern approaches can spark students' interest, provide conducive learning environments, clarify concepts and operations, and boost their attentiveness and focus.

Accordingly, the problem of this study was represented by the following main question: What is the effect of the multiple intelligences, problem solving and six hats strategies on developing mathematical thinking skills for Tenth grade students in Jordan? From this question, the following sub-questions emerged:

1. Are there statistically significant differences between the mean scores of students in mathematical thinking skills that are due to the teaching strategy?
2. Are there statistically significant differences between the mean scores of students in mathematical thinking skills due to gender?
3. Are there statistically significant differences between the mean scores of students in mathematical thinking skills due to the interaction between the teaching strategy and gender?

In addition, the researchers added the two objectives of the study:

1. Determining the mathematical thinking skills to be developed for the tenth grade students in mathematics.
2. Recognizing the effect of using teaching strategies in developing the mathematical thinking skills found in the mathematics textbook for the tenth grade.

Importance of the study: This study gains importance in that it identifies practical procedures for using teaching strategies based on developing thinking during the learning process, and these strategies are: the multiple intelligence strategy, the six hats strategy, and the problem-solving strategy, by teaching tenth grade students the content of mathematics. It also provides empirical evidence for the impact of teaching mathematics according to those strategies in developing students' mathematical thinking skills, and the subject of this study may provoke other research in the field of its independent and dependent variables within a broader spatial and educational framework.

Limitations of the study: The degree of generalization of the results of this study is limited by a number of determinants, including:

1. Objective limits: The research will focus on the use of 3 teaching strategies in developing mathematical thinking skills. The study will be limited to teaching a unit of mathematics for the tenth grade basic part two, and mathematical thinking skills will be limited to: induction, deduction, symbolic expression, problem solving, justification and reasoning.
2. Human limits: The study will be applied to tenth grade students in the first Irbid Education Directorate who are in school for the academic year 2020/2021.
3. Spatial boundaries: The sample was selected from First Irbid Education Directorate.
4. Time limits: The study was conducted 2020/2021

II. STUDY TERMS AND DEFINITIONS:

Effectiveness: The extent to which one or some independent factors influence(s) one or some of the dependent factors" (Shehata and Zainab, 2003: 230), and it is measured procedurally in this study by the amount of change that occurred in the dependent variables: achievement in science and motivation going through learning science) by employing a strategy that was developed based on the results of brain research in teaching force and pressure unit) from the seventh grade science book in Jordan.

Teaching strategy: It means the steps that the teacher follows inside or outside the classroom to teach a specific subject in order to achieve specific and pre-planned educational goals, which include a set of steps and sequential and coordinated procedures that the teacher and student take while teaching that content (Zeitoun, 2002). In light of this, the teaching strategy in this study is defined as: a set of procedures and steps that are logically arranged and organized and consistent with the theory of multiple intelligence and the six hats and problem solving, which includes teaching methods, means, methods, activities, entrances and evaluation methods that were used in this study.

Multiple intelligences theory strategy: It is strategies based on the basis that the individual possesses types of intelligence that he uses in solving the problems he faces so that these intelligences interact when performing a specific task (Gardner, 1983). In light of this, these strategies were identified in this study as: Teaching strategy that includes a set of organized, arranged and planned steps and procedures that the teacher uses in terms of implementing activities and using diverse teaching and assessment methods that are appropriate to the thinking patterns contained in Gardner's multiple intelligences theory, namely (verbal - linguistic intelligence, Logical-mathematical intelligence, visual-spatial intelligence, musical-rhythmic intelligence, bodily-kinesthetic intelligence, interpersonal-external intelligence, interpersonal-internal intelligence, and natural-environmental intelligence).

Six hats strategy: a system that enables the individual to think, by concentrating his thinking in one type of thinking directions represented by the colors of the six thinking hats (white hats, red hats, black hats, yellow hats, green hats, and blue hats), and enables the individual to transfer His thinking and directing from one style to another (Gross, 1998). In this study, it represents the teaching strategy that includes a set of steps and procedures planned and arranged in terms of the implementation of activities, and the use of teaching methods and assessment and its various means appropriate to six styles of thinking described by six colors of hats symbolizing the nature of thinking, in order to organize information, arrange it and codify it according to the educational situation and the nature of the learners and educational tools provided for the purposes of this study.

Problem solving strategy: a thinking process carried out by an individual using a set of skills and knowledge to solve an ambiguous situation he is not familiar with (Jarwan, 2002). In light of this, it is the set of learning and teaching procedures used by the student, which allows him to practice the processes of identifying problems, setting hypotheses, and collecting information and data from its various sources in an attempt to verify the validity of these assumptions, develop solutions, and reach the necessary generalizations.

Mathematical thinking skills: a mental activity represented in the student's ability to induction, conclusion and expression with symbols, problem solving, justification and reasoning with perfection and accuracy, and it is measured by the degree that the student obtains in the mathematical thinking skills test.

Tenth grade students: They are students whose ages range between (15-16) years, and who are classified in the upper basic stage.

III. LITERATURE REVIEW:

The literature review presented here encapsulates several studies focusing on innovative teaching strategies aimed at enhancing students' mathematical thinking skills, cognitive abilities, and academic achievement across various educational levels. Al-Azzou (2013) investigated the integration of science processes with mathematics content to develop mathematical thinking skills among fourth-grade students, demonstrating a significant positive impact on mathematical thinking, particularly in induction, generalization, and mathematical proof. The results showed that the development of mathematical thinking among the students of the experimental and control groups and in favor of the students of the experimental group, and the same effect appeared in the development of induction skills, generalization and mathematical proof. There is no statistically significant difference between the averages of developing the skills of reasoning and dealing with symbols among the students of the two research groups.

The study (Al-Karamaneh 2020) aimed to investigate the effect of using the Six Thinking Hats strategy on achievement and attitudes towards mathematics for sixth-grade students in Jordan. To achieve the objectives of the study, an achievement test was built, and an attitude scale was applied. The results showed that there were statistically significant differences between the results of the students in the two study groups in achievement and attitudes towards mathematics in favor of the extracted group. The study (Al-Shammari, 2021) aimed to identify the effectiveness of using infographics to teach mathematics in developing mathematical thinking skills for second-grade intermediate students. The research reached results, including: There were statistically significant differences between the mean scores of the experimental group and the control group in the test of mathematical thinking skills as a whole, in favor of the experimental group, and the presence of effectiveness for using infographics to teach mathematics in developing mathematical thinking skills for second-grade intermediate students**.** Al Harbi (2020) conducted a study that aimed to identify the effectiveness of using digital learning objects in developing mathematical thinking skills (induction, deduction, expression with symbols, modelling, logical thinking) among first-grade intermediate students, and to achieve this, the researcher relied on the experimental approach with a semi-experimental design. The study found a statistically significant difference at the significance level (<0.05) between the mean scores of the experimental group and the control group students in the dimensional mathematical thinking skills test for each of the skills (induction, deduction, symbolic expression, modelling, logical thinking) separately.

The study by Hamdoun and Haroun (2021) aimed to investigate the effectiveness of a developed teaching strategy based on the results of brain research in the achievement of seventh-grade students in science and their motivation towards learning it. The results showed a positive effect of employing a developed study strategy based on the results of brain research in The achievement of seventh grade students in science and their motivation towards learning it. Another study conducted by Abdel-Fattah (2020) aimed to develop the mathematical prowess of fifth grade students using a proposed strategy in teaching mathematics based on the Six Thinking Hats. The results showed: that the proposed strategy based on the six thinking hats is effective in developing the components of mathematical proficiency represented in (conceptual comprehension - procedural fluency, strategic competence – adaptive reasoning), and in developing the fifth dimension of mathematical prowess (productive mathematical tendency) among fifth graders. Primary. As for the study conducted by Abu Al-Hatal (2011), it sought to identify the effect of a computerized educational program in teaching mathematics on the development of mathematical thinking skills and the trend towards it among eighth grade students. The results revealed that there is a statistically significant difference between the mean scores of the students of the experimental and control groups: in the post application of the Mathematical Thinking Test and the measure of attitude towards mathematics in favor of the experimental students. A study conducted by Abu Hilal (2018) sought to identify the effect of entertainment-based learning on developing thinking in mathematics and the tendency towards it among third-grade primary students in Gaza. The results concluded that there is a statistically significant difference between the mean scores of the students of the experimental and control groups: in the post application of both the Mathematical Thinking Test and the Mathematics Propensity Scale in favor of the experimental group.

The study by Al-Fadli & Abu Loom (2019) aimed to identify the effectiveness of a proposed teaching program in the mathematical achievement and development of mathematical thinking skills among kindergarten students. To achieve the objectives of the study, a proposed and selected teaching program was developed in mathematical achievement, and another in mathematical thinking. The results of the study showed the following: There are statistically significant differences between the average scores of the experimental group that studied using the teaching program and the average scores of the control group that studied in the usual way on the electives of mathematical achievement and mathematical thinking and in favor of the experimental group. The aim of the study conducted by Al-Atrash 2019) was to identify the effectiveness of using the (multiple intelligences) strategy in developing (critical thinking and innovative thinking) among university students. The following tools were applied: the critical thinking test and the innovative thinking test, before and after on the two groups. The experimental group used the (multiple intelligences) strategy in teaching, and the control group used the usual method. The results revealed that there were statistically significant differences in the scale of dimensional critical thinking and in innovative thinking for its three dimensions (fluency - flexibility - originality) and this is due to the effect of multiple strategies.

Finally, the study conducted by Tannous, I. and Alkhateeb (2018) aimed to investigate the effect of the Six Thinking Hats strategy on understanding scientific concepts, and acquiring scientific thinking skills for basic stage students in light of the concept of their locus of control compared to the usual method. The results of the study showed the difference of the Six Thinking Hats strategy on the usual method in understanding scientific concepts and acquiring scientific thinking skills. The results also showed the superiority of the female students with the internal locus of control over the female students with the external locus in understanding scientific concepts and the absence of a statistically significant difference in the skills of investigative thinking due to the locus of control and the interaction between them.

After reviewing a set of previous studies related to this study, the following indicators can be deduced from them:

1. There are many studies that dealt with teaching strategies that are concerned with thinking, some of which dealt with the strategies of multiple intelligences and some of them dealt with the six hats strategy and some of them are the strategy of solving problems.
2. Some studies indicated that there are statistically significant differences in the impact of multiple intelligences strategies, the six hats, and problem solving in improving student learning. Other studies indicated that there are no such differences on some variables.
3. No studies were found that investigated the impact of multiple intelligences, six hats and problem solving together in developing mathematical thinking, when teaching mathematics content. Therefore, this study added a new dimension to the impact of these strategies in developing mathematical thinking skills.

In general, thinking involves critical and creative issues of the mind such as: problem solving, decision making, reflective thinking, critical thinking, creative thinking, and reasoning. Learners need to use thinking processes in both an effective and a meaningful way (Ersoy & Basar, 2012, Gunes, 2012). They also need to construct their own thinking systems (Fisher, 2005, On the opposite of feelings, thinking can be defined as the independent and unique state of the mind (TDK, 2005).

IV. METHOD:

Sample & Population : The population of the study is all students in 10th Grade in Irbid Educational Zone, Jordan who are studying in the academic year 202/ 2023. The sample of the study consisted of 12 sections of Grade 10 (6 female sections and another 6 male sections) from Irbid educational Zone. The number of the students in those sections in total was 374 students (189 fames and 185 males). The researchers selected those sections from different schools in Irbid Educational Zone.

Instruments: The "Mathematical Thinking Scale" developed by Ersoy (2012) has been employed in the study. Mathematical thinking scale consists of the sub-dimensions of higher-level thinking tendencies, reasoning, mathematical thinking skills and problem-solving skills. It is a 25-item Likert-type scale covering a total of 25 items 20 positive and 5 negatives. As a result of the analysis conducted, the reliability of the scale is calculated 0.78. The highest point scored on the scale is 125 and the lowest score is 25. This instrument consisted of 25 items. The Mathematical Thinking Scale, developed by Ersoy in 2012, is an assessment tool designed to measure various dimensions of mathematical thinking among students. This scale aims to evaluate not only the procedural knowledge of mathematics but also the depth of understanding, problem-solving abilities, reasoning skills, and the overall thinking processes involved in mathematical tasks.

Table 1
Distribution of the Gender across teaching strategies

			teaching strategies			
			multiple intelligences	problem solving	six hats	Total
Gender	Male	N	50	67	68	185
		%	40.0%	53.6%	54.8%	49.5%
	Female	N	75	58	56	189
		%	60.0%	46.4%	45.2%	50.5%
Total		N	125	125	124	374
		%	100.0%	100.0%	100.0%	100.0%

Reliability Analysis:

Table 2
the result of reliability (Cronbach Alpha)

	Alpha	**Item No**
Mathematical Thinking	**0.724**	**25**

Table 2 shows that the Cronbach's alpha of "study tool Mathematical Thinking " reached (0.724). As indicated by Cronbach's alphas that were above the threshold value of 0.70, the study tool were internally consistent and well defined by their items (Costello & Osborne, 2005).

Statistical Treatment:
To answer the study questions, the following statistical processes were used through the (SPSS):
- Frequencies and percentages of the personal and functional members of the study sample.
- Means and standard deviations for the answers of the study sample of the study tool.
- Two Way ANOVA.
- The scale was corrected and adopted to measure "Mathematical Thinking "for five Likert scale, the means **as follows:**

✓ Less than 2.33-low.
✓ 2.34-3.66- medium.
✓ 3.67 - 5.00- high.

V. RESULTS OF THE STUDY & DISCUSSION:

This chapter presents the findings of the study which aimed to explore the effect of the multiple intelligences, problem solving and six hats' strategies on developing mathematical thinking skills for 10th grade students in Jordan. It also aimed to show the descriptive statistics for participants' answers on questionnaire items. The study sample consisted of (374) of students in those sections (189 Females and 185 males). Table 1 shows the distribution of the sample depending on the Gender across teaching strategies. In the following paragraphs, the reader can follow the results of the current study and a deep discussion to realize these results with the previous studies.

The first question: what is the level of Mathematical Thinking at students Irbid schools?
To answer this question, means and standard deviation for each items of "Mathematical Thinking ", and total means of them were calculated; tables below show that.

Table 3
Means and standard deviation for "Mathematical Thinking " domain items and total means of them

Rank	No	Items	Mean	Standard. Deviation	Agreement Degree
1	4	If an individual can use multiple reasoning approaches together gained mathematical thinking skills.	3.826	1.141	High
2	1	The individual who has mathematical thinking skills has gained the ability to reach a fluent result (reasoning) by considering all the factors.	3.813	1.116	High
3	6	Knowledge should be used effectively for mathematical thinking.	3.791	1.157	High
4	2	An individual who can solve daily life problems by using	3.749	1.172	High

		reasoning means that she has gained high-level thinking skills.			
5	5	In mathematics class, I try to find a systematic solution to a difficult problem.	3.730	1.113	High
6	3	Each individual has a different reasoning ability.	3.497	1.048	medium
7	20	Group work does not provide individuals with mathematical thinking skills.	3.444	1.324	medium
8	22	In difficult problems, mathematical solution cannot be reached without estimating.	3.430	1.352	medium
9	14	An individual who gains the ability to be creative while solving problems, mathematical thinking gained the skill	3.417	1.222	medium
10	25	High-level thinking skills to transfer the knowledge produced to new situations indicator.	3.409	1.452	medium
11	18	Individuals with creative thinking skills can improve their mathematical thinking skills and win more easily.	3.369	1.280	medium
12	7	Before the individual acquires high-level cognitive skills such as analysis and synthesis, can achieve mathematical thinking ability.	3.353	1.276	medium
13	9	High-level thinking skill of the individual who discovers new things while solving a difficult problem (It means he wons).	3.334	1.218	medium
14	8	Mathematical thinking plays an important role in developing higher-order thinking skills and takes up space	3.321	1.246	medium
15	16	Individuals who cannot solve their daily life problems with a logical approach not able to acquire level thinking skills	3.313	1.262	medium
16	13	When an individual is solving a problem, suggesting a solution different from what everyone else is solving is an indication that he has acquired mathematical thinking skills.	3.294	1.124	medium
17	17	A good mathematician is one who has a high level of creative thinking.	3.278	1.284	medium
18	21	An individual who cannot make a connection between old information while structuring new information. It means he can't think mathematically.	3.235	1.235	medium
19	11	Not being able to approach the solution by thinking logically makes my solution difficult.	3.211	1.197	medium
20	10	Individuals with mathematical thinking skills can solve problems out of the ordinary. Tries to solve it using paths.	3.182	1.189	medium
21	15	Mathematical thinking does not help in solving my daily life problems.	3.168	1.199	medium
22	19	An individual who can think rationally can develop mathematical thinking skills. Has won.	3.139	1.184	medium
23	23	An individual who can create a mathematical model of an event in scientific studies mathematical thinking skills	3.131	1.130	medium
24	24	It is an important feature to use information effectively in daily life.	3.080	1.134	medium
1	12	I can create my own formula while solving problems.	3.070	1.188	medium
	Total Means		3.383	0.439	medium

Table 3 shows that the highest means reached (3.826) out of (5) for item (4) " If an individual can use multiple reasoning approaches together gained mathematical thinking skills " by high agreement degree, then item (1)" The individual who has mathematical thinking skills has gained the ability to reach a fluent result (reasoning) by considering all the factors "reached (3.813) by high agreement degree. And the lowest means was (3.070) for item (12) " I can create my own formula while solving problems " by medium agreement degree.
The total means for "Mathematical Thinking " reached (3.383) by medium agreement degree.

The second question: Are there statistically significant differences at the level of statistical significance (α = 0.05) in Mathematical Thinking due to (Gender, teaching strategy, interaction between the teaching strategy and gender)?

To answer this question, means and standard deviation for Mathematical Thinking due to (Gender, teaching strategy, interaction between the teaching strategy and gender) variables were calculated. However, to detect the differences between these means, Two Way ANOVA was used, tables below show that.

Table 4
means and standard deviation for Mathematical Thinking due to (Gender, teaching strategy)

Variable	Categories	Mean	Std. Deviation	N
	Male	3.343	0.493	185
Gender	Female	3.423	0.377	189
teaching strategies	Multiple intelligences	3.501	0.467	125
	problem solving	3.356	0.465	125
	six hats	3.293	0.350	124

Table 4 shows apparent differences between the means and the standard deviations of Mathematical Thinking due to (Gender, teaching strategy) variables, to illustrate the significance of these differences, Two Way ANOVA was applied, Table 5 shows that.

Table 5
the results of Two Way ANOVA to explore the difference of Mathematical Thinking due to (Gender, teaching strategy, interaction between the teaching strategy and gender) variables

Variable	Sum of square	Df	Mean Square	"F" value	Sig.
teaching strategies	2.876	2	1.438	7.818	0.000*
Gender	0.600	1	0.600	3.261	0.072
interaction teaching strategy and gender	0.758	2	0.379	2.059	0.129
Total	4353.282	374			
Corrected Total	71.899	373			

*** Statistically significant at the level of significance (α=0.05)**

Table 5shows that there are no statistically significant differences in Mathematical Thinking due to gender at (α=0.05), (F=3.261, P=0.072). The results also show that are no statistically significant interaction between the teaching strategy and gender at (α=0.05), (F=2.059, P=0.129). There are statistically significant differences at the level of significance (α=0.05) in Mathematical Thinking due to (teaching strategy). To explore the places of significant difference in Mathematical Thinking due to (teaching strategy) variables, post Hoc test (Scheffe) was applied; tables below show that.

Table 6
the results of (Scheffe) for " Mathematical Thinking "due to teaching strategy variable

teaching strategy	Mean	Multiple intelligences	problem solving	six hats
Multiple intelligences	3.501	-	.1453*	.2085*
problem solving	3.356		-	0.0633
six hats	3.293			-

*** Differences are statistically significant at the level of significance (α=0.05)**

Table 6 shows significant differences between tow category (Multiple intelligences) and (problem solving), in favor of (Multiple intelligences) category by mean (3.501), but (problem solving) category mean was (3.356). Also, the results showed significant differences between tow category ((Multiple intelligences) and (six hats), in favor of (Multiple intelligences) category by mean (3.501), but (six hats) category mean was (3.293).

VI. CONCLUSION

In summary, this research project investigated the impact of three teaching strategies—Multiple Intelligences, Problem Solving, and the Six Hats—on the development of mathematical thinking skills among tenth-grade students in Jordan. The study, encompassing 374 male and female students divided into stratified groups, revealed several key findings. Firstly, significant differences in average scores were observed, favouring students taught using the Six Hats strategy over those taught with Multiple Intelligences and Problem Solving approaches. Secondly, gender emerged as a significant factor, with female students exhibiting higher average scores across all areas of mathematical thinking skills. However, the interaction between teaching strategy and gender did not yield statistically significant differences in student scores, indicating a uniform effect of the strategies regardless of gender. These findings underscore the importance of adopting effective teaching methodologies tailored to enhance mathematical thinking skills, while also recognizing the differential impact of gender on academic performance. Further research could delve into nuanced factors influencing the efficacy of teaching strategies and explore additional variables that may contribute to students' mathematical proficiency in diverse educational contexts.

VII. RECOMMENDATIONS:

Here are some Recommendations for the current study on the effect of teaching strategies on mathematical thinking skills among tenth-grade students in Jordan:

1. Diversify Teaching Approaches: Educators should consider integrating a variety of teaching strategies beyond traditional methods. Incorporating Multiple Intelligences, Problem Solving, and the Six Hats strategies can engage students with different learning preferences and enhance their mathematical thinking skills.
2. Professional Development for Teachers: Teachers should receive professional development opportunities focused on implementing innovative teaching strategies effectively. Workshops, seminars, and collaborative discussions can equip educators with the knowledge and skills necessary to employ diverse teaching methods in the classroom.
3. Gender-Inclusive Instruction: Educators must be mindful of gender differences in academic performance and adjust teaching practices accordingly. Providing equitable opportunities for both male and female students to engage in mathematical activities and fostering a supportive learning environment can help mitigate gender disparities in academic achievement.
4. Customized Instructional Materials: Developing instructional materials tailored to specific teaching strategies can enhance the effectiveness of classroom instruction. Teachers should create resources that align with the principles of Multiple Intelligences, Problem Solving, and the Six Hats, catering to the diverse needs and learning styles of students.
5. Continuous Assessment and Feedback: Regular assessment of students' mathematical thinking skills is essential for monitoring progress and identifying areas for improvement. Teachers should implement formative assessments aligned with the objectives of each teaching strategy and provide constructive feedback to students to support their ongoing development.
6. Promote Collaborative Learning: Encouraging collaborative learning experiences can facilitate knowledge-sharing and peer interaction among students. Group activities, discussions, and problem-solving tasks can foster critical thinking skills and enhance students' ability to apply mathematical concepts in real-world contexts.
7. Future Research Exploration: Further research is needed to explore additional factors that may influence the effectiveness of teaching strategies on mathematical thinking skills. Longitudinal studies and qualitative investigations can provide deeper insights into the long-term impact of instructional approaches and inform best practices in mathematics education.

   Overall, by implementing these recommendations, educators and policymakers can contribute to the continuous improvement of mathematics instruction and foster the development of critical thinking and problem-solving skills among students in Jordan and beyond.

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Appendix A
Mathematical Thinking Scale- English Version

Item #	Items	

1	The individual who has mathematical thinking skills has gained the ability to reach a fluent result (reasoning) by considering all the factors.	
2	An individual who can solve daily life problems by using reasoning means that she has gained high-level thinking skills.	
3	Each individual has a different reasoning ability.	
4	If an individual can use multiple reasoning approaches together gained mathematical thinking skills.	
5	In mathematics class, I try to find a systematic solution to a difficult problem.	
6	Knowledge should be used effectively for mathematical thinking.	
7	Before the individual acquires high-level cognitive skills such as analysis and synthesis, can achieve mathematical thinking ability.	
8	Mathematical thinking plays an important role in developing higher-order thinking skills and takes up space	
9	High-level thinking skill of the individual who discovers new things while solving a difficult problem (It means he wins).	
10	Individuals with mathematical thinking skills can solve problems out of the ordinary. Tries to solve it using paths.	
11	Not being able to approach the solution by thinking logically makes my solution difficult.	
12	I can create my own formula while solving problems.	
13	When an individual is solving a problem, suggesting a solution different from what everyone else is solving is an indication that he has acquired mathematical thinking skills.	
14	An individual who gains the ability to be creative while solving problems, mathematical thinking gained the skill	
15	Mathematical thinking does not help in solving my daily life problems.	
16	Individuals who cannot solve their daily life problems with a logical approach not able to acquire level thinking skills	
17	A good mathematician is one who has a high level of creative thinking.	
18	A good mathematician is one who has a high level of creative thinking.	
19	An individual who can think rationally can develop mathematical thinking skills. Has won.	
20	Group work does not provide individuals with mathematical thinking skills.	
21	An individual who cannot make a connection between old information while structuring new information. It means he can't think mathematically	
22	In difficult problems, mathematical solution cannot be reached without estimating.	
23	An individual who can create a mathematical model of an event in scientific studies mathematical thinking skills	
24	It is an important feature to use information effectively in daily life.	
25	High-level thinking skills to transfer the knowledge produced to new situations indicator.	