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The Effectiveness of an Educational Program Based on the Theory of the Five Minds in the Achievement of Fifth-Grade Science Students in their Complex Thinking

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Abstract. *This study aimed to identify the effectiveness of an educational program based on the theory of the five minds in the academic achievement of fifth-grade students in biology and in developing their complex thinking. The researcher utilized both descriptive and experimental methods. An educational program was prepared that included educational objectives, teaching methods, appropriate strategies, activities, educational resources, and evaluative methods, which consisted of a teacher's guide and a student's book. The researcher purposefully selected secondary and middle schools in Dhi Qar Governorate / Al-Gharraf District to represent the research community, specifically choosing Al-Gharraf Martyrs Preparatory School. The Fifth Scientific Division (A) was randomly selected to represent the experimental group that teaches biology according to the educational program, consisting of 41 students, while the Fifth Scientific Division (B) represented the control group that teaches the same subject using the conventional method, also with 41 students. Thus, the research sample totaled 82 students. The researcher prepared two tools to measure the research variables: the first was an achievement test, in its final form consisting of 60 test items, for which the researcher verified validity, discrimination, and reliability; the second was a complex thinking test, which in its final form consisted of 33 test items, also verified for validity and reliability. The researcher used the Statistical Package for the Social Sciences (SPSS), version 27, to analyze the results. After performing statistical analyses, the researcher concluded that the experimental group outperformed the control group in both achievement tests and post-compositional thinking.*

Key words: *The Theory of Five Minds.*

Research Problem:

Education is considered the main gateway to the progress of nations in all fields. Countries that have achieved scientific progress have done so by emphasizing the importance of the educational process. Therefore, advanced nations prioritize education. The educational system in Iraq often relies on the methods of indoctrination, memorization, and information storage without real application in life situations. Most subjects are taught traditionally, focusing on theoretical aspects without encouraging student interaction with educational content. The teacher remains the primary focus of the educational process due to a lack of modern teaching methods that emphasize skills such as inference, identifying assumptions, and evaluating arguments. The acceleration of information and the explosion of knowledge necessitate a reevaluation of our educational systems. We must construct modern educational programs that enhance student achievement, develop their thinking, and place students at the center of the educational experience. From the researcher's twenty years of experience as a biology teacher, it has been observed that there is a significant weakness in both achievement and

complex thinking among students, largely because many teachers rely on traditional teaching methods centered on memorization and indoctrination, treating students as passive recipients of information. Therefore, there is a critical need to develop an educational program aimed at improving student achievement and fostering complex thinking skills, which encompass critical, reflective, creative, and metacognitive thinking. Thus, the research problem is defined by the following question: What is the effectiveness of an educational program based on the theory of the five minds in the achievement of fifth-grade science students in biology and the development of their complex thinking?

Importance of research:

The National Science Teachers Association of Georgia, USA, emphasizes that the primary function of science education in the middle school stage is to provide more opportunities for students to explore the importance of science in their lives and to be personally engaged and prepared. Nations are engaged in a rapid race towards scientific progress towards broad horizons of knowledge to serve humanity towards the development of the earth. Education, like other sciences, aims to prepare learners scientifically. It should be a comprehensive, intense and integrated preparation with all sciences to provide them with the skills, knowledge and abilities that make the learner a human being with a mind that understands and interprets what he has learned and faces the problems of the future with strength, creativity and distinction. (Muslih, 2010, 2). Education is a planned process to bring about positive changes in the learner's behaviour to transfer knowledge and develop the individual's self (Hamshari, 2007, p. 19). Al-Hussaini (2004) adds that educational programs are one of the important elements in the educational process that help achieve educational efficiency and meet the needs of society. They reflect the extent of progress achieved in all areas of life. Educational programs must meet the progress achieved in information technology (Al-Hussaini, 2004, p. 1).

(Salama, 2004) indicates that it is necessary to continuously update and develop educational programs to help achieve educational efficiency and meet the needs of society (Salama, 2004, p. 74). (Zarii and Behrozi, 2016) indicated that one of the most important educational theories is the theory of the five minds of the scientist Gardner, which he established in 2006 and in which he explained the mental abilities that must exist in the individual in the future, as he divided the human mind metaphorically into five types: the specialized, synthetic, creative, flexible, and moral mind (Zarii & Behrozi, 2016, p. 131). (Mustafa, 2020) indicated that Gardner stressed the need to develop educational mechanisms to care for the five minds in order to prepare a generation capable of absorbing and understanding knowledge and information and technological development, as one of the requirements of the future is to expand minds to absorb all the changes that will occur in the future (Mustafa, 2020, p. 10). (Gardner, 2019) explained that attention must be paid to developing the five minds in the next generation, i.e., current students, because they are the leaders of tomorrow, without neglecting those currently in the workplace. Gardner believes that we must rely on individuals who possess specialized, synthetic, creative, flexible and ethical minds and try to continue developing all types of the five minds (Gardner, 2019, p. 25). Al-Jalali (2011) stated that experts in the educational field were interested in academic achievement because of its importance in the student's life and in ensuring the student achieves an integrated knowledge base. Achievement represents the student's mental and cognitive activity, resulting from what happens within the educational institution regarding learning processes for different skills, sciences and knowledge. Achievement is affected by different variables, including cultural, social and economic variables related to the student's school environment (Al-Jalali, 2011, p. 21). (Mr. Ali, 2009) pointed out that academic achievement is significant for students, but it is not the only goal of educational institutions. Instead, other goals include developing thinking skills, employing knowledge and sciences in public life, broadening the learner's horizons, strengthening moral values, developing the learner's abilities, and building the student's personality (Mr. Ali, 2009, p. 63). (Guay and others, 2003) indicated that educational institutions were interested in academic achievement because it is a clear indicator of the progress of the educational process towards achieving educational goals, in addition to its connection to the concept of learning. The results of achievement result in important educational decisions related to the student's future and the educational process. Achievement represents an incentive for students to compete and excel with other students (Guay and others, 2003, 124). (Abdul Wahab, 1983) stated that thinking is a cognitive

and emotional process based on the outcome of other psychological processes such as perception, imagination, sensation, and mental processes such as memory, discrimination, and reasoning.

Thinking is considered the pinnacle of psychological, mental, and cognitive processes, and the more we move from the tangible to the abstract, the more complex thinking becomes (Abdul Wahab, 1983, p. 45). (Sharif, 2000) believes that higher thinking skills are the fundamental pillar on which society depends. Without these skills, the process of creativity and development does not occur. We now need an educational society whose members are characterized by the ability to think critically, reflectively, creatively, and metacognitively, make decisions, and continue communicating life's requirements. These skills are found in complex thinking (Sharif, 2000, p. 156). On the other hand, (Muqallada, 2013) believes that there are reasons that push the individual to have a certain level of complex thinking in order to face life's challenges and practice his work positively, creatively and distinctively. He must develop his intellectual abilities so that he can use complex thinking skills (Muqallada, 2013, p. 14). In this regard, (Al-Zayat, 2004) stated that today, we need someone who can provide creative solutions to the problems we suffer from that help develop life in the age of cognitive acceleration, as all institutions need leaders who possess complex thinking skills through which they can manage those institutions and work to develop them because most of the goals of societies cannot be achieved except by using higher thinking skills (Al-Zayat, 2004, p. 91). The researcher believes that the problems facing the individual change and accumulate as a result of multiple factors and reasons, and getting rid of these problems and finding solutions to them requires thinking processes that constantly develop with the complexity of the problems. All of this makes developing thinking extremely important and necessary. Thinking helps discover new facts and concepts and deal with available information creatively, giving it new dimensions that were not known before. Complex thinking includes complex solutions and issuing a judgment or giving an opinion, and it improves with training and consists of critical, creative, reflective, metacognitive and decision-making thinking (Jarwan, 2007, p. 43). From what has been presented, the importance of the research can be summarized as follows:

1. Educational programs are considered effective methods in solving many educational and teaching problems because they are an integrated and harmonious system that addresses most of the elements of the educational process.
2. Drawing the attention of specialists and students to the importance of relying on organizing thinking and methods of organizing scientific knowledge, goals means and educational activities.
3. The need for biology teachers and students to have educational programs based on modern psychological and educational theories to keep pace with rapid scientific and technical development.
4. Attracting specialists' attention to the importance of employing teaching methods compatible with the theory of the five minds in teaching because it may improve students' complex thinking and thus raise their academic achievement.
5. To the best of the researcher's knowledge, the first research that deals with an educational program according to the theory of the five minds in Iraq is used to raise students' academic achievement and develop their complex thinking.
6. According to the researcher's knowledge, the current research represents a new addition to the educational and pedagogical field and responds to the need to reconsider the methods of teaching life sciences and using modern educational programs.
7. Focus on academic achievement as the essential cognitive variable in most global educational systems' educational and teaching process.
8. Focus on complex thinking by experimenting with a modern educational program that is compatible with complex thinking patterns
9. Biology for the fifth scientific grade is important in the educational process because it is an essential subject that middle school students study.

10. Complex thinking is important because it depends on higher mental abilities, which increases students' learning ability

Research objective:

The research aims to identify the effectiveness of an educational program based on the theory of the five minds in the achievement of fifth-grade science students in biology and the development of their complex thinking.

Research hypotheses:

A) There is no statistically significant difference at the level of (0.05) between the average scores of the students of the experimental group who study biology according to the educational program based on the theory of the five minds and the average scores of the students of the control group who study the same subject in the usual way in the achievement test.

b) There is no statistically significant difference at the level of (0.05) between the average scores of the students of the experimental group who study biology according to the educational program based on the theory of the five minds and the average scores of the students of the control group who study the same subject in the usual way in the post-complex thinking test.

C) There is no statistically significant difference at the level of (0.05) between the averages of the pre-and post-tests of the scores of the experimental group students who study biology according to the educational program based on the theory of the five minds in the complex thinking test.

Research limits:

The search was limited to:

1. Human borders: Fifth-grade science students
2. Spatial limits: Preparatory and secondary schools affiliated to the General Directorate of Education in Dhi Qar
3. Temporal limits: Academic year3.(2024 - 2023)
4. Objective limits: Biology book for the fifth-grade science, tenth edition 20234

Research terms:

1. Effectiveness: It was defined by (Attia, 2008) as the ability to create an effect. The effectiveness of something is measured by the effect it creates on something else (Attia, 2008, p. 61).
2. Educational program: Defined by (Ibrahim, 2009): A systematic educational method based on scientific experimental foundations that aims to present information and concepts in an organized manner while providing appropriate activities and means to ensure the program's success (Ibrahim, 2009, p. 195).
3. The theory of the five minds: Defined by Awad R 2009) as the competencies and abilities that learners should have in the future, and educational institutions should seek to develop them in students throughout the study period due to the future being characterized by cognitive, economic and technological competition (Awad, R, 2009, 21)
4. Achievement: It was defined by (Alam, 2009) as achievement in a specific skill or knowledge acquired in various academic fields and is represented in the test scores set by the teacher (Alam, 2009, p. 55)
5. Complex thinking: It was defined by (Jarwan, 2007) as a group of mental processes that include critical, creative, reflective, metacognitive and decision-making thinking, as it includes the three highest levels of Bloom’s taxonomy of educational objectives, which are analysis, synthesis and evaluation (Jarwan, 2007, p. 363)

Theoretical Framework:

First axis: Constructivism:

Constructivism refers to the cognitive construction process that takes place through the individual's interaction with the things and people around him and, thus, directs his behaviour with everything around him, from things to people and events.

Ideas of Constructivist Theory: Constructivist theory includes the following ideas:

- Focus on learning, not education, i.e. the shift from traditional education to modern learning and encouraging and accepting the independence, subjectivity and initiatives of the student learner
- It views the learner as an individual with a will, purpose and goal, encourages investigation and inquiry and nourishes the learner with natural exploration

Encourages students to participate and engage in dialogue, supports cooperative learning, and considers the learner's beliefs and attitudes.

- Emphasizes thinking, understanding, reasoning, and applying knowledge (Zaytoun, 2007, p. 29)

One of the most prominent theorists of constructivism is (Van Klaaserveld), who is considered the founder of constructivism as a cognitive theory that represents beliefs about knowledge that start from truth, then concepts, and how to build them. Klaaserveld explains constructivism as documented by (Yaker, 1999) as follows:

- Knowledge is built due to the learner's activity and is not received from the external environment. Accessing knowledge represents an adaptation process based on the learner's experience.

Learning is based on comparing new experiences and knowledge formed from previous experiences, and shared meanings are reached through discussion with members of the learning group, leading to a typical general understanding among them.

- The role of the constructivist teacher is to help the learner find connections between concepts that help him reach applicable meanings of his own (Yaker, 1999, p. 35).
- Constructivist theory as a cognitive theory is based on two assumptions. The first focuses on knowledge, as knowledge is acquired through its construction by the learner himself and through his activity and interaction with the world around him and his acquisition of experiences. The second assumption focuses on the process of knowledge. It includes adapting to the world of experience and its usefulness to the learner, not through its conformity to reality (1998, 78, Bischof and Anderson).

Klaserfeld presents the basic contents of the constructivist theory, which are:

1. The goal of education is for learners to understand knowledge and focus on conceptual processes and not all apparent behaviours.
2. Learning is a social activity: Each learner has his activity through dialogue, discussion and forming ideas. The teacher must know the student's ideas and experiences before the learning process and look for the connections that link the ideas. (Zaytoun, 2007, 38)

The second axis: The educational program:

Theoretical foundations of the educational program:

The educational program was launched from the most important psychology theories, including behavioural and cognitive theories. Behavioural theory focuses on studying the relationship between stimulus and response. This theory helped to identify the stimuli of the educational environment and organize programs in a way that helps to learn to show responses, the sum of which is the learning process (Al-Hila, 2003, p. 37). The scientist Skinner is considered one of the most prominent behaviourists who applied the principles of his theory in the field of education, which is the theory of operant conditioning, where he divided the learning process into steps and determined the response to each step, accompanied by feedback and giving appropriate reinforcement (Qalada, 1981, p. 272).

As for cognitive theories, they helped the educational program to identify how to organize educational programs in a way that suits the cognitive characteristics of the learner so that it helps him to store information in an organized way and then link experiences to come up with appropriate solutions (Al-Hila, 2003, p. 38). Among the cognitive theories in educational programs is Ausubel's theory, which was interested in and contributed to building educational designs through advanced organizations, in which ideas and concepts are arranged in programs in a hierarchical manner consistent with the learner's cognitive structure. This leads to meaningful learning, which occurs when the educational subject is linked to ordered, organized, and cumulative cognitive processes (Abdul Rahman & Abdul Karim, 1999, p. 97).

Foundations of building educational programs:

It is necessary that educational programs be built based on educational philosophy and thought that considers the philosophy of society, the nature of learning, and the type of knowledge and material and human capabilities. The foundations are divided into:

1- Philosophical foundations: Each program depends on an educational philosophy derived from the philosophy of society and is closely linked to it. Educational institutions work to serve society by forming their educational program in light of the philosophy of education and society together. What is meant by the philosophy of education is the intellectual framework that deals with educational issues in their broad social context, i.e. it is the theoretical basis that directs the educational system and programs. As for what is meant by the philosophy of society, it is that aspect of society's culture related to the goals, principles and beliefs that guide the behaviour of every individual in that society (Jamel, 2000, p. 46).

2- Cognitive foundations: Knowledge is the information, concepts, facts, and laws included in the educational program, and this knowledge reaches the students. There is a set of criteria that must be available in knowledge, which are:

- ✓ Knowledge does not conflict with the Islamic religion.
- ✓ It includes logical, sensory, rational and experimental sources of knowledge
- ✓ The successive and interconnected presentation of knowledge
- ✓ Emphasis on practical application
- ✓ Knowledge is related to the needs of learners.
- ✓ The continuous development of knowledge. (Al-Hashemi and Taha, 2008, 15)

3 -Psychological foundations:

It is concerned with the nature of the student, his growth characteristics, tendencies, readiness, and the nature of learning that must be considered when planning and implementing programs, and the development of the educational process depends on the development of psychological sciences. Among the psychological foundations of learning that must be taken into account in building educational programs are the following:

- ➢ Taking into account individual differences among students
- ➢ Focus on previous educational experiences
- ➢ Focus on reinforcement and motivation
- ➢ Organizing the educational process according to the principles of growth
- ➢ Providing the appropriate school environment for learning to occur
- ➢ Focus on meaningful learning. (Hamdan, 1982, 172).

The third axis:

Brain-Based Learning Theory: The brain is a complexly organized part of the human being and is a part that distinguishes it from other living creatures. It is the guiding force and control system behind

all its movements. The brain is a widely extended communication network. The brain consists of two hemispheres that process information in two different ways. The right half of the brain specializes in reassembling parts to form an integrated whole. It also recognizes the relationships between separate parts and works in a comprehensive, compatible and parallel manner. While the left half of the brain shows effectiveness in visual and spatial processing processes, its language ability is minimal. We use both halves in higher mental processes. (Obaid and Afana, 2003, 117). The brain consists of two halves, right and left, and they work in turns, meaning that the right half controls the left side and vice versa. The two halves are connected by a bundle of fibres that connect the two halves of the brain, and each half has characteristics that differ from the other half and complement it. This theory is based on the structure and function of the brain. As long as the brain continues its operations automatically and naturally, the learning process will undoubtedly occur, unless learning is associated with some phenomena that we may see in traditional methods, such as ignoring, lack of encouragement, and fear, which leads to hindering the natural learning processes in the brain. This theory is derived from understanding the brain's functions so that the teacher can provide education consistent with those functions so that the learner can benefit effectively from learning strategies that align with his learning conditions. (Laxman & Chin, 2010) referred to in (Abdullah, 2017, p. 445). Therefore, (Wolfe, 2002) believes that brain-based learning is learning based primarily on brain functions, where incoming information is dealt with and processed in the brain, which is considered the centre of learning. It differs from one person to another, as people differ in their knowledge, experiences, and abilities to employ their brains in learning. (Al-Taiti and Rawashdeh, 2013, 15).

The fourth axis:

The theory of the five minds: Howard Gardner's theory of the five minds (2007) is considered one of the modern educational theories, in which he presented a set of mental processes that are supposed to exist in the next generation. The five minds are specialized, synthetic, creative, flexible, and ethical. The goal is to create and prepare a generation that can adapt to the scientific climate of rapid development on all levels. Accordingly, Gardner sees the formation of the next generation's minds in five ways to be compatible with the continuous changes in the global system of knowledge because the strength of the minds leads to a better future (Gardner, 2008, p. 51). The future is influenced by modern information technology and the tremendous scientific and technological progress accompanying it; search engines are present everywhere, and self-controlled devices and other advanced devices require extraordinary behavioural and cognitive abilities. Whoever wants to face the future world according to its conditions must begin by nurturing levels of thinking, including the five minds (604) (Saeid et al., 2020). Karner believes that studying more than one specialization, in addition to developing the ability to integrate information, the need for innovation and creativity, dealing with others with respect, and focusing on ethical values, are among the conditions that develop the cognitive skills of individuals (Chojnacka, 2013, p. 66). Karner focuses through the theory on employing great uses of the mind that can be refined in the professional field or school and works to cover many human and cognitive aspects. The specialized, synthetic, and creative mind deals with cognitive aspects, while the flexible and ethical mind deals with human relations (Kimberly, 2014, p. 3). The specialized mind means that a person masters one method of knowledge and thinking in at least one scientific specialization, and thus, he will master a specific profession with complete mastery. As for the synthetic mind, it means that the individual will take information from multiple sources and evaluate it objectively. Accordingly, the single specialization and the synthesis of information will make the creative mind more important because it will work to generate new ideas and reach unexpected answers. The respectful mind accepts individual differences between individuals and groups, tries to understand and accept each other, and works with him effectively. In such an interconnected world, disrespect is no longer a viable option. The ethical mind seeks to contemplate the nature of the work of individuals and the needs of society. It establishes the concept of self-denial and serves broad goals away from self-interest and selfishness (Gardner, 2007, p. 15). Developing the five minds is one of the tools through which the teacher can include it within the educational objectives. The student needs to learn modern ways of thinking, and this happens by providing students with educational methods and skills to face future challenges (Qatami & Abu Naim, 2016, p. 44). Unprocessed data is constantly increasing, and to help students process this data

and organize it scientifically, we need the skills of synthesis and creativity, which are supposed to be among the objectives of teaching (. (Pava, 2008,)

Fifth axis: Achievement: It is the knowledge that the student obtains when he goes through an educational experience, and it is calculated by conducting tests of all kinds, or it is the search for solutions to the educational problems that the student faces by relying on his skills and experiences towards a specific educational task, whether simple or complex (Abu Jado, 2009, p. 432). The concept of achievement refers to the exam score that the student obtains in the academic field, and it also means acquiring educational skills and experiences and the ability to use them in the future. Achievement is also used to refer to the student's ability to achieve the educational goals specified in advance (Shahata & Al-Najjar, 2003, p. 89). Achievement is the criterion to clarify the student's mastery of the scientific material to transfer them to a higher educational stage or distribute them to various scientific and human specializations (Tunisiya, 2012, p. 105). The researcher believes that academic achievement is all the knowledge the learner acquires, whether inside the educational institution or outside it from his private life. It is the learner's achievement by acquiring knowledge and skills through a set of experiences. It is a numerical degree of knowledge that the learner has reached in an educational or training field.

Academic achievement goals:

Specialists have set multiple goals for achievement, including:

1 -Through achievement, we know the student's academic orientation and the specialization that suits their academic level.

2 -The student's emotional, cognitive and skill abilities are identified through achievement.

3 -Identify the student's previous information and know his strengths and weaknesses.

4 -Making the appropriate decision for the student based on the scientific background he possesses.

5 -Preparing scientific activities and experiences that suit the student's abilities.(Ali, 2001, 93)

The sixth axis, Complex thinking, Consists of the following:

First:

Critical thinking:

Classification (Facione, 1998) He explained that critical thinking consists of the following basic cognitive skills:

1 -Interpretation, which is the comprehension and expression of a broad meaning of situations, data, experiences, rules and standards

2 -Analysis, which refers to determining the inductive and deductive relationships between phrases, questions, concepts and attributes

3 -Evaluation, which refers to the credibility of phrases or the person's perception (his judgment, belief, opinion)

4 -Inference, which is determining the elements necessary to draw reasonable results

5 -Explanation, which is announcing the results of thinking and justifying it in light of evidence, concepts, context and convincing arguments

6 -Self-organization, the individual's ability to question and verify the credibility of organizing ideas and results (Facione, 1998, 126).

Second:

Reflective thinking:

Al-Dhaib (2002) defined it as the learner contemplating the problem or situation and drawing up the necessary plans to understand and implement it until he reaches the desired results. Then, he evaluates those results in light of the plans set. (Al-Dhaib, 2002, 113). Lyons (2010) also defined it as thinking

that depends directly on mental perceptions, giving them clear attention according to their degree of importance. Schoon defined it as an active, conscious and solid mental investigation of the individual's beliefs, experiences and conceptual and procedural knowledge in light of the reality in which he works, which enables him to solve scientific problems and show implicit knowledge with a new meaning. This meaning helps him in deriving inferences for his experiences that he wants to achieve in the future. (Schoon, 1987, 87).

Gondewy defines it as insight into business that leads to the analysis of procedures and outcomes through the evaluation of the processes by which those procedures and outcomes are reached. (Killion and Todenem, 1999, 112). The researcher believes that reflective thinking is reflective thinking, i.e. it directs mental processes to specific and pre-determined goals, and procedures are planned with self-awareness and knowledge, contemplation, and generating ideas that depend on focusing deeply on the procedures and results that are reached, and their analysis leads to decision-making, verifying its validity, and reaching a solution to the problem.

The importance of reflective thinking:

(Al-Khatib, 2013) stated that the importance of reflective thinking can be explained in the following points:

1-Reflective thinking includes the analysis process and the decision-making process.

2-The learner who possesses reflective thinking becomes able to link ideas to previous and current experiences

3-The reflective learner is the one who plans, monitors, and evaluates his method in the processes and steps he takes to issue a judgment

4-Reflective thinking is considered one of the basic skills in problem-based learning

(Al-Khatib, 2013, 64)

Third: Creative thinking

Kurt defines it as the ability to produce original ideas and solutions using imaginations and perceptions (Court, 1998, 118). This idea is confirmed by (Al-Surur, 2002), as she understands creativity as the ability to find and develop new, unexpected connections and relationships and to develop new meanings (Al-Surur, 2002, 119).

Creative thinking is a set of complex skills and abilities that include working independently, thinking unconventionally, and being open to new experiences (Kerka, 1999, p. 153).

The researcher believes creative thinking is diverse, logical rules do not determine original thinking, and its results cannot be predicted. It is high-order thinking that requires multiple cognitive sources. It is an individual mental ability with multiple stages and the ability to form new structures of ideas. It attempts to search for unconventional ways to solve a specific problem.

Fourth:

Metacognitive thinking:

Scientists have developed many definitions of metacognitive thinking, including- :

a. Bonds and Bonds' definition: It is the individual's knowledge and awareness of knowledge processes and his ability to organize, evaluate, and monitor his thinking so that this monitoring allows for more effective control of the individual's knowledge processes (Bonds & Bonds, 1992, p. 193)

b. Wilson's definition is the individual's knowledge and awareness of thinking processes and strategies and his ability to evaluate and organize his own thinking processes. (Wilson, 1998, 115). The researcher believes metacognitive thinking is thinking about thinking, consciously using learning strategies, understanding and controlling knowledge, monitoring the learner's cognitive performance, and thinking about self-treatment of the problem.

Fifth:

Decision-making:

is a mental process that aims to choose the most appropriate solutions that suit the learner in a specific situation. It requires many thinking skills, such as evaluation, analysis, deduction, and induction. There is a difference between a decision and decision-making. A decision is a conscious choice between the alternatives presented in a specific situation, while decision-making is choosing the best alternatives after studying the consequences of each alternative and its impact on the goals to be achieved. The choice is made based on information obtained by the decision-maker from multiple sources, which helps to reach the best results. (Habib, 2007, 625) Decision-making can be defined as the act of choosing courses of action. (Farmawy, 2005, 266)

(Martinez Selva & Navarro, 2009) Decision-making involves a broad cognitive activity, including the presence of stimuli, recalling previous experiences, and estimating the consequences of choices. Decision-making is not an abstract thinking process consisting of balancing the losses and gains resulting from a particular decision, but rather the emotional aspects derived from similar experience situations or from the context in which the decision was made play an important role in it. (Martinez Selva & Navarro, 2009, 198). Research Methodology: The researchers followed the descriptive and experimental

research methodology: as the most appropriate method for building the educational program.

Research Community:

The research community consisted of all fifth-grade science students in middle and secondary schools in the General Directorate of Education in Dhi Qar / Al-Gharraf District for the academic year-2023) .(2024

Research Sample:

The research sample is defined as a subset of the original research community that bears the characteristics and qualities of that community and represents it as the phenomenon and subject of the research (Malham, 2000, p. 63). The research sample consisted of fifth-grade science students in (Al-Gharraf Martyrs Preparatory School for Boys) in Al-Gharraf District in Dhi Qar Governorate for the academic year (2023-2024), totalling 120 students.

Research Tools:

The current research required the preparation of two tools to measure the dependent variables: an achievement test and a complex thinking test. The following explains the procedures for constructing these tools:

Test validity:

Validity means the validity of the tool to measure what is intended to be measured, or the validity of the research tool to achieve the study tool and thus the high level of confidence in the results reached by the researcher so that it can be moved from them to generalization (Al-Mashhadani, 2019, p. 169). Validity also means the tool's validity to measure what it was designed to measure and its validity in measuring the traits or traits the researcher wants to measure. When the purpose is to measure achievement in a specific subject, the tool's validity means that it is valid to measure achievement in that subject and provide the necessary data about achievement (Attia, 2009, p. 108).

Test stability:

It is the consistency of the scores obtained by the same students at different times of the procedure, or it is the test that, if it is re-applied to the same students, gives the same or close results. It is one of the characteristics that the measurement tool must have, and it means stability so that its degree does not change fundamentally by repeating the test, meaning that the test can achieve the same results if it is applied twice to the same group and under the same circumstances (Al-Kaabi, 2007, p. 200)

Presentation and interpretation of results:

Table (27). The arithmetic mean, standard deviation, calculated and tabulated t-value of the scores of the students in the experimental and control groups in the achievement test

Statistical significance	T-value		Standard deviation	Arithmetic mean	Number of sample students	The group
	Table values	calculated value				
significant	1.99	9.81	4.83	80.12	41	Experimental group
			4.23	71.92	41	Control group

Accordingly, the first main null hypothesis is rejected and the alternative hypothesis is accepted, which states: There is a statistically significant difference at the level (0.05) between the average scores of the experimental group students who study biology according to the educational program based on the five minds theory and the average scores of the control group students who study the same subject in the usual way in the achievement test.

Table(28) . The arithmetic mean, standard deviation and t-value (calculated and tabulated) of the scores of the students of the experimental and control groups in the post-complex thinking test

Statistical significance	T-value		Standard deviation	Arithmetic mean	Number of sample students	The group
	Table values	calculated value				
Significant	1.99	4.92	3.22	32.24	41	Experimental group
			2.77	22.26	41	Control group

Accordingly, the second main null hypothesis is rejected, which states: There is no statistically significant difference at the level (0.05) between the average scores of the experimental group students who study biology according to the educational program based on the theory of the five minds and the average scores of the control group students who study the same subject in the usual way in the post-complex thinking test, and the alternative hypothesis is accepted.

Table (29). Arithmetic mean, standard deviation, calculated and tabulated t-value of the experimental group students' scores before and after the experiment in the complex thinking test

Statistical significance	Degree of freedom	Table value	calculated value	deviation of differences	Average difference	Standard deviation	Arithmetic mean	Sample size	Measurement
significant	40	2.00	20.6	1.7	8	2.61	21.80	41	Pre-test
						3.22	32.24		Post-test

Accordingly, the third main null hypothesis is rejected, which states: There is no statistically significant difference at the level (0.05) between the averages of the pre-and post-tests of the scores of the experimental group students who study biology according to the educational program based on the theory of the five minds in the complex thinking test, and the alternative hypothesis is accepted.

Table (30) Effect size values for the research variables

Effect size	value (d)	Effect size	Eta square value	Degree of freedom	Calculated T-value	Dependent variable	independent variable
middle	0.64	large	0.54	80	9.81	Academic achievement	Program. Educational
middle	0.75	large	0.23	80	4.92	Complex thinking	Program. Educational

It is clear from the Table above that the effect size for the values of Eta Square is large, and the effect size for the values of (d) is medium after comparison with the standard values of Eta Square and (d) values as in the following Table:(31)

Table (31) . Standard values for the effect size

large	middle	small	value
0.14	0.06	0.01	Eta square value
0.80	0.50	0.20	

Conclusions:

In light of the research results obtained by the researcher, we can make the following conclusions:

1- Relying on the educational program based on the theory of the five minds contributed to the student's interaction with the scientific material, which increased his academic achievement.

2- The educational program helped the student bear the responsibility of his learning and rely on his cognitive structure, which raised the level of complex thinking in him.

Recommendations:

In light of the research results, the researcher recommends that the relevant committees in the Iraqi Ministry of Education do the following:

1. Inviting biology teachers at different levels to rely on the educational program based on the theory of the five minds in teaching biology to the fifth scientific grade for its effectiveness in raising academic achievement and developing complex thinking in them.
2. Allocating topics in teaching methods courses at the level of university education, secondary education and continuing education related to developing complex thinking

Suggestions:

In continuation of this study, the researcher proposes the following:

1. The effectiveness of an educational program based on the theory of the five minds in the achievement of fifth-grade science students in chemistry and developing their complex thinking
2. The effectiveness of an educational program based on the theory of the five minds in the achievement of third-stage students in the Department of Life Sciences in the subject of genetics and the development of their complex thinking

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