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استخدام حل المشكلات القائم علي سقالات التعلم لتنمية مهارات التفكير الناقد في مادة العلوم لدي تلاميذ المرحلة الإبتدائية

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المستخلص:

هدف البحث الحالي تعرف فاعلية حل المشكلات القائم على سقالات التعلم لتنمية مهارات التفكير الناقد في مادة العلوم لدى تلاميذ المرحلة الابتدائية. اعتمدت هذه الدراسة على المنهج التجريبي ذو التصميم شبه التجريبي. ولتحقيق هدف البحث تم استخدام اختبار مهارات التفكير الناقد من اعداد الباحثة واعداد دليل للمعلم وكراسة نشاط التلميذ. وتكونت عينة الدراسة من (٦٠) تلميذ من تلاميذ الصف الرابع الابتدائي. وقد أسفرت النتائج على فاعلية استخدام حل المشكلات القائم على سقالات التعلم لتنمية مهارات التفكير الناقد لدي التلاميذ. وفي ضوء تلك النتائج قدم الباحث بعض التوصيات والبحوث المقترحة.

الكلمات المفتاحية: حل المشكلات – سقالات التعلم – التفكير الناقد.

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

Abstract

This study aimed at investigating the effectiveness of problem-solving based on learning scaffolding to develop primary school pupils’ critical thinking skills in science. This study depended on an experimental approach with a quasi-experimental design. The researcher used a critical thinking skills test as research instruments. A teacher’s guide and a pupil activity book were also developed and used. The study sample consisted of (60) participants from fourth grade pupils. The results revealed that (PSLSc) positively affected pupils' critical thinking skills. Results also showed a statistically significant difference at (α=0.01) level between the mean score of the experimental group and the mean score of the control group in favor of the experimental group in critical thinking skills in science. In the light of the results, the researcher presented some recommendations and suggested research.

Key words:

Problem solving- Learning Scaffolding - Critical Thinking.

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

Introduction:

Successful education is education that focuses on teaching a person how to think, not to rely on the ideas reached by others. Therefore, the teacher has become tasked with raising pupils' minds and teaching them how to learn to be independent in their learning, using various scientific and mental processes that help learners reach comprehensive and integrated growth, each according to his abilities. (Martin, Prieto, & Jimenez, 2016; ذوقان عبيدات وسهيلة ابو السميد، ٢٠١٣، ٢٢٧)

For many years, cognitive science has been interested in studying what scientific thinking is and how it can be taught in order to improve pupils' science learning (Klarh et al., 2019). To this end, Kuhn et al. propose taking a characterization of science as an argument (Kuhn, 1993; Kuhn et al., 2008). They argue that this is a suitable way of linking the activity of how scientists think with that of the pupils since science is a social activity which is subject to ongoing debate, in which the construction of arguments performs a key role.

Therefore, Dewey said that learning to think is the fundamental objective of education (Quoted from Shamboul, 2022). The emphasis has been shifted from imparting information and content to the learners to enhancing their thinking skills. Education systems worldwide are shifting their focus to improving learners' higher mental processes comprising critical thinking and problem-solving (Ashraah et al., 2012).

Furthermore, Critical thinking is one of the vital issues in recent educational strategies, so all instructors in the field of education are interested in teaching critical thinking to their pupils. The pupils learn critical thinking skills by conducting investigations, analyzing information, and reflecting. Furthermore, Critical thinking skills are also basic skills needed in the world of work including decision-making, leadership, and scientific reasoning, leading to professional success (Kola, Rauscher, & Haupt, 2019).

Consequently, Tawfiq Ahmed and Mohamed Mahmoud (توفيق أحمد ومحمد محمود، ٢٠١٤) demonstrated that the traditional curriculum neglected the pupil's aptitudes, and often prioritized rote memorization of facts and information, rather than fostering critical thinking, problem-solving skills, and conceptual understanding. This can hinder the development of higher-order cognitive abilities and the ability to apply knowledge in real-world contexts.

According to Beichner (2014), pupils' involvement in the educational process is one of the most important predictors of their academic success. In this sense, the better the activity is, the higher the pupils' participation and understanding of the content to be learned. pupils should be challenged to work things out for themselves, so they remain always active and motivated. Therefore, constructivist approaches and effective strategies have to be used and developed.

The constructivist theory represents a contemporary educational trend that has received wide popularity and increasing interest in contemporary educational thought, as it has become an educational activity and an important approach to teaching. Additionally, supports authentic and situated learning experiences. Learners engage in real-world tasks and problem-solving situations that reflect the context in which the knowledge will be applied. This helps learners understand the relevance and practicality of their learning. (Wolfock, 2015)

Unlike traditional instructional methods (i.e., chalk, talk, and rote memorization), PBL uses problem-based instruction, self-regulated learning, and small-group learning to help pupils construct their topics. PBL transforms learning from memorizing abstract factual knowledge to developing knowledge that can be transferred to real-life situations, from passively acquiring knowledge to actively seeking knowledge, from a mere individual understanding of learning to building shared knowledge in collaboration with others. As a result of this transformation, PBL enables pupils to acquire integrated knowledge, skills, and attitudes to become independent problem solvers, better knowledge seekers, and lifelong learners (Hung et al., 2019).

Reviewing the teacher's guide for the fourth grade of primary schools revealed an emphasis on scientific process skills. The scientific process skills refer to the six procedures of observation, communication, measurement, reasoning, prediction, and drawing conclusions based on the evidence or results obtained. As the present research deals with primary school pupils, the teacher initially has to provide them with significant guidance and support to practice these skills, and then gradually reduce this support as the learner gains proficiency.

Therefore, the learning scaffolding strategy represents one of the strategies derived from the constructivist philosophy, which is concerned with preparing pupils to learn independently under the supervision and guidance of the teacher. This strategy was developed for pupils' learning processes. Gradual learning is established by the teacher and is defined in educational situations as supportive tools chosen by the teacher that extend to the learner's skills. It is the means that allows the pupils to accomplish their tasks. So, the teacher first starts with what the pupils are familiar then begins to construct on it, and provides the necessary support for the learner to use to reduce the gap between the requirements of the task and the level of skill of the learner. (Shin, Brush, & Glazewski, 2020)

The learning scaffolding strategies assist and support pupils at the beginning of their learning and according to their needs to master learning so that they can acquire scientific concepts and activate thinking and skills instead of focusing on preserving and demonstrating knowledge. (Trif, 2015).

The educational scaffolding strategy provides clear guidance and direction to learners to clarify the purpose of learning a topic and the required learning requirements to ensure that learners continue to learn and complete tasks correctly. It additionally allows learners to predict expectations by answering the questions posed to them. Thus, it reduces the unexpected outcomes and frustrations that overwhelm learners and draws their attention to the topic of the lesson, generating motivation to learn and increasing their enthusiasm. (Molenaar, Chiu, Sleegers & Boxtel, 2011)

There are many challenges and hurdles that the teacher encounters when using educational scaffolding in the classroom, including the complexity of information and the short learning period in the class, as well as pupils requiring extensive experience and information richness as a clear criterion for scaffolding to achieve its objectives. (Fisher & Frey, 2014, 347)

Training pupils to solve problems with scaffolding is necessary because challenging situations arise in every individual's life, and solving problems develops sound thinking skills. It develops pupils' ability to think critically by guiding them in using different ways of thinking, integrating the use of information, and raising mental curiosity towards discovery, as well as developing pupils' ability to think practically, interpret data logically and correctly, and develop their ability to draw plans to overcome difficulties. Hence, giving pupils

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

confidence in themselves while advancing the scientific trend in facing unfamiliar problem situations to which they are exposed.

Based on the aforementioned, the researcher concluded that for science curricula to achieve their objectives, they need to use problem-solving based on learning scaffolding to enrich critical thinking skills so that pupils can deal with the material they are learning innovatively based on mastering each step of the scientific method to solve problems from one side, and the integrated view of science as a subject and method on the other.

Research problem:

The present research's problem is summarized in pupil’s lack of practice thinking in general and critical thinking in particular as a primary objective of science teaching, which necessitates the use of modern teaching methods and strategies to encourage that thinking in pupils and push them to conduct research, investigation, conclusion, and evaluation of evidence and arguments. As a result, the present research seeks to identify the effectiveness of problem-solving based on learning scaffolding in developing primary school pupils' critical thinking skills in science.

Statement of the problem:

The Research problem was identified by answering the following main question: "What is the effectiveness of using problem-solving based on learning scaffolding to develop primary school pupils’ critical thinking skills in science"?

Research importance:

The importance of the current research can be reflected as follows:

1. Helping learners develop critical thinking skills and build their knowledge of themselves by employing their prior knowledge, thinking, research, and investigation in order to find solutions to problems and apply them in new situations, whether inside or outside the classroom.
2. Providing science teachers in the fourth grade of primary school with a teacher's guide that could be used in teaching the "Motion" unit using problem-solving based on learning scaffolding and guided by it in teaching other units, which could assist in addressing the problem of primary school pupils' low ability to think critically.
3. Paving the way for researchers to conduct future research and studies on problem-solving based on learning scaffolding across different science disciplines at all stages of education.

4. Keeping abreast of recent trends in science teaching by employing effective modern teaching strategies and methods, such as problem-solving based on learning scaffolding, which could contribute to achieving the objectives of teaching science to an elevated level, which is based on discovery and recognizing, thinking innovatively and unconventionally, and interacting with the learning process.

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

Research Hypotheses:

Based on the theoretical framework and previous studies, the present research formulated the following hypotheses:

- There is no statistically significant difference at ($\alpha \leq 0.05$) between the mean scores of the experimental group and the control group in the post critical thinking skills test.

Research Delimitations:

The present research was limited to the following limits:

1) **Human limits:**
It was limited to a sample of fourth-grade pupils in language schools at the city of Dikirnis.

2) **Temporal limits:**
The current research was administered during the first semester of the academic year (2023/2024).

3) **Spatial limits:**
Dikirnis Official Language School (for the experimental group), and Salem Madin Official Language School (for the control group), which are located with the Dikirnis Educational Administration in Dakahlia Governorate.

4) **Objective limits:**

The objective limits of the research were represented in the "Motion" unit of the science textbook for the fourth-grade of primary school for the year 2023/2024, and the Critical thinking test included skills: (knowledge of assumptions - interpretation - evaluation of argumentation - deduction - draw conclusion).

Research Methodology:

In the present research, the hypothetical deductive approach, which was termed the scientific method in the research, or the quantitative and qualitative approaches (Mixed Methods Research) that Creswell (2014, 43) defined as a method for collecting, analyzing, and combining qualitative and quantitative data into a single study for the purpose of breadth and depth of understanding a research problem; in its aspects:

a) Analytical descriptive methodology (qualitative): This includes examining previous research and studies, analyzing, interpreting, and debating the findings.

b) Experimental methodology (quantitative): This consists of an experimental approach with a quasi- experimental design to use problem-solving based on learning scaffolding to develop primary school pupils' critical thinking skills in science by dividing the research group as follows:

The experimental group: A group of fourth-grade pupils who were taught using problem-solving based on learning scaffolding.

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

The control group: A group of fourth-grade pupils who were taught using the usual method.

Research Tools:

The following tool were designed and used by the researcher in order to collect data:

- Critical thinking test in science for fourth grade pupils, and included five skills (knowledge of assumptions - interpretation - evaluation of argumentation - deduction – draw conclusion). (Prepared by the researcher)

Review of Literature and Related Studies

Section one: Problem-Solving Method:

A. Definitions of Problem-Solving:

A problem could be defined as a situation that makes discomfort for the individuals who encounter the situation. This kind of problematic discomfort leads individuals into imbalance and this ambiguous situation reaches balance only through a plausible, reasonable, and practical solution. In parallel with these descriptions, Dewey (2013, 59) defined a problem as an ambiguity in an individual’s mind while analyzing a problem or when faced with a situation. A problem is a situation that individuals may encounter anytime throughout their lives so, it is important to learn problem-solving skills to overcome the problems encountered.

Therefore, the researcher identified the concept of the problem-solving method operationally as an educational activity performed by the learner within a set of sequential and organized procedures, in which fourth-grade pupils use a set of facts, generalizations, and information in the science subject, that helps them formulate appropriate hypotheses, test their validity, and then find solutions to the problems have to contend with, by both the teacher’s guide and the pupil's activity book prepared in the present research.

B. Problem-solving procedures:

The problem-solving method is a sequenced and structured way of finding out the results through experiments. The problem-solving procedures are introduced into nine steps, as indicated by (Butterworth & Thwaites, 2013, 79; Richards, 2015, 44).

1. **Identifying or sensing the problem:** The teacher should take the students to a situation or problem area where the students could identify or sense the problem by asking questions. A competent science teacher always encourages his students to ask questions and tries to answer them simply and understandably. Such situations or the problematic area will stimulate reflective thinking setting up arriving at a rational solution.
2. **Defining the problem:** After identifying or sensing the problem students will define the problem in scientific language and proceed toward a solution. The statement of the problem is such that it clearly defines the scope of the problem as also its limitation.
3. **Analyzing the problem:** In this step, students are allowed to identify the keywords in the problem and this help to pursue the next step.
4. **Collection of data:** In this step, the teacher is allowing and suggesting the students refer to books, periodicals, internet to collect information on keywords. Unnecessary data should be discarded by discussing it with friends or teachers. The data should be free from mechanical and personal errors.

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

5. **Interpreting the data:** In this step, the student is allowed to organize the data on the basis of similarity and difference. This phase of problem-solving demands a great amount of guidance from the teacher because students may not be able to interpret data in the correct way due to a lack of experience. The superfluous data should be discarded.
6. **Formulating hypotheses:** In this step, students will frame the tentative hypotheses to the problem after the interpretation of data. A hypothesis is in fact a certain tentative solution to the problem. The hypothesis should be free from bias and self-inclination.
7. **Testing the most likely hypothesis:** In this step, students are allowed to select a suitable hypothesis or solution for testing with the help of a discussion and experimentation. The experiment or discussion will show the occurrence or nonoccurrence of the expected phenomenon and from this, we will be able to accept or reject or modify the hypothesis.
8. **Drawing conclusion and generalization:** In this step, a conclusion is drawn from the selected hypothesis. The results should support the expected solution. Experiments can be repeated to verify the consistency and correctness of the conclusion. After drawing conclusions, the teacher will make generalizations by arranging a set of experiments in a systematic manner.
9. **Its application to the new situation:** In this step, the teacher will be allowing the student to associate the current problem solution with the different problems or situations. This step will help in minimizing the gap between classroom situations and real-life situations.

As the current research adopts the use of problem-solving based on learning scaffolding in teaching science, and by extrapolating the aforementioned steps presented to problem-solving, the researcher could summarize in the following steps how to apply problem-solving based on learning scaffolding procedurally with pupils during the educational process as follows:

1) Firstly, the teacher elevates the pupils' knowledge by presenting a problem or challenge related to the topic being studied by using verbal scaffolding, pictures, videos, or scientific presentations besides encouraging students to identify the key issues and questions that need to be addressed.
2) Then, the learners with the teacher's assistance accurately determine the problem to be investigated, which allows for setting limits for this problem and distinguishing it from other problems. Through the use of books and references provided by the teacher to the students; in order to scaffold them to the desired results.

3) After that, the pupils collect information and data that will assist them in solving the problem under consideration. In this step, the teacher helps the students as follows:

   a) Providing students with important information at a suitable time so that they could distinguish between information related to the problem and information that isn't.
   b) directing pupils to books and references that could help them gather information related to the problem under consideration. Furthermore, provide them with background information, resources, and examples that will help them make connections between what they already know and what they need to learn.

4) Then, students formulate a set of appropriate hypotheses to solve the problem under consideration so that they can be tested or observed. In this step, the teacher provides assistance to the students through the following:

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

a) Introducing the concept of hypothesis by explaining what a hypothesis is and why it's important in scientific inquiry, providing examples of hypotheses from real-world situations, and asking students to identify the key components of a hypothesis.
b) Giving students opportunities to practice formulating hypotheses with support from them or their peers. This could involve working in pairs or small groups or providing feedback on their ideas.
c) Teachers gradually release responsibility as the students become more confident and proficient at formulating hypotheses, gradually reduce the amount of support provided, and encourage them to work independently.

5) After that, the students test the validity of the most appropriate hypothesis to solve the problem under consideration. In this step, the teacher assists the students through the following:

a) Breaking down the experiment into smaller, more manageable steps for helping students have a clear understanding of the problem, as will help them focus on one aspect of the problem at a time and avoid feeling overwhelmed.

b) Modeling problem-solving strategies to Demonstrate how to use different mental processes for solving problems, such as brainstorming, Means-ends analysis, trial and error, or using analogies, besides encouraging students to try out these strategies themselves.

6) finally, the pupils not only solve the problem under consideration but also generalize the solutions and results they attained in other situations, whether in educational situations or outside the discipline of the study.

Section 2; Learning Scaffolding:

A. Scaffolding Definitions:

Scaffolding is described as temporary support made available for students learning until the students can perform independently of that support (Verhagen &Collis, 1996).

In the same context, Sawyer (2006) indicated that instructional scaffolding is a learning process designed to promote a deeper level of learning. It is the support given during the learning process which is tailored to the needs of the learners to help them achieve their learning goals.

Accordingly, Instructional scaffolding can be utilized in various contexts such as in giving advice to students and providing coaching or assistance. This support or assistance is removed gradually to make learners develop a form of autonomous learning that could help in the development of their three domains of learning (cognitive, effective, and psychomotor). The support given to learners may include but is not limited to documents, outlines, or key questions. When a teacher incorporates scaffolding in the classroom, learners become more of a mentor and facilitator of knowledge rather than the dominant content expert or have a solution to all problems.

While originally scaffolding was viewed as an interaction between the teacher and student, it is increasingly viewed as any support provided (human or otherwise) to help students learn successfully (Puntambekar & Hübscher, 2005).

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

By examining the aforementioned definitions, the researcher defined learning Scaffolding operationally as a set of procedures and steps that the teacher takes within the classroom to gradually provide assistance and temporary support to pupils to help them overcome difficulties during educational situations, which includes assisting in the form of supports that vary in type and level to acquire skills that can only be obtained with assistance and support. This is planned and could take many forms, such as breaking down complex tasks into smaller, more manageable steps, providing examples and models, providing feedback and encouragement, and then reducing the level of support for 4th-grade primary pupils, as learners become more confident and competent.

B. Scaffolding Procedures:

Scaffolding helps students bridge the gap between what they know and what they need to know, supports them as they develop new skills, and breaks down unfamiliar skills into smaller, easily accessible ideas. consequently, five steps must be followed to achieve the educational goals using scaffolding, as referred to by Lipscomb, Swanson & West (2010, 231) as follows:

1. **Presentation:** through that, the teacher presents the task that has to be accomplished and represents it to the students. This is done by using hints, questions, and thinking aloud to explain the steps to achieve the task. writing down the steps to attain the task, and presenting a model of the steps and processes related to the tasks' achievement.

2. **Group practice:** in which students explore simple and then difficult tasks gradually in small working groups, or each student with his classmate, in preparation for the work of each student alone. The teacher monitors errors, corrects them, and directs students to ask questions about the tasks to be accomplished. relying on verbal hints.

3. **Individual learning:** in which the teacher leaves each learner to learn by himself and under his supervision. The teacher also engages in a mutual dialogue with the students.

4. **Feedback:** through which the teacher gives helpful feedback and corrects students' errors, and then demands each student to use feedback by themselves.

5. **Transfer of responsibility to the learner:** All educational responsibilities are transferred from the teacher to the student, with the cancellation of the support provided to him by the teacher, and the student's performance is reviewed periodically until he reaches mastery of learning. After the transfer of responsibility to the student, the degree of autonomy of the student increases, leaving him to learn on his own without.

C. Problem-Solving Based On Scaffolding:

During problem-based learning activities, the teachers must be well-equipped with enough skills to stimulate, guide and provide relevant sources to the students. Scaffolding refers to the assistance offered to the students in the form of support to help them achieve their tasks. Thereby, the tasks are the ones that cannot be achieved by the students themselves. Once the students have more ability to do the tasks, the assistance and the support will be decreased; and these are no longer necessary when the students can do the tasks by themselves.

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

According to recent research, it is found that the integration of problem-based learning activities and scaffolding will increase the problem-solving skills of the students (Hung et. al, 2012).

Although Barrows did not use the scaffolding metaphor in his early descriptions of problem-based learning, the small-group tutorial sessions he recommended were designed to support students' efforts to become independent learners. That is, Barrows recognized, and others have since confirmed (Hmelo-Silver et al., 2007; Wu & Pedersen, 2011), the critical role of scaffolding plays when transferring the responsibility for learning over to students in a problem-centered environment.

Scaffolding performs a crucial role in the problem-based learning problem-based learning process, no matter the context in which it occurs. That is, the problem-based learning model, as originally conceived by Barrows (1986), involved consistent and regular support in the context of one expert tutor per team of medical students. As Barrows described, the role of the tutor was to (a) move students' learning forward through discussions, (b) keep students' learning processes on track, and (c) facilitate and manage productive group work. As such, Barrows considered the tutor's scaffolding role to be the "backbone of problem-based learning" (p. 93).

The teacher's actions in supporting students' learning in the problem-solving process toward the goals of their zone of proximal development are called scaffolding (Wood, Bruner, & Gail, 1976). Scaffolding is a contingent interactive process between the teacher and the students (Van de Pol, Volman, & Beishuizen, 2010). In scaffolding, the teacher facilitates students' learning by offering them guidance that she tailors to the student's needs in a certain phase of the problem-solving process (Hermkes, Mach, & Minnameier, 2018; Van de Pol et al., 2010). The teacher's intentions for scaffolding can be divided into three categories: cognitive, affective, and metacognitive (Van de Pol et al., 2010).

With cognitive scaffolding, the teacher structures and adapts the problem task to better correspond with students' competencies (Van de Pol et al., 2010). To provide help of the right quality and quantity, the teacher has to analyze carefully how students construct and try to solve the task (Hermkes et al., 2018). Elaborate introduction as well as tailored, activating questions on the strategies and contents of the problem to advance students' cognitive learning during the process (Kojo, Laine, & Näveri, 2018).

Therefore, the researcher identified the features of problem-solving based on the scaffolding strategy as follows:

- It transfers knowledge to the learners through activities, correcting errors continuously, expecting the possibility of occurrence of something contingency during learning, and Directing learners towards the goal using appropriate methods of presenting knowledge of the topics.
- The gradual decay until diminishing scaffolding gradually when the learners reach the required level of proficiency so that they continue to complete and accomplish their work and their tasks by themselves until the responsibility is wholly transferred to the learner.
- Controlling frustration and directing it to ensure that the learner accomplishes his task, seeking help, clarification, modeling, examples, or knowledge building, and highlighting salient methodological features.

- Promote different thinking skills as well as higher-order thinking skills. And the industry of the scientific sense of the learners.
- It Gives pupils the freedom to employ their creative abilities in the context of tasks and improves self-confidence, which enhances the learner's self-efficacy in completing tasks and performing them.
- It emphasizes the temporary or fading nature of scaffolding, where help and support are provided for the time needed to enable students to progress with their learning, but which can then be withdrawn as students become increasingly familiar with new concepts or skills.

Section three; Critical Thinking:

A. The concept of critical thinking:

Critical thinking represents one of the higher thinking skills that is concerned with evaluating arguments, the individual's ability to self-organize to carry out evaluation, analysis, and conclusion skills (Astleitner, 2002).

By examining the previously extracted points, the researcher defined critical thinking operationally as a reflective thinking process in which the notions and information that the fourth-grade students have been subjected to examine, inquiry, collect data and evidence to ensure the validity of his data, then judgment the data, interpret and evaluate it in the light of main criteria which develops their critical thinking skills, and was measured in the present research through a critical thinking skills test designed for that purpose, and revolves around several skills:(Recognition of assumptions - interpretation - evaluation of arguments - deduction - Draw conclusion) while learning the science subject.

B. Multiple categories of critical thinking skills:

Critical thinking as a psychological concept includes a number of sub-skills, so there are many classifications of critical thinking skills according to its multiplicity of definitions and theoretical frameworks that explain it. The most famous of these classifications is the Watson & Glaser classification.

Watson-Glaser's critical thinking classification defined that critical thinking involves several things: 1) a wise attitude in considering problems, 2) knowledge of the logical investigation, 3) skills in applying the methods of critical thinking. Watson-Glaser has researched and developed critical thinking skills. This development is based on encouragement in combining the attitudes, knowledge, and skills that are formed from critical thinking skills (Watson & Glaser, 1994, 53-55). The steps of Watson-Glaser examine how students with critical thinking when they solve a problem are described as follows:

R**ecognition of Assumptions:** Understanding what is being stated and considering whether the information presented is true and whether any evidence has been provided to back it up. Correctly identifying when assumptions have been made is an essential part of this, and being able to critically consider the validity of these assumptions – ideally from a number of different perspectives – can help identify missing information or logical inconsistencies.

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

Interpretation: It is the individual's ability to identify a problem, identify logical explanations, and decide whether generalizations and conclusions based on certain information are acceptable or not.

Deduction: It is the ability of the individual to determine some of the consequences arising from premises, or information prior to them.

Draw Conclusion: It is the ability of the individual to draw a conclusion from certain observed or assumed facts, and he has the ability to realize the correctness or error of the conclusion in the light of the given facts.

Evaluation of arguments: It means the individual's ability to evaluate the idea, accept or reject it, distinguish between primary and secondary sources, strong and weak arguments, and issue a judgment on the adequacy of the information.

Udall & Daniels:

Udall and Daniels defined critical thinking as the ability to verify and correct a phenomenon and to base it on specific criteria. Also, it was additionally defined as a self-organized judgment that aimed at interpreting, analyzing, evaluating, and conclusion. They further classified critical thinking skills into three categories: inductive thinking, deductive thinking, and orthodontic thinking. (Udall & Daniels, 1991)

Paul & Scriven:

The intellectually disciplined process of deliberately and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information obtained from or generated by observation, experience, reflection, reasoning, or communication as a guide to belief and action is known as critical thinking. It is built on universal intellectual values that transcend subject matter divides in its exemplary form: clarity, accuracy, precision, consistency, relevance, sound evidence, good reasoning, depth, breadth, and fairness. (Paul & Scriven, 1987)

Paul & Scriven summarized critical thinking as skills and activities that include the following: the ability to interpret, evaluate, observe, and conceptualize information skillfully, and the ability to argue (fisher, 2001, p. 10).

Facione classification of critical thinking skills:

The consensus reached by the researchers and teachers, who participated in the American Philosophical Association's Delphi project on the definition of Critical thinking, is that the characteristics of a critical thinker include traits such as being inquisitive, fair-minded, flexible, diligent, and focused on inquiry (Facione 1990).

It could be discerned from the preceding discussion of critical thinking skills classifications that:

- There are some differences in the classifications of critical thinking skills and their number, as identified by the aforementioned researchers, but most of them included skills such as recognition of Assumptions, conceptualizing information skillfully, and evaluating evidence and arguments.
- Critical thinking includes inductive, deductive, and evaluative thinking skills.

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

- It is noted that the classification presented by Watson and Glaser includes all these skills, so the researcher relied on this classification in her current study.

The study (Jacob, 2010) demonstrated the effectiveness of using critical thinking skills in achievement in physics and the level of critical thinking among the pioneers of an electronic forum of university students. The results of the study showed a positive effect of using critical thinking skills on achievement in physics and the level of critical thinking and its sub-skills (Deduction, evaluation) among the forum's visitors, which lasted about (11) weeks, and the participants received training sessions to solve physical exercises using critical thinking skills.

By examining Watson & Glaser's critical thinking skills, and by examining the science textbook prescribed for fourth-grade pupils, the researcher was able to identify some critical thinking skills operationally that could be developed using problem-solving based on learning scaffolding in teaching science to fourth-grade pupils. These skills are:

Recognition of Assumptions: It is the ability to examine the facts and data contained in a subject so that the individual can judge whether an assumption is valid or not based on his examination of the given facts.

Interpretation: It is the individual's ability to draw a certain conclusion from supposed facts with a reasonable degree of certainty.

Evaluation of Arguments: It is represented in the individual's ability to realize the important aspects related to an issue, and the ability to distinguish its strengths and weaknesses.

Deduction: It is the ability of the individual to derive the relationships between certain facts that are given to him, so that he can judge in the light of this knowledge whether a result is completely derived from these facts or not, regardless of the validity of the given facts or the individual's perspective on them.

Draw Conclusion: It is the ability to distinguish between the degrees of probability of the truth or error of a result according to the degree of its connection to certain facts that are given to it.

As it is clear from the previous presentation of critical thinking skills, critical thinking is not just a reception of information, but rather a mental process that requires the work of the mind, focus accurately, and the ability to issue judgments on the problems that the individual faces. Thus, individuals who have the ability to think critically must have characteristics that differ from others.

Research Procedures:

The following Procedures were carried out to answer the research questions and verify the hypotheses of the research: -

1. Reviewing the literature and previous studies related to research variables (problem-solving based on learning scaffolding, academic achievement, critical thinking skills) to establish the theoretical framework for research and get benefit in preparing tools and materials.

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

2. Selecting the scientific content, which is represented in the unit of "Motion" from the science textbook prescribed for 4th-grade primary school pupils, then preparing it according to problem-solving based on learning scaffolding.
3. Preparing experimental treatment materials.
4. Consulting a group of jurors to verify the validity of the research materials and tools thereby, making adjustments according to their opinions.
5. Verifying the validity of the research tools and conducting a piloting of tools to determine psychometric parameters to ensure their reliability and internal consistency.
6. Selecting the two research groups in two different language schools, in the Dikirnis Educational Administration at Dakahlia Governorate, and dividing them into two groups, one of them: an experimental group at the Dikirnis Language School that studied the "Motion" unit using problem-solving based on learning scaffolding, and the other: a control group at Salem Madin Language School who studied the same unit using traditional method.
7. Obtaining administrative approvals from the competent authorities to administer the current research.
8. Conduct pre-administration of the research tools as a pre-application to the sample to ensure that the two groups are equivalent in the critical thinking skills test.
9. Teaching the unit of "Motion" to the pupils of the experimental group using problem-solving based on learning scaffolding and teaching the same unit to the pupils of the control group in the traditional method.
10. Conduct a post-administration of tools on both groups.
11. Analyzing the collected data statistically using appropriate statistical methods.
12. Discussing, Analyzing, and interpreting the results.
13. Providing a set of appropriate recommendations and suggested forthcoming research in light of the results.

Results and Discussion:

The statistical methods used to verify the hypotheses were a t-test to compare the mean score of the study group in the pre and post-application, Pearson correlation coefficient, Kuder Richardson Equation 21, and Eta square ($\eta 2$) to identify the effect size of the treatment on the improvement of the pupils' critical thinking skills after implementation of the treatment.

Testing the Hypotheses:

"There is no statistically significant difference at ($\alpha \leq 0.05$) between the mean scores of the experimental group and the control group in the critical thinking skills test".

To verify this hypotheses, t-test of the independent groups was used to determine the significance of differences between the mean scores of the two groups (the experimental group and the control group), in the critical thinking skills test, as shown in Table (1):

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

Table (1)

t- values for difference between the mean scores of the two research groups in the post administration of critical thinking skills test

Skills	The group	N.of cases	Means	S.D	Df	t.Value	Statistical significance
Recognition of Assumptions	Control	30	2.67	1.446	58	3.751	0.01 Sig.
	Exp.	30	4.30	1.896			
Interpretation	Control	30	1.83	0.986		12.913	0.01 Sig.
	Exp.	30	5.37	1.129			
Evaluation of Arguments	Control	30	2.20	1.375		8.667	0.01 Sig.
	Exp.	30	5.00	1.114			
Deduction	Control	30	2.23	1.305		8.415	0.01 Sig.
	Exp.	30	5.03	1.273			
Draw Conclusion	Control	30	2.37	1.273		4.726	0.01 Sig.
	Exp.	30	3.77	1.006			
Total score of Test	Control	30	11.30	2.855		15.957	0.01 Sig.
	Exp.	30	23.47	3.048			

Significance level according to Bonferroni is 0.01

The results in Table (1) show that all t-values came in a statistically significant manner at the level (α= 0.01), which means that there are differences between the two groups' mean scores in critical thinking in favor of the experimental group. This indicated that the experimental group outperformed the control group in both critical thinking skills and total score.

The Effectiveness of problem-solving based on learning scaffolding on Developing critical thinking skills:

The effectiveness of the problem-solving based on learning scaffolding was determined in developing critical thinking skills was calculated by using the "η^2" equation, as shown in the following table:

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

Table (2)
The "η^2" value and the effect of problem-solving based on learning scaffolding on developing critical thinking skills

Critical thinking skills	η^2 effect size	The effect level
Recognition of assumptions	0.195	High
Interpretation	0.742	High
Evaluation of Arguments	0.564	High
Deduction	0.55	High
Draw Conclusion	0.278	High
Total score	0.814	High

It is clear from the previous table (2) that all values of "η^2" are of high effect as its values for the critical thinking dimensions that were included in the test ranged from (0.195 - 0.742). It also appears that the effect of using problem-solving based on learning scaffolding on developing the critical thinking skills as a whole reached to 0.814. This means that the contribution of using problem-solving based on learning scaffolding to the variance in achievement was 81.4%, which is a value that expresses a high impact according to the graduation based on the values of "η^2".

This indicated that the experimental group outperformed the control group in both critical thinking skills dimensions and total scores. The null hypothesis was; therefore, rejected, and the alternative hypothesis was accepted, it is stated as:

"There is a statistically significant difference at the level (α=0.01) between the mean scores of the experimental group and the control group in the post-administration of the critical thinking skills test in favor of the experimental group".

These results could be explained and attributed to the pupils practicing higher thinking skills through problem-solving based on a learning scaffolding approach to develop critical thinking skills where:

- The nature of the science course for the fourth grade of primary school necessitates asking many questions in the form of exciting problems, requiring effort to solve these problems and thus, deducing solutions, as well as drawing conclusions to interpret these solutions. These are critical thinking skills that using problem-solving based on learning scaffolding has been beneficial for developing them within fourth-grade elementary school pupils.

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

- Using the appropriate feedback for pupils, whether material or moral, and showing approval and encouragement to pupils, all of this has a role in developing critical thinking skills.
- The teacher's role as an effective mediator between pupils and the activities they solve is guiding and directing them to the basic steps that must be followed, encouraging learners to solve the activities and leading to the continued functioning of learning impact.
- Through problem solving based on learning scaffolding, the greater assurance of the learner acquired the desired skill, knowledge, or ability besides creating momentum through the structure provided by scaffolding, pupils spend less time searching and more time learning and discovering resulting in quicker learning, engaging the learners, motivates the learner to learn, and minimizes the level of frustration for the learners.
- The pupil's activity book, which was prepared by the researcher in the context of the unit's content, includes various activities based on the pupils' inferring of the generalizations and facts included in the unit by themselves.

Recommendations:
In light of the research findings, the following recommendations could be made:

1. The necessity of instructing teachers before and during service to use problem-solving based on learning scaffolding in the classroom so that the pupil's role changes from passive to active participant in the learning process.
2. Holding training courses for science teachers to teach critical thinking skills and integrating them into science curriculum content at the planning and implementation stages of development.
3. Reformulating the science curriculum allows for the application of problem-solving based on learning scaffolding. In addition to the transformation of academic content into problems; this motivates pupils to engage with the material and provides them with opportunities to practice various mental processes, which the teacher could even use in class.

Suggestions:

In light of the research results, the following suggestions are stated for further research:

1. Using Problem-solving based on learning scaffolding in developing science process skills and intrinsic motivation in an online learning environment for primary school pupils.

2. The effectiveness of using problem-solving based on learning scaffolding to improve the learning outcomes of special needs pupils.

3. Challenges facing science teachers in using problem-solving based on learning scaffolding while teaching a science course for the primary stage.

Vol.28, No. 1, Oct, 2024 ISSN: 2090-5890 & 2735-3222

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