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The Effectiveness of SWOM Strategy on Developing Branching Thinking Skills and Solving Numerical Physics Problems for Language Secondary Stage Students with Different Cognitive Style

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Abstract

This study aimed at investigating the effectiveness of SWOM strategy on developing branching thinking skills and solving numerical physics problems for language secondary stage students with different field dependent (FD) and field independent (FI) cognitive style in the first semester of academic year 2022/2023. This study depended on a quasi-experimental design. Data were collected through a hidden figure test, a branching thinking skills test, and a solving physics problems skills test. The study sample consisted of (60) participants from first grade Secondary Stage, which was distributed into two groups: experimental group (n=30) and control group (n=30). The results revealed the following: there is a significant effect of SWOM strategy on enhancing students' branching thinking and solving numerical physics problems skills. There are significant differences in solving numerical physics problems between students with field different field dependent (FD) and field independent (FI) cognitive style. The researcher recommends that physics teacher should pay attention to students' differences in cognitive styles, especially in the FD/FI cognitive style.

Keywords: SWOM Strategy, Branching Thinking, Physics Problems, Cognitive Style, Field Dependent, Field Independent.

Introduction:

Learners' understanding the purpose of their education is reflected in their behavior and lead to meaningful learning. Also, it contributes to keep pace with the current cognitive development. Thus, it is important to teach students how to think to understand what they learn. Developing thinking is an urgent demand to help students be able to face the society challenges.

In addition, Creative responding is a helpful skill for adapting to the demands of a highly complicated and evolving society (Lee, 2004). Rabari, Indoshi& Omusonga (2011) confirms that creativity and innovative thinking are viewed as the essential abilities to successfully address unforeseen challenges that call for innovative solutions in a world that is undergoing rapid transformation.

Antink-Meyer& Lederman (2015) refer that branching thinking recognized as an essential component of creativity. Branching thinking is an important thinking to generate creative and innovative solutions to a given problem (Reddy, Iyer, Sasikumar, 2016). It is a type of thinking that helps learners to find various answers and solutions to problems (Wronska, Bujacz, Goclowska, Rietzschel& Nijstad, 2019).

On the other hand, Hidayati, Supriyati& Budi (2021) documented that the ability to think is required in problem solving, particularly in physics. They also confirm that an individual’s branching thinking way can help in solving a problem and achieving a certain goal by employing various ways or ideas that are not only one-way.

In spite of the importance of problem solving, students continue to struggle with poor mastery of problem-solving skills. Gambari& Yusuf (2015) agreed that poor performance caused by a variety of factors, including students' lack of problem-solving skills and mathematical ability. Thus, devolving problem-solving skills is an important demand.

Serway& Jewett (2018) strongly advised developing the skills required to solve a wide range of problems in keeping with the statement of Feynman, Nobel laureate in physics “You do not know anything until you have practiced”. They also stated that solving problems skills will be one of the main tests of physics knowledge and advised trying to solve as many problems as possible Hegde& Meera (2008) noticed that training in solving physics problems can help learners in acquiring the required skills.

On the other side, lee (2004) agreed that traditional instructional methods largely ignored encouraging thinking. Physics difficulties are caused by a variety of factors, including the lack of physics learning process that does not enhance students' problem-solving skills (Adianto& Rusli, 2021). As a result, it is critical to employ methods that rely on skill training in either thinking or problem solving.

In the same context, one of these methods is the SWOM strategy. It is one of the metacognitive strategies that focuses on teaching students both creative and critical thinking skills through educational activities that help integrate ideas for understanding (Routman, 2012). It aims to prepare a generation of intellectuals, producers and lifelong learners by integrating a set of skills in teaching different disciplines according to clear techniques and practical procedures (www.idrac.org).

According to El-Banna& Al-Ghannam (2001, in Arabic), focusing on teaching methods without considering students' personal preparations resulted in deficiencies in the teaching and learning process. Learning process is a form of student interaction with both teaching methods and environment (Hardiyansyah, Doyan, Jufri, Susilawati& Jamaluddin, 2019).

Therefore, taking into consideration the students' differences, in addition to teaching strategies, is an essential demand.

One of these differences is cognitive style, which referred to individual differences in preferred methods of processing information (e.g., perception, organization, analysis) using cognitive brain-based mechanisms and structures (Armstrong, Peterson, & Rayner, 2012). The most widely investigated cognitive style is field dependence (FD) and field independence (FI). It can be also known as a psychological differentiation, which refers to the extent to which an individual is dependent versus independent of the organization of the surrounding perceptual field (Sternberg& Grigorenko, 1997). A person with FD cognitive style prefers to consider at one pattern as a whole. It is difficult to focus on one element or to analyze the pattern to another. In contrast, a person with FI cognitive style can achieve more separate parts from the whole pattern and analyze the pattern into its elements (Anif, Prayitno, Narimo, Fuadi, Sari & Adnan, 2021).

As a result of students' differences in cognitive style, which affects their thinking and problem-solving abilities as well as their interactions with different teaching strategies, it is critical to investigate the impact of the difference in cognitive style on using the SWOM strategy on developing branching thinking skills and solving numerical physics problems.

Statement of the Problem:

The research problem can be formulated in the following main question:

Is there any statistically significant effect at the level ($\alpha \leq 0.05$) for either teaching method, cognitive style, or the duel interaction between them on the branching thinking skills and solving physics problems skills for first grade secondary stage students in language schools?

This main question is subdivided into the following sub-questions:

1. Is there any statistically significant effect at the level ($\alpha \leq 0.05$) for either teaching method, cognitive style, or the duel interaction between them on the branching thinking skills for first grade secondary stage students in language schools?
2. Is there any statistically significant effect at the level ($\alpha \leq 0.05$) for either teaching method, cognitive style, or the duel interaction between them on solving physics problems skills for first grade secondary stage students in language schools?

Research Aims:

The present research aimed at achieving the following aims:

1. To identify the effectiveness of SWOM Strategy on developing branching thinking skills for language secondary stage students with different cognitive style.
2. To identify the effectiveness of SWOM strategy on developing solving numerical physics problems for language secondary stage students with different cognitive style.

Research Significance:

The Significance of the current research can be represented in the following points:

1. Attracting the attention of physics teacher to use SWOM strategy instead of traditional method.
2. Providing physics teachers with SWOM strategy procedural steps that contribute to the development of different thinking skills and solving physics problems.
3. Contributing to the development of some branching thinking skills among first-grade secondary students.
4. Developing physics problem solving skills among first-grade secondary students.
5. Providing physics teachers with a teacher's guide and student activity book in the second unit, Linear Motion, in light of the SOWM strategy that can be used as a guide for teaching other units.
6. Providing researchers with procedural results for the SWOM strategy.

Research Design:

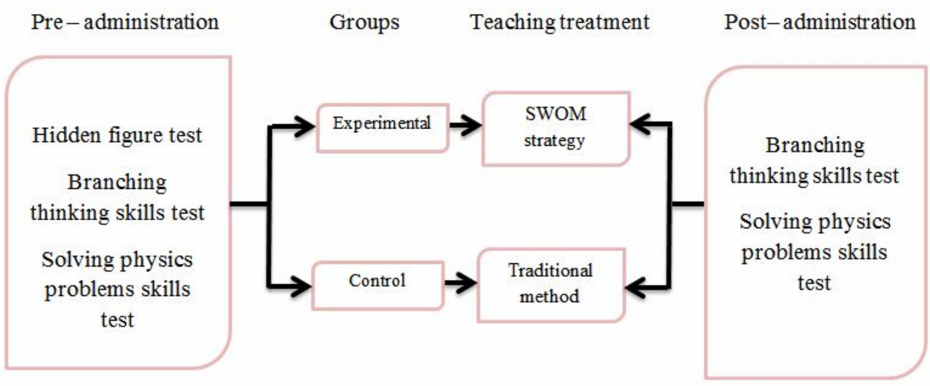

Figure (4) Quasi- experimental Design

Literature Review:

SWOM strategy:

The SWOM strategy called the All-Inclusive School Model, which is built on the philosophy of the US National Center and in collaboration with the Idrak Center in Abu Dhabi. (aseery@emirates.net.ae) The SWOM strategy was created by Omer Ahmed, the Director of Idrak Center for Learning Thinking and Talent Development in the United Arab Emirates, as a response to learners' needs to learn and practice thinking skills. This strategy relies on integrating thinking skills into content in order to improve students' learning. The SWOM strategy is the abbreviation of the first letter of each word in the English language, which is known as the School Wide Optimum Model, the wide ideal model for each school. (aseery@emirates.net.ae).

The definition of SWOM strategy:

It refers to integrating thinking skills into the curriculum using a set of organized ideas and questions that the teacher follows when teaching critical and creative thinking skills, in a way that ensures the improvement of students' thinking in the future and enhances the content learning process (Swartz, 2003).

Also Al Hashemi and Al Dulaimi (2008, in Arabic) define it as one of the most recent trends in teaching thinking skills that aims to improve learning in order to prepare a conscious generation that thinks holistically through a set of organized questions that the teacher and student follow when studying a specific topic.

Branching Thinking:

One of the ultimate goals of science is the development of thinking skills. As thinking involves a variety of cognitive activities, including memory and curiosity, observation and attention, imagination, and judgment (Valijonovna & Qizi, 2022). In addition, thinking is a mental process that underpins our era's massive scientific progress. Thus, pedagogues seek to enhance students' branching thinking as it is a type of thinking.

Alhanan (2016, in Arabic) pointed out that branching thinking is based on current educational principles that aim to achieve the greatest possible link between concepts, ideas, and information related to a subject in order to achieve effective learning with meaning. Furthermore, branching thinking allows many ideas and alternative solutions to be explored, and unexpected connections are formed as it occurs in a spontaneous, free-flowing manner. (Ni, Li Yang, Jinzi Chen, Hong Chen& Li, 2014).

Characteristics of Branching Thinking:

Branching thinking is characterized by its ability to opens new avenues for thought by employing various strategies to solve a specific problem or task. (Aderonmu, Ideozu& Otuaga, 2014).

While, Herbert (2016) refers that branching thinking is characterized by:

- Defer making judgments.
- Look for novelty.
- Establish connections.

On the other hand, Mardiana& Kuswanto (2017) ensure that branching thinking is distinct from creativity in that it is the ability to think from a central point and then spread out in various directions. Also, refer to the fact that branching thinking is required in order to generate creative ideas.

Therefore, branching thinking can be regarded as an indicator of creativity, and this is supported by Runco& Acar (2012) as they illustrate that branching thinking usually leads to originality, which is the major characteristic of creativity.

Numerical physics problems skills:

Physics is one of the scientific disciplines that plays a critical role in the development of science and technology. (Naqiyah, Rosana, Sukardiyono& Ernasari, 2020). Furthermore, problem-solving skills are regarded as the core of learning physics. Therefore, students' possession of the problem solving skills is indispensable. Anderson explained that Problem solving is a skill that includes the analyzing, interpreting, reasoning, predicting, evaluating, and reflecting processes. Thus, students who are able to gain problem-solving skills will be able to solve their life problems by using their physics skills (Marwazi, Masrukan& Putra, 2019).

The skills of solving physics problem:

Various perspectives on identifying problem-solving skills are revealed; some of these perspectives are discussed in the following paragraphs:

According to Docktor, Strand, Mestre, and Ross (2015), there are five skills for solving physics problems, including:

1. Focus on the problem.
2. Describe its relation to the concept of physics.
3. Planning solutions.
4. Execute the plan.
5. Evaluate solutions.

. In addition, Zaitoun (2002, in Arabic) stated four general skills for solving physics problems; each skill consists of subskills as follows:

1. **Identify problem's variables:**
    a. Understand the problem.
    b. Determine the givens and requires.
    c. Draw the problem if possible.
2. **Planning to solve the problem:**
    a. Select the appropriate strategy.
    b. Determine the used law.
3. **Implement the solution plan:**
    a. Standardize the units.
    b. Use the law.
    c. Implement the mathematical processes.
4. **Solution evaluation and interpretation:**
    a. Review the solution's steps.
    b. Interpret the solution.

Polya also proposes four steps for solving problems: (Selçuk,& Çalýskan, 2008)

1. **Understanding the problem:** means realizing what is required.
    a. What is the requirement?
    b. What are the givens?
    c. Can you draw a figure?
2. **Devising a plan:** Finding the relation between the data and the unknown
    a. Have you seen a similar problem before?
    b. Do you know a law that could be useful?
    c. Did you use all the data?
3. **Carrying out the plan:** Carrying out your plan and check each step.
    a. Can you see clearly that the step is correct?
    b. Can you prove that it is correct?
4. **Looking back:** Examine the solution obtained
    a. Can you check the result?
    b. Can you derive the solution differently?

Cognitive styles:

The learning process occurs as a result of the interaction of the learning environment's components, which include curriculum content, teaching strategies, teachers, means, and activities on the one hand, and the preparations, mental abilities, and personal characteristics of students on the other. (El-Banna& Al-Ghannam, 2001, in Arabic) Thus, it is important to take students' characteristics into consideration when selecting a teaching strategy.

Every individual differs in their ability to solve problems, intelligence level, and ability to think. Students, in particular, differ in how they obtain information, organize it, apply knowledge, and respond to specific teaching methods (Prayekti, 2018). Danili (2004) explains that individuals' differences in arranging and processing information as well as their experiences enable them to have different cognitive styles.

The current study is concerned with **field dependent/independent** cognitive style. Witkin & Moore state that individuals with global characteristics prefer to receive things from a global perspective and struggle to separate themselves from their surroundings Individuals who exhibit these characteristics are said to have a FD cognitive style. While individuals with analytical characteristics tend to explain things by providing loose descriptions drawn from their surroundings and are also able to separate objects from their surroundings. Individuals who exhibit these characteristics are said to have a FI cognitive style (Prayekti, 2018).

Research Hypotheses:

This study attempted to verify the following hypotheses:

1. There is no statistically significant effect at the level ($\alpha \leq 0.05$) for either teaching method, cognitive style, or the interaction between them on the branching thinking skills for first grade secondary stage students in language schools.
2. There is no statistically significant effect at the level ($\alpha \leq 0.05$) for either teaching method, cognitive style, or the interaction between them on the solving physics problems skills for first grade secondary stage students in language schools.

Methodology:

In order to achieve the aims of the study, the following steps were applied:

1. The experimental methodology with quasi-experimental design was adopted.
2. Select a research sample from the first grade secondary students. The sample consisted of (60) students who were enrolled in two language schools: Ahmed Mowafy Distinguished Language School and Talkha Official Distinguished Language School (2). Four classes were selected from the two schools, two from each school.

3. Select the content from the physics text book for first grade secondary students for the first semester of the academic year (2022/2023).
4. Prepare teacher's guide.
5. Prepare student's activity book.
6. Prepare research instruments.
7. Applying the tests to a pilot sample of (30) students in the first grade of the secondary stage enrolled in Fakhr Al Dakahlia Governmental Language Schools (other than the basic study sample) to calculate the test reliability coefficient and internal consistency.
8. Carrying out the pre- application of the study tests on both groups.
9. Applying the experiment.
10. Carrying out the post- application of the study tests on both groups.
11. Statistically analyzing the collected data.
12. Presenting the results of the study.
13. Providing a set of recommendations.

Statistical methods:

The following Statistical methods were applied to verify the research hypotheses:

1. Pearson correlation coefficient.
2. Kuder Richardson Equation 21.
3. T-test for independent samples.
4. Two-way ANOVA to study the effect of both teaching method, cognitive style and the interaction between them.

Results and Dissections:

Testing the first hypothesis:

3. The first hypothesis stated that **“**There is no statistically significant effect at the level ($\alpha \leq 0.05$) for either teaching method, cognitive style, or the interaction between them on the branching thinking skills for first grade secondary stage students in language schools.”

To test this hypothesis, the researcher depends on the means and standard deviations of the students’ scores in the post-test of branching thinking skills, as shown in the following table:

Table (1): Means and standard division of the study group in the post-administration of branching thinking skills.

Dimensions	Groups	Cognitive style	N	Means	S.D
Realizing new relationships	Experimental	Indep	18	5.72	1.18
		Dep	12	4.75	0.87
		Total	30	5.33	1.15
	Control	Indep	13	4.00	0.91
		Dep	17	4.00	1.06
		Total	30	4.00	0.98
	Total	Indep	31	5.00	1.37
		Dep	29	4.31	1.04
		Total	60	4.67	1.26
Reclassification	Experimental	Indep	18	5.61	1.72
		Dep	12	5.67	1.15
		Total	30	5.63	1.49
	Control	Indep	13	4.46	1.66
		Dep	17	4.59	1.42
		Total	30	4.53	1.50
	Total	Indep	31	5.12	1.76
		Dep	29	5.03	1.40
		Total	60	5.08	1.59
Introducing new improvements	Experimental	Indep	18	5.56	1.29
		Dep	12	5.50	1.57
		Total	30	5.53	1.38
	Control	Indep	13	4.00	1.15
		Dep	17	3.76	1.44
		Total	30	3.87	1.31
	Total	Indep	31	4.90	1.45
		Dep	29	4.48	1.70
		Total	60	4.70	1.58
Synthesis and assembly	Experimental	Indep	18	6.11	1.45
		Dep	12	5.67	1.15
		Total	30	5.93	1.34
	Control	Indep	13	4.15	1.72
		Dep	17	3.94	1.34
		Total	30	4.03	1.49
Synthesis and authoring	Total	Indep	31	5.29	1.83
		Dep	29	4.65	1.51
		Total	60	4.98	1.70
Total score	Experimental	Indep	18	23.05	4.98
		Dep	12	21.67	3.49
		Total	30	22.50	4.43
	Control	Indep	13	16.46	3.62
		Dep	17	16.24	4.19
		Total	30	16.33	3.89
	Total	Indep	31	20.29	5.49
		Dep	29	18.48	4.72
		Total	60	19.42	5.17

It is clear from the results in Table (1) that there are differences between the means of the study group. Results also demonstrated the superiority of experimental group over control group in both dimensions of branching thinking skills and the total score.

In order to determine the effect of the teaching methods, cognitive style, and interaction between them on the branching thinking (dimensions and total score), the researcher used the Two –Way ANOVA. the results were as following:

Table (2): The results of two ways ANOVA for the differences between the study groups in the post-administration of branching thinking skills.

Dimensions	Variance resources	Sum of squares	df	Mean squares	f	Sig. level	η^2
Realizing new relationships	Cognitive style level (A)	3.44	1	3.44	3.22	0.078	0.054
	Teaching Treatment (B)	22.25	1	22.25	20.81	0.000	0.271
	Interaction (A×B)	3.45	1	3.45	3.22	0.078	0.054
	Inside groups (Error)	59.86	56	1.06			
	Corrected Total	93.33	59				
Reclassification	Cognitive style level (A)	0.120	1	0.120	0.051	0.82	0.001
	Teaching Treatment (B)	18.07	1	18.07	7.77	0.007	0.122
	Interaction (A×B)	0.018	1	0.018	0.008	0.929	0.001
	Inside groups (Error)	130.29	56	2.326			
	Corrected Total	148.58	59				
Introducing new improvements	Cognitive style level (A)	0.308	1	0.308	0.165	0.686	0.003
	Teaching Treatment (B)	39.43	1	39.43	21.13	0.000	0.274
	Interaction (A×B)	0.118	1	0.118	0.063	0.802	0.001
	Inside groups (Error)	104.50	56	1.87			
	Corrected Total	146.60	59				
Synthesis and assembly	Cognitive style level (A)	1.57	1	1.57	0.765	0.385	0.013
	Teaching Treatment (B)	49.38	1	49.38	24.03	0.000	0.300
	Interaction (A×B)	0.195	1	0.195	0.095	0.759	0.002
	Inside groups (Error)	115.07	56	2.055			
	Corrected Total	170.98	59				
Total	Cognitive style level (A)	9.49	1	9.49	0.535	0.467	0.009
	Teaching Treatment (B)	526.55	1	526.55	29.67	0.000	0.346
	Interaction (A×B)	4.92	1	4.92	.277	0.601	.005
	Inside groups (Error)	993.90	56	17.74			
	Corrected Total	1578.58	59				

Additionally, it is noticed from Table (2) that the effect of SWOM strategy on all branching thinking dimensions and the total score is high, except for reclassification dimension, which has a value of $\boldsymbol{\eta^2}$ 0.12, indicating a medium effect.

It is also obvious that the effect of cognitive style on all branching thinking dimensions and the total score is low, as all values of $\boldsymbol{\eta^2}$ are less than 0.6. Moreover, the size of the effect of the interaction between the teaching method and cognitive style on all branching thinking dimensions and the total score is low.

4. In the light of the previous results, the null hypothesis was partially rejected, which stated that "There is no statistically significant effect at the level ($\alpha \leq 0.05$) for either teaching method, cognitive style, or the interaction between them on the branching thinking skills for first grade secondary stage students in language schools."

The alternative hypotheses were accepted, which state that:

- "There is statistically significant effect for teaching method at the level ($\alpha \leq 0.05$) between the mean scores of the study groups in the post administration of the branching thinking skills test(dimensions and total score). "
- "There is no statistically significant effect for cognitive style and the interaction between the teaching method and cognitive style at the level ($\alpha \leq 0.05$) between the mean scores of the study groups in the post administration of the branching thinking skills test(dimensions and total score)."

The previous results demonstrated the superiority of the experimental group that was taught with the SWOM strategy over the control group that was taught with the traditional method in all branching thinking dimensions and the total score. **These results could be explained in light of previous related studies and theoretical frameworks for the following reasons:**

- The SWOM strategy goes through organized and related steps that help students to think in an organized manner, which led to develop thinking skills.
- The SWOM strategy depends on integrating thinking skills with content that provides students opportunities to practice some skills that contributed effectively to the development of branching thinking skills.

- Branching thinking skills require practice and training. This is the core of the SWOM strategy, which is based on continuous and extensive skill training.
- The SWOM strategy allows students to discuss with other classmates while thinking actively, which contributes to sharing ideas. These helped students generate a variety of ideas and solutions, which led to the development of branching thinking skills.
- Diversity in practicing and applying different skills related to branching thinking through SWOM strategy contributes to the development of the branching thinking skills.

Testing the second hypothesis:

5. The second hypothesis stated that **"**There is no statistically significant effect at the level ($\alpha \leq 0.05$) for either teaching method, cognitive style, or the interaction between them on the solving physics problems skills for first grade secondary stage students in language schools."

To test this hypothesis, the researcher depends on the means and standard deviations of the students' scores in the post-test of solving physics problems skills, as shown in the following table:

Table (3): Means and standard division of the study group in the post-administration of solving physics problems skills.

Dimensions	Groups	Cognitive style	N	Means	S.D
Understanding the problem	Experimental	Indep	18	6.00	1.03
		Dep	12	4.92	0.79
		Total	30	5.57	1.07
	Control	Indep	13	3.62	0.87
		Dep	17	2.71	1.05
		Total	30	3.10	1.06
	Total	Indep	31	5.00	1.53
		Dep	29	3.62	1.45
		Total	60	4.33	1.63
Devising a plan	Experimental	Indep	18	5.72	1.36
		Dep	12	4.58	0.67
		Total	30	5.27	1.26
	Control	Indep	13	3.31	0.75
		Dep	17	2.76	0.97
		Total	30	3.00	0.91
	Total	Indep	31	4.71	1.66
		Dep	29	3.52	1.24
		Total	60	4.13	1.58

Dimensions	Groups	Cognitive style	N	Means	S.D
Carrying out the plan	Experimental	Indep	18	8.72	2.08
		Dep	12	7.17	1.85
		Total	30	8.10	2.11
	Control	Indep	13	6.85	1.77
		Dep	17	3.82	1.33
		Total	30	5.13	2.15
	Total	Indep	31	7.94	2.14
		Dep	29	5.21	2.27
		Total	60	6.62	2.58
Looking back	Experimental	Indep	18	4.00	0.84
		Dep	12	3.17	0.72
		Total	30	3.67	0.88
	Control	Indep	13	2.31	1.25
		Dep	17	1.65	0.70
		Total	30	1.93	1.01
	Total	Indep	31	3.29	1.32
		Dep	29	2.28	1.03
		Total	60	2.80	1.29
Total score	Experimental	Indep	18	24.44	4.02
		Dep	12	19.83	2.85
		Total	30	22.60	4.22
	Control	Indep	13	16.08	3.20
		Dep	17	11.00	3.08
		Total	30	13.20	4.00
	Total	Indep	31	20.95	5.56
		Dep	29	14.66	5.31
		Total	60	17.90	6.25

It is clear from the results in Table (3) that there are differences between the means of the study group. Results also demonstrated the superiority of experimental group over control group in both dimensions of solving physics problems skills and the total score.

In order to determine the effect of the teaching methods, cognitive style, and interaction between them on the solving physics problems (dimensions and total score), the researcher used the Two –Way ANOVA. The following table shows the results:

Table (4): The results of two ways ANOVA for the differences between the study groups in the post-administration of solving physics problems skills.

Dimensions	Variance resources	Sum of squares	Df	Mean squares	f	Sig. level	η^2
Understanding the problem	Cognitive style level (A)	14.46	1	14.46	15.72	0.000	0.219
	Teaching Treatment (B)	76.89	1	76.89	83.57	0.000	0.599
	Interaction (A×B)	0.110	1	0.110	0.120	0.731	0.002
	Inside groups (Error)	51.52	56	0.920			
	Corrected Total	157.33	59				
Devising a plan	Cognitive style level (A)	10.30	1	10.30	9.88	0.002	0.150
	Teaching Treatment (B)	65.24	1	65.24	62.62	0.000	0.528
	Interaction (A×B)	1.29	1	1.29	1.24	0.270	0.022
	Inside groups (Error)	58.36	56	1.042			
	Corrected Total	146.93	59				
Carrying out the plan	Cognitive style level (A)	76.32	1	76.32	24.08	0.000	0.301
	Teaching Treatment (B)	99.19	1	99.19	31.30	0.000	0.35
	Interaction (A×B)	7.84	1	7.84	2.47	0.121	0.042
	Inside groups (Error)	177.44	56	3.17			
	Corrected Total	394.18	59				
Looking back	Cognitive style level (A)	8.13	1	8.13	10.27	0.002	0.155
	Teaching Treatment (B)	37.56	1	37.56	47.46	0.000	0.459
	Interaction (A×B)	0.109	1	0.109	0.137	0.712	0.002
	Inside groups (Error)	44.32	56	0.791			
	Corrected Total	97.60	59				
Total	Cognitive style level (A)	341.75	1	341.75	29.95	0.000	0.348
	Teaching Treatment (B)	1077.32	1	1077.32	94.41	0.000	0.628
	Interaction (A×B)	0.790	1	0.790	0.069	0.793	0.001
	Inside groups (Error)	639.03	56	11.41			
	Corrected Total	2307.40	59				

Additionally, it is noticed from Table (4) that the effect of SWOM strategy on all solving physics problems dimensions and the total score is high. It is also obvious that the effect of cognitive style on all solving physics problems dimensions and the total score is high, while the value of the dimensions and the total score exceed 0.14. Moreover, the size of the effect of the interaction between the teaching method and cognitive style on all solving physics problems dimensions and the total score is low, as all values of η^2 are less than 0.6.

6. In the light of the previous results, the null hypothesis was partially rejected, which stated that "There is no statistically significant effect at the level ($\alpha \leq 0.05$) for either teaching method, cognitive style, or the

interaction between them on the solving physics problems skills for first grade secondary stage students in language schools. ”

The alternative hypotheses were accepted, which state that:

- “There is statistically significant effect for teaching method and cognitive style at the level ($\alpha \leq 0.05$) between the mean scores of the study groups in the post administration of the solving physics problems skills test(dimensions and total score). ”
- “There is no statistically significant effect for the interaction between the teaching method and cognitive style at the level ($\alpha \leq 0.05$) between the mean scores of the study groups in the post administration of the solving physics problems skills test(dimensions and total score).”

The previous results demonstrated the superiority of the experimental group that was taught with the SWOM strategy over the control group that was taught with the traditional method in all solving physics problems dimensions and the total score. **These results could be explained in light of theoretical frameworks for the following reasons:**

- Teaching the skills of solving physics problems through the SWOM strategy as thinking skills that helped students acquire and assimilate these skills.
- Using thinking maps, which include a set of guided questions, students can better understand physics problems and organize their thoughts from the first skill to the final skill, which includes the final solution.
- Allowing students to discuss together and then writing down their solution in a graphic organizer helps students share ideas and solutions that lead to improve their solving problem skills.
- Using graphic organizers and thinking maps also enables students to assimilate the problem, identify the requirements and givens, as well as relate between the skills to achieve the correct solution.

Recommendations:

In the light of the results of the study, the following recommendations are formed:

- Conducting training courses/ programs for science teachers in general and physics teachers specifically on SWOM strategy and how to apply it.
- Teaching solving physics problems as skills that can be practiced and mastered.
- Include branching thinking skills in the physics curriculum, as well as support them with suitable and appropriate activities to develop.

- Training physics teachers on how to pay attention to students' differences in cognitive styles, especially in the FD/FI cognitive style.
- It is important to take into consideration that students differ in their interactions with teaching methods and strategies according to their differences in cognitive styles.

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