فاعلية استراتيجية العصف الذهني في التحصيل والتفكير المنتج في مادة الأحياء لدى طلاب الصف الأول المتوسط

The Effectiveness of Brainstorming in the Achievement and Productive Thinking in Biology for First-Grade Intermediate Students

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الملخص:

يهدف البحث إلى التعرف على "الأثر الذي تخلّفه استراتيجية "العصف الذهني" في مستوى التحصيل الدراسي لدى طلبة الصف الأول المتوسط و"التفكير المنتج" لديهم في الأحياء"، وذلك خلال الفصل الأول من العام الدراسي 2023– 2024. أما عينة الدراسة فقد تكونت من (50) طالبًا في متوسطة مدرسة خالد بن الوليد، مقسمة على شعبتين، كل شعبة (25) طالبًا. وتم التحقق من الصدق والثبات، واعتمد الدراسة على الأدوات الإحصائية المناسبة، وتوصلت الدراسة إلى العديد من النتائج نذكر منها: تسهم استراتيجية "العصف الذهني" في رفع مستوى تحصيل الطلبة، وبالاستطاعة اعتماد استراتيجية "العصف الذهني" في تعليم الطلبة على مختلف المراحل الدراسية. وقد أوصت الدراسة ب: ضرورة تضمين موضوعات "العصف الذهني" في مناهج التدريس بكليات التربية. واقترحت الدراسة ما يلي: إجراء دراسة مماثلة للبحث الحالي في مجالي الفيزياء والكيمياء عبر مراحل دراسية مختلفة.

الكلمات المفتاحية: فاعلية، التفكير المنتج، التحصيل.

Abstract:

The research aimed to identify the impact of the brainstorming strategy on the academic achievement and productive thinking of first-grade intermediate students in biology during the first semester of the 2023/2024 academic year. The sample consisted of 50 students from Khalid bin Al-Waleed Intermediate School, divided into two groups, each one with 25 students. Besides, Validity and reliability of the research tools were verified, and also, appropriate statistical methods were used, the study reached a number of conclusions, including: The brainstorming strategy contributes to raising student achievement, and can be adopted in teaching students at various educational levels. The study recommended a number of recommendations, most notably, the need to include brainstorming topics in the curricula of faculties of education. The study also proposed a number of proposals, most notably: Conducting a study similar to the current research in the fields of physics and chemistry across different educational levels.

Keywords: Activity, productive thinking, Achievement.

Chapter 1: Methodological Framework of the Study

The Introduction and Problem of the Study:

The core problem of the study lies in the low academic achievement of students in the biology subject, and the negative consequences this issue generates in the field of education. This problem is considered one of the most significant challenges faced by both teachers and researchers within the educational process.

Researchers' opinions have differed regarding the cases of students' low academic achievement. Some believe it is due to biology teachers' reliance on traditional teaching methods, while others attribute it to the Lack of teacher competence and experience in using modern instructional techniques (Al-Tamimi, 2006: 26). Still others argue that the noticeable decline in the academic achievement of first-grade intermediate students in biology is due to teachers' inability to effectively integrate auditory and visual information during instruction (Al-Malki, 2008: 59).

A study indicated that the decline in students' academic achievement is due to the lack of teaching methods that promote positive attitudes toward the subject. Modern teaching methods—whether electronic or traditional—provide an interactive classroom environment that encourages students to participate actively by stimulating their interest, developing their readiness, and enhancing their ability to innovate and solve problems. These methods also allow students to generate multiple ideas regarding the topics being discussed, making learning more effective compared to traditional methods that focus on memorization and rote learning (Saleh, 2004: 22).

Biology is one of the academic subjects in which teachers face several difficulties and obstacles in teaching and conveying the content to students, resulting in students' lack of understanding and comprehension.

These challenges may be attributed to the teaching methods commonly used in classrooms in our schools. Contemporary educational trends emphasize the need to adopt strategies and teaching approaches that focus on the student's role as the central, active, and engaged participant in the learning process, reflecting a clear shift in perspectives within the classroom environment.

These educational practices do not rise to the level of genuine thinking, as they fail to incorporate the various types of thinking or to encourage and stimulate what is known as *receptive thinking* (listening and receiving). This is due to an overemphasis on the quantity of information at the expense of other important sides, such as neglecting the student's role, abilities, needs, and interests. Consequently, the desired educational goals are not achieved—particularly those related to thinking in general, and *productive thinking* in both its creative and critical dimensions in particular.

Despite the widespread adoption of various teaching methods that clearly emphasize the central role of the learner in the educational process worldwide, the teaching of biology still largely relies on rote memorization and passive listening. Little attention is given to activating strategies that promote critical and creative thinking. The methods used tend to focus on memorization and repetition, while curricula continue to follow a traditional approach, rendering the student a passive recipient rather than an active participant in the learning process.

In order to further support and define the research problem, a survey was conducted involving a randomly selected sample of ten male and female biology teachers for first-grade intermediate students, all of whom had no less than five years of teaching experience. A questionnaire consisting of seven questions was administered, and the following results were obtained:

1. 80% reported facing difficulties in teaching biology to first-grade intermediate students.
2. 100% were dissatisfied with the students' achievement in biology at the first-grade intermediate level.
3. 50% did not use external examples related to the biology subject for this grade level.
4. 90% relied on traditional teaching methods when teaching biology.
5. 50% were not interested in adopting modern strategy-based teaching methods for biology.
6. 100% had no prior knowledge of the "brainstorming strategy".
7. 90% had no information about "productive thinking".

Based on the above, the research problem lies in the lack of attention given to strategies and methods. Therefore, it is necessary to seek alternative approaches—particularly those grounded in theories that aim to enhance and invest in students' cognitive abilities. This encouraged the researcher to adopt the *brainstorming strategy* and examine its impact on students' academic achievement and *productive thinking*, as it is one of the strategies that fosters insight into new ideas, making them memorable and long-lasting in students' minds. It also provides a structured way to explore and generate suitable ideas. Accordingly, the research problem was defined by the following question:

"What is the effectiveness of the brainstorming strategy in improving academic achievement and productive thinking in biology among first-grade intermediate students?"

Significance of the Study:

With the rapid pace of global changes, it has become essential to benefit from and keep up with modern scientific advancements by

encouraging students to engage in active learning. In light of this accelerating progress, it is increasingly important to emphasize the scientific growth of students in order to continuously improve their educational level, help them adapt to success, and prepare them to become productive members of society (Al-Heela, 2008: 21).

Science plays a fundamental and influential role in life, as it has contributed to various fields of human activity. It has become a defining feature of the modern era and a primary tool for development in all its dimensions. Moreover, science has witnessed remarkable progress in recent years, particularly in many areas of science education (Ambusaidi & Suleiman, 2009: 17).

As a result, advanced trends in education have proven to be positive and effective in achieving their goals, which has led the educational system to place greater emphasis on teaching methods and their implementation (Razouqi & Fatima, 2005: 7).

The secondary stage is considered one of the most important stages in the development of students' personalities, which calls for a reconsideration of the work of the educational system and its components (Yaseen & Raji, 2012: 7-8). Biology teaching is regarded as a top educational priority in all countries due to its practical importance in daily life, which in turn contributes to the progress and development of the nation (Al-Rabaie, 2002: 6).

Brainstorming involves a form of challenge between the posed problem and the learner's mind. This can be understood as the problem serving as a stimulus to the intellect, which is then provoked to grasp, engage with, and solve it. This method helps involve the largest possible number of students in achieving the learning goal by stimulating learners, encouraging their talents, and enhancing their cognitive abilities (Mohsen, 2008: 219), through thought-provoking and challenging questions that

awaken students' awareness and guide them toward learning and acquiring the scientific foundations of various types of knowledge.

In recent years, there has been growing interest in the factors of *productive thinking* among students, as well as in raising their academic achievement (Abdulsalam, 2001: 77).

The significance of this study lies in considering *brainstorming* as an approach used in biology to generate new ideas that may help in finding solutions to various problems by stimulating the mind and placing it in a state of productive thinking in more than one direction. It also helps in fostering talents, enhancing mental abilities, reducing intellectual stagnation, encouraging students to find new solutions, and increasing classroom interaction. This highlights the following:

1. The necessity of using *brainstorming* to address study problems.
2. Its usefulness for biology teachers and curriculum developers, especially at the secondary stage.

Research Hypotheses:

The research is based on two main hypotheses it seeks to verify:

1. There is no statistically significant difference between the mean scores of the experimental group and the control group in the achievement test.
2. There is no statistically significant difference between the mean scores of the students in the experimental group and the mean of their scores in the control group.

Research Delimitations:

1. First-grade intermediate students at Khalid ben Al-Waleed Intermediate School.

2. Unit 1: Sections 1 and 2.
3. Unit 2: Sections 3, 4, and 5.

Terminology:

1. **Effectiveness:** Defined by Magdy (2009: 745) as the effort made to achieve the best possible result in attaining the objectives. Operational Definition: It refers to the impact of learning on first-grade intermediate students.
2. **Brainstorming Strategy:** Defined by Shehata and Zainab (2003) as encouraging students to generate new ideas and provide creative suggestions within a relatively short period of time (Shata & Zaynab, 2003: 325). Operational Definition: It refers to finding solutions through collaborative work to generate ideas in a short period.
3. **Achievement:** Defined by Abu Jado (2008: 425) as the academic level attained by the student after successfully completing a carefully designed test. Operational Definition: It refers to what the first-grade intermediate student learns and successfully masters with distinction.
4. **Productive Thinking:** Defined by Rzouki et al. (2019) as a scientific tool that includes self-organization, innovative thinking, and critical thinking. Through this, the learner interacts with everything in the environment in a qualitative manner, employing behavioral quality that helps them achieve unique results beyond the ordinary (Rzouki et al., 2019: 15). Operational Definition: It refers to the type of thinking used by students to generate new ideas.

Chapter 2: Theoretical Framework and Previous Studies

First: "Brainstorming"

The American scholar (Osborn) is considered the first to use this method in 1938, during his work in the fields of media, advertising, and publishing. In 1954, he founded the Creative Education Foundation, utilizing *brainstorming* to train individuals and groups in solving problems through creative methods, aiming to reach to new and innovative solutions. In the following year, that is, in 1955, he established the principles and rules governing this method in his book *"Applied Imagination"*, highlighting its applicability across various practical fields—whether scientific, administrative, or industrial.

Since then, it has been developed and applied in many areas, such as administrative staff development and problem-solving in economics, sociology, and law.

Brainstorming is considered one of the effective methods for generating creative ideas. It originated and developed in the educational field to be employed in solving various problems across a wide range of academic subjects (Hussein, 2003: 197).

Several terms have been used to refer to the concept of "brainstorming" in various studies and literature, all of which express the same idea. These terms include: *brainstorming*, *brain storm*, *brain shower*, *idea shower*, *ideation*, *idea flow*, *idea generation*, *group ideation*, *suspended judgment*, and *deferred evaluation* (Al-Titi, 2001: 165).

Saadah (2003) indicates that educators and those interested in the brainstorming technique have offered several definitions of it. Among the most prominent is that it is “an ideal state of the mind that enables it to generate new and original ideas”. Some view it as part of a problem-solving method that relies on postponing judgment or decision-making in

order to produce innovative ideas, while others believe that brainstorming is a technique that enhances the ability to generate ideas.

Another definition of brainstorming holds that it refers to the method or methods used in the process of generating ideas or producing new solutions that were previously unfamiliar or unconventional (Saadah, 2003: 165).

Objectives of Brainstorming:

1. **This method aims to develop what is known as *divergent thinking*:** Divergent thinking refers to the process of allowing the mind to move in multiple and varied directions. It is achieved through various activities and ideas related to brainstorming, which help guide the mind to think in different and diverse directions.
2. **Brainstorming aims to foster innovation:** This is achieved by generating innovative and applicable ideas. The activities associated with this method are considered common practices in major international companies.
3. **Work on developing the capabilities and increasing the number of ideas:** Fluency, flexibility, and originality are key abilities for generating ideas. The activities associated with this method help in developing these capabilities as follows:
    a. **Fluency:** This is defined as the process of generating the maximum amount of information. It refers to the number of ideas generated by the students. Therefore, the fluency in brainstorming is the total number of ideas proposed by an individual in response to the given question or problem.
    b. **Flexibility:** This refers to generating ideas across different and diverse areas. It is the number of categories the students have generated ideas for, which are classified into main categories.

c. **Originality**: This refers to uniqueness, meaning generating distinctive ideas that are different from those of other participants. It is the degree of novelty of an idea compared to others. To calculate originality, the ideas provided by participants are first classified into categories. Then, the frequency of each category within the sample is counted, and points are assigned to each category based on its frequency. An idea that receives high scores is considered more original than one with lower scores. Therefore, a student's originality score is the total score of all the ideas they proposed (Hussein, 2003: 227).

4. **Brainstorming aims to encourage openness and mental productivity**: It is important to note that the traditional classroom suffers from the problem of a single answer. Most classroom questions seek only one answer, which is either found in the textbook or known by the teacher, leaving no room for alternative correct answers. These types of questions are known as closed-ended or convergent questions, which do not allow for openness, idea generation, or expression of inner thoughts. Traditional education does not encourage much dialogue, discussion, or free group brainstorming. Therefore, brainstorming, with its divergent and encouraging questions, provides learners with the opportunity to express their ideas openly and honestly.

5. **Brainstorming aims to build confidence in the learner**: The activities associated with brainstorming significantly contribute to enhancing learners' self-confidence. They provide a supportive environment that encourages idea-sharing without constraints, allowing for immediate thinking to be productive. It is not necessary for the learner to memorize what was covered in the lesson or the textbook information in order to participate actively in the class. This contrasts with traditional education, which often discourages many learners from

participating due to their lack of memorization of the material or the absence of time to think through the question.

6. **Brainstorming aims to facilitate free association of ideas**: Ideas flow freely, and the teacher writes down everything that comes to mind without evaluating them during the free association phase. Evaluation is left for a later stage. During the free association phase, the teacher does not consider the effectiveness or feasibility of each idea but simply writes down whatever comes to mind. Some ideas may initially seem unrelated to the topic, but upon further development in the evaluation stage, they may reveal innovative solutions. The free association phase, which involves idea generation in various areas, allows for the production of ideas that are outside the narrow thinking scope an individual might limit themselves to when focusing solely on the problem, which could hinder the generation of creative ideas.

7. **Brainstorming aims to overcome the problem of anxiety among students**: There is no creativity with anxiety, and no innovative ideas with fear. Anxiety and fear are the locks of the mind that prevent it from being creative. A student may think about providing an answer to a question posed by the teacher in class, but fear of giving an inaccurate answer or possibly facing criticism from the teacher and ridicule from peers may cause them to remain silent. As a result, the fear of failure overshadows the classroom atmosphere, disrupting the thinking process and preventing the mind from producing ideas or the tongue from speaking. However, brainstorming activities, through their reliance on divergent questions, allow learners to contribute their ideas freely and openly when they realize that all ideas are welcome. In this way, the learner is able to overcome the anxiety that weighs on their mind or traps their thoughts.

8. **Brainstorming aims to strengthen the connections between concepts and academic subjects**: The activity of brainstorming encourages learners to make links between various concepts and academic subjects, as well as to connect them to everyday life. It offers students the opportunity to view academic content in an integrated manner and to recognize its relevance and capacity to address real-life challenges (Roshka, 1989: 183).

Steps for Conducting a Brainstorming Session:

Any brainstorming session is typically implemented through three main stages:

1. **First Stage**: The session leader begins by presenting the key ideas related to the discussion topic and then poses questions aimed at clarifying the problem for the participants and highlighting the need for an innovative solution. Participants are encouraged and motivated to generate as many ideas as possible. During this stage, a recorder is assigned to accurately document all the ideas presented.

2. **Second Stage**: This stage focuses on generating solutions, beginning with individual idea generation followed by group discussion. Participants are expected to refrain from criticism and to accept all ideas presented. The emphasis is placed on developing and refining these ideas to arrive at the most effective possible solutions.

3. **Third Stage**: In this stage, the proposed solutions are presented and evaluated, with the best ones being selected, while repeated or incorrect ideas are excluded.

An alternative brainstorming technique involves giving participants a set amount of time to write down their ideas individually, which are then collected periodically. Each participant is asked to present their suggestions in order of seating, and the process is repeated several

times. If a participant has no new idea to offer, the turn moves to the next person. This method encourages active participation from all individuals and is among the most widely used techniques. In the applied research adopted, this method was utilized by dividing participants into three experimental groups (Majdi, 2000: 802).

General Steps for Conducting a Brainstorming Session:

1. **Identifying the Topic:** The teacher selects the topic to be addressed in the brainstorming activity, choosing it from the lessons they are currently teaching.

2. **Framing the Problem as a Question:**

   The topic or problem is reformulated into a question to help clarify and more precisely define its scope. This can be done using prompts such as:

   - What are your suggestions for...? * What are the possible solutions to...?
   - What if ... became ...? * What if ... no longer existed?
   - What if ... was lost? * How can ... be improved?
   - How can ... be developed? * How can ... be transformed?

3. **Creating a Creative Environment:**

In this step, the teacher fosters an atmosphere of creativity and idea generation with the students. The teacher then instructs them as follows:

- "Say whatever comes to your mind."

- "Do not hesitate to share any idea, regardless of how relevant it may seem."
- "Do not worry about its feasibility—just write it down." (Mutalaqa, 1998: 18)

This ensures that students are not preoccupied with finding the "correct" answer, which could slow down their ability to recall ideas. Instead, they are encouraged to engage in free association and allow their thoughts to flow naturally.

4. **Initiating the Mental Focusing Process:**

At this point, the teacher presents the brainstorming question and encourages students to generate ideas freely, setting a time limit of 3 to 10 minutes. During this period, students are encouraged to write down everything that comes to mind, allowing their thoughts to move across various areas and directions without restriction (Al-Aleimat, 2008: 102).

5. **Reviewing the Ideas:**

After completing the idea recall process, students present and share their ideas with the rest of the group. During this stage, the teacher avoids criticizing any idea regardless of its content—unless it is intentionally offensive or mocking. Otherwise, all ideas are welcomed and accepted.

6. **Refining the Ideas:**

The teacher asks students to select the best ideas from those that were shared and written on the board.

7. **Developing the Ideas:**

At this stage, students select one of the most outstanding ideas and work on transforming it from a written abstract concept into a practical, applicable solution.

8. **Commenting on Ideas:**

In this stage, the teacher highlights the most outstanding ideas to emphasize the value of thinking across diverse areas during brainstorming. This encourages learners to develop flexibility and originality in their ideas. The teacher also recognizes students who contributed the highest number of ideas to promote fluency in idea generation. Furthermore, the teacher comments on the presented ideas and points out those that may contain scientific inaccuracies—without identifying the student who proposed them. (Abu Ryash, 2007: 320)

Second: Productive Thinking

A. Concept and Conditions:

- Atiyyah (2015: 131) defines it as a mental process involving the integration of sensory perception and experience. It relies on various skills and abilities to discover new relationships or create unique and unconventional methods for a specific purpose, driven by internal or external motivation—or both.
- According to Rzouqi et al. (2019: 15), productive thinking is a pattern that combines both critical and creative thinking. It involves employing both types of thinking to generate new, positive, practical, and applicable ideas.
- Al-Zayyat (2019: 239) views productive thinking as an essential component of students' cognitive development. Life presents various situations that require the teacher to confront them using theoretical knowledge, which drives progress toward desired goals. These goals are achieved through harmony between production and action, making productive thinking an effective way for overcoming problems and obstacles.

B. **Conditions for Productive Thinking:**

Several conditions must be met to achieve productive thinking:

1. Maintaining continuous thinking through a sequence of successive ideas.
2. Generating a variety of new and unconventional ideas.
3. Contributing additional ideas to help students develop more beneficial and productive outcomes (Al-Surur & Thaer, 2010: 10).

Characteristics of Productive Thinking:

1. It incorporates elements of both *divergent* and *convergent* thinking, where solutions are identified and classified into groups, and optimal solution criteria are applied.
2. It is considered one of the pillars of creative thinking, equipping students with scientifically-based skills that enable them to generate diverse and novel ideas.
3. It emphasizes the creative aspect of the thinking process.
4. It represents an essential and active component of students' cognitive development.
5. It involves discovering new relationships and methods to solve problems with precision and objectivity in a systematic way.
6. It enables the reformulation of ideas in a productive and refined manner through cognitive and mental structures within a different framework.
7. It is characterized by variety and the potential for social acceptance through innovative outputs.
8. The problem should be left for a certain period to allow for what is called *"internal insight"* (Razouqi et al., 2019: 25).

Third: Literature Review

A. Studies on the Brainstorming Strategy:

(1) Arabic Studies							
#	Study/ Year/ Country	Methodology and Design	Purpose of the Study	Sample Size	Study Tool	Statistical Methods	Results
1	Study by Saleh (2004): Iraq.	Experimental.	To examine the effect of "brainstorming" on the development of both scientific thinking and academic achievement among middle school students.	80 male and female students.	1. Achievement Test. 2. Scientific Thinking Scale.	The use of the (SPSS) for Humanities.	There are statistically significant differences between the average scores of students who study using the "brainstorming" strategy and the average scores of students who study using the traditional method, in favor of

							the experimental groups and the "experimental group".
2	Study by Al-Aleimat (2008): Jordan.	Experimental.	To examine the effect of the brainstorming and discovery methods on developing creative thinking in science among eighth-grade students.	85 students.	Creative Thinking Scale in Science Subject.	The use of the (SPSS) for humanities.	There is an effect of both methods: "brainstorming" and (discovery), on the development of creative thinking among eighth-grade students in the subject of science, in favor of the "experimental group".
(2) Foreign Studies							
1	Study by Mao (2006):	Experimental.	To examine the effect of reinforcement and	70 students.	1. Achievement test in mathematics.	The use of the (SPSS) for	The results showed that providing reinforcement in

	China.		teaching methods using "brainstorming" on learning mathematics, attitudes, academic achievement, and problem-solving ability.		2. Attitude toward mathematics scale. 3. Problem-solving ability scale.	humanities.	learning mathematics through "brainstorming" improved students' problem-solving ability.

B) Studies Addressing "Productive Thinking":

#	Study/ Year/ Country	Methodology and Design	Study Tool	Purpose of the Study	Sample Size	Statistical Methods	Results
1	Hilal (2018): Iraq	Descriptive.	1. A training program for chemistry students based on knowledge economy.	A training program for chemistry teachers based on the knowledge	288 students (male and female).	Using the SPSS statistical package.	The students who studied according to the knowledge economy training program outperformed the

			2. "Productive Thinking" for students.	economy and its impact on their teaching practices, as well as how their students' productive thinking is developed.			students who were subjected to the "training program" in "productive thinking".
2	Al-Araq (2018): Iraq	Quasi-experimental.	1. Training program for productive thinking. 2. Measure of astute thinking.	A training program based on productive thinking for biology teachers and its impact on students' astute thinking.	A group of biology teachers in the secondary stage.	The use of the SPSS package for humanities.	1- There are statistically significant differences between the average scores of biology teachers who participated in the training program based on productive thinking

							and the average scores of biology teachers who did not participate in the training program based on measuring critical thinking.

Chapter 3: Study Procedures

1. Experimental design based on partial control.

2. Figure (1): Research Design.

Gr.	Equivalence	Independent Variable	Dependent Variable
Exp.	1. Pre-test. 2.Prior knowledge. 3. IQ.	Brainstorming strategy.	Achievement. Productive Thinking.
Cont.		Traditional Method.	

2. Re-identification of the study population:

1. First-year intermediate (Grade7) students at Khalid ben Al-Waleed Intermediate School.
2. Class/1 – Academic Year 2023/2024.
3. The population consists of 50 students divided into two groups: 25 in the experimental group and 25 in the control group.

Table (1): Distribution of the Experimental and Control Groups

Sta.	Group	Num. of stud
A	Experimental	25
B	Control	25

3. Parity

Previous Achievement: The data were obtained from the grade records of the school administration. The mean score for the experimental group was (M = 3.25, SD = 8.56), while the control group had a mean of (M = 33.58, SD = 78.11).

Table (2): Statistical Significance of the Equivalence Between the Two Study Groups in the Pre-Achievement Variable

Group	Number of Participants	Degree of Freedom	Mean	St.de	t-test		Significance
					Con.	Cal	
Experimental	25	48	3.5	80.56	2.011	0.56	Not significant
Control	25		33.58	78.11			

It was found that the value of (t) was (0.56), which is less than the tabulated value (2.011); therefore, the two groups are considered equivalent in terms of prior achievement.

Prior knowledge: A test consisting of 20 multiple-choice items was prepared. The results showed that the (t) value was (0.75), which is less than (2.011); thus, the two groups are considered equivalent.

Table (3): Statistical Equivalence of the Two Research Groups in Prior Knowledge

Group	Sample Participants	Deg.	Mean	St.	T value		Significance
					St.	Cal.	
Exp.	25	48	12.93	5.75	2.011	0.95	Not significant
Con.	25		11.43	6.52			

IQ Test: The equivalence in the IQ test administered to the experimental and control groups was verified, with a t-value of (0.923), which is smaller than the t-stan value, indicating that both groups are equivalent in the intelligence variable. Table No. (4).

Table (4): Equivalence of the Two Groups in IQ

#	Gro.	Num.	Mean	St.de.	Deg.	t-test		Significance
						Sta.	Cal	
1	Exp.	25	59.333	839.892	48	2.00	0.923	Not

2	Con.	25	52.647	857.479		00		significant

4. Study Supplies:

Scientific material:

- Unit 1: Biology and Technology
  - Section 1: Microscopes
  - Section 2:
- Unit 2: Building the Body of Living Organisms
  - Sections 3, 4, 5.

- Formulation of Behavioral Objectives:

The number of behavioral objectives is approximately (110) behavioral objectives (Table No. (4)).

Table No. (5): Distribution of Behavioral Objectives and Educational Content

#	Levels Content		memory	Assim.	Applic.	Total
Unit 1 Sections 1, 2	4	Microscopes	28	18	11	57
Unit 2 Sections 3, 4, 5	5	Building the Body of Living Organisms	35	12	6	53
		Total	63	30	17	110

Preparing Teaching Plans: A total of 12 teaching plans were prepared, 6 for the experimental group and 6 for the control group. These plans were reviewed by experts, judges, and several biology teachers.

5.Study Tool:

First: Achievement Test: It consists of objective items, with a total of 20 questions.

Test Map: A test map was prepared, which included the items of this test from units 1 and 2 of the prescribed curriculum, covering the first three levels (Remembering, Understanding, Applying) (Table (6)).

Table No. (6): Test Map

Content	Section	The Lesson	Lesson Time (in Minutes)	Levels of Objectives			Total 100 %
				Applying 9%	Understanding 27.25 %	Remembering 57.20 %	
45%	Section 4	5	240	28	15	4	41
55%	Section 5	7	240	35	12	6	53
Total		12	280	63	27	10	100 %

6. Test Validity:

The test was presented to a group of teachers and experts for review. The agreement rate was 80%, indicating that the test is valid.

7.The Achievement Test:

The reliability coefficient for this type of test was calculated and found to be 0.82, which is considered a good coefficient.

8. Statistical Methods:

The SPSS package was used to obtain accurate results.

Second: "Productive Thinking" Test

The test was designed for first-year middle school students for the 2023/2024 academic year. It combines the skills of (critical and creative thinking) and their application to generate new ideas. The test consists of (8) skills, each with (3) scenarios.

Table No. (7): Components of "Productive Thinking"

Components of "Productive Thinking"	Skills	n. of par. Spaces
Critical Thinking	Assumptions	3
	Interpretation	3
	Evaluation of arguments	3
	Inference	3
	Conclusion	3
Creative Thinking	Fluency	3
	Flexibility	3
	Originality	3
Total.		24

Table No. (8): Correct Skills of Critical and Creative Thinking

Critical thinking skills	no. of par. space	no. of parag.	Degree
Assumptions	3	9	9
Interpretation	3	9	9
Evaluation of	3	9	9

arguments			
Deduction	3	9	9
Conclusion	3	9	9
Creative thinking skills	Number of Situations	Number of Items	Score
Fluency	3	3	3
Flexibility	3	3	3
Originality	3	3	9
Total scores			60

The "Productive Thinking" test was presented to several judges and educational specialists, and the items of the test were approved by the majority.

A sample of 20 students from "Omar bin Abdul Aziz Middle School" was selected to calculate the reliability using Cronbach's Alpha formula to estimate internal consistency reliability. The result was 0.707, which is considered high and above the standard reliability threshold.

Chapter 4: Presentation of Results and Interpretation

Results of the Achievement Test:

The mean and standard deviation were calculated, and their values were as follows:

- The mean for the experimental group was 26.85, with a standard deviation of 4.46.
- The mean for the control group was 18.75, with a standard deviation of 4.88.

Table No. (9): Results of the Achievement Test

Group	Nu.	Mean	Sta.de.	t-test		Stat. fun
experimental	25	26,85	4,46	St.	Cal.	Statistically significant
control	25	18,75	4,88	2.011	2.336	

The calculated t-value (2.336) is greater than the t-table value (2.011), indicating that the result is statistically significant.

Table No. (10): Tukey's Test Between (Experimental Group and Control Group) in the Achievement Test.

Group	Num.	Mean.	Value Q Cal.	Value Q Sta.	Static.fun.
Experimental	25	26,85	8,10	3,40	Statistically significant
Control	25	18,75			

It is evident from Table (10) that the value of (Q-ca.l) is greater than the value of (Q_st), indicating statistical significance in favor of (Experimental Group).

Interpretation of Results:

Axis One: Results Related to Academic Achievement

Students in (Experimental Group) outperformed those in (Control Group) in the (Achievement Test) for the subject of Biology. The researcher believes that presenting information in the form of a problem to be solved helps open students' minds. The teacher's role in having students write down their solutions, classify them, discuss them, and select the best solutions, as well as encouraging problem-solving and participation in discussions, contributed to the students' learning. This approach enhanced their creativity and innovation in problem-solving, idea generation, and development. It also facilitated the understanding and development of new ideas, as well as reaching conclusions and

solutions. This led to the acquisition of scientific knowledge and improved students' ability to comprehend and retain the material for a longer period. This result contradicts the expected outcome.

Axis Two: Results Related to the Thinking Test

The (t-test) tool was used to highlight the differences between the two groups that make up the research, as shown in Table (11).

Table No. (11): Use of the (t-test) to Identify the Differences Between the Research Groups.

group	Num	Mean	S.D	Free.d.	t-test		Statis.fu.
Experimental	25	44.624	72.633	48	Sta.	Cal.	significant
Control	25	33.965	52.317		2.011	2.336	

From the table, it is evident that students in (Experimental Group) outperformed students in (Control Group) in the 'Productive Thinking' test. It was found to be statistically significant in favor of the Experimental Group in this test. The value of (d) is as shown in Table (12):"

Table (12) shows the effect size of the 'independent variable' (Brainstorming Strategy) on the 'dependent variable' (Productive Thinking).

Independent Variable	Dependent Variable	Effect Size (d) Value	Effect Size Magnitude
Brainstorming Strategy	Productive Thinking	0.660	Medium

It is evident that the effect size of the independent variable on the dependent variable is medium.

Results Related to "Productive Thinking":

The results showed the following:

1. The activity used contributes to improving the level of "productive thinking" for students.
2. Increased perseverance, creating an exciting and enjoyable atmosphere, and developing a positive and favorable attitude.
3. Generation of new ideas that help cultivate (originality) and fluency skills by linking Biology content to real-life situations, as well as flexibility and diversity in presenting ideas and asking questions in multiple ways.
4. Motivating students by placing them in various thinking situations, providing proposed solutions to many problems, thus offering comfort and reassurance through exchanging opinions, reducing anxiety and fear, and enabling students to make judgments in certain situations by drawing conclusions from the facts they have.
5. Linking questions and answers, selecting the most purposeful ones supported by evidence and reasoning, thereby raising their intellectual level.

Conclusions:

1. The strategy known as brainstorming significantly contributes to improving students' academic achievement.
2. After proving its effectiveness, this strategy can be adopted in teaching students at various educational stages.

Recommendations:

Based on the results, the study recommends:

1. The necessity of training staff on various teaching methods, especially the "brainstorming" strategy, and expanding its development.
2. The necessity for those responsible for educational curricula to include topics related to this strategy in the teaching curricula at the Colleges of Education in Iraq.
3. The necessity of teaching students at the College of Education these strategy topics in a broader and more comprehensive manner.

Suggestions:

The researcher presents several suggestions, including:

1. The necessity of conducting numerous studies similar to the current research in different directions, especially in the fields of physics and chemistry across various educational stages.
2. The necessity of conducting comparative studies between boys' and girls' schools to explore the importance and effectiveness of creative thinking and "productive thinking" in both genders.

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