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RESEARCH ARTICLE

The Effectiveness of the Appleton Model supported by Educational Scaffolding in Developing Geometric Thinking for Fifth Graders

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ABSTRACT

This study aims to identify the effectiveness of the Appleton model supported by educational scaffolding in developing geometric thinking among fifth graders. To achieve the study objective, a geometric thinking test was built according to the Van Hiele model in the first three levels (visual, analytical, and ordinal), and verifying its validity and reliability. The quasi-experimental approach was used with a pre-post measurement. The research sample consisted of 54 female students who were distributed equally between the control and experimental research groups. The results showed statistically significant differences between the arithmetic means of students in the experimental and control groups at each level of geometric thinking and on the geometric thinking test as a whole, attributed to the teaching method and in favor of the experimental group. In light of the research results, we recommend employing the Appleton model supported by educational scaffolding in teaching mathematics to fifth graders.

INTRODUCTION

Mathematics is an important tool for use and application, and is characterized by continuous growth, development and change over time. Mathematics was created to help a person arrange the affairs of his life and take care of his issues. There are skills that a person needs to live and adapt in society and interact with it in various fields, which requires a good level of mental knowledge that It makes him critical, active and participatory. Mathematics is an independent and integrated system of knowledge and methods. It is a pattern and method of thinking. In addition, it has become a basic component of various natural sciences. For this reason, everyone must benefit from the minimum of it in order to keep pace with the world and its development (Faradallah, 2014).).

Mathematics is also an essential pillar of education curricula and a foundationaImportantaTo develop mathematical thinking that aims to prepare students capable of interpreting, analysing, predicting, making decisions and solving problems, as it aims to link knowledge with life situations; Which helps to develop different thinking methods, the effective use of technology, the development of self-learning, and to move away from memorization and memorization, and the diversity of educational materials..(Raphael and Youssef, 2001).

Geometry is considered an essential part of the content of school mathematics curricula for students at all levels of education. It is also considered a basic mathematical skill, as geometry supports the development of students' spatial sense and deductive thinking, and forms the basis for various

mathematical and non-mathematical fields, and plays a major role in them. (Pavloviˇcová & Boˇcková, 2021).

When reading mathematical expressions and problems related to geometry consciously, the learner is ablea To define and understand terms and concepts and then translate them into a Mathematical shapes and symbols. In order for the translation of the educational situation to be a conscious translation, it is necessary to harness the network of conceptual knowledge, which is an interconnected network through which the learner can interpret things and use new information (Van De Walle, 1994).

Mathematical thinking is considered a major focus in mathematics curricula, and there is a necessary need to develop and practice mathematical thinking in school mathematics, and this was confirmed by the National Council of Teachers of Mathematics. National Council of Teachers & Mathematics); He pointed out that developing mathematical thinking is one of the most important goals of teaching mathematics, as it is considered an elementa BasicaIn developing students' ability to understand mathematics,(NCTM,2000)) ,Mathematical thinking also represents an essential and vital element in developing students' ability to understand mathematics and other subjects, and it also helps in acquiring mathematical knowledge that lasts with students. (Ibrahim,2005).

One of the types of mathematical thinking is geometric mathematical thinking. This type of thinking is linked to images, shapes, and geometric models and their properties and composition in the mental structure, asachar dendial (Dindyal,2007), afor mean engineering thinking onea The form of mathematical thinking that helps students understand geometry and deal with it correctly, as improving The levels of geometric thinking is one of the most important goals of teaching mathematics in general, and teaching engineering in particular, because geometric thinking is very important.aIn various scientific, technological and professional topics.(Olkun, Sinoplu & Deryakulu, 2005).

Pierre Van Hiele and his wife, Dina Van Hiele, presented Van Hiele's theory of citationaTo two studies on the difficulties faced by students studying engineering in Germany. The two studies showed that engineering thinking and learning engineering proceed at successive levels that include developmentaIn the ways and quality of thinking, each level has its own languageAnd his own terminologyWhich can be used, learning any level depends on the previous level, and also requires moving from one level to anotheraThe last timeaTo mature before moving to the next level, the theory warns that if the learner is at a certain level and the teaching is at a higher level, learning will not occur but it is only possible to memorizeLearnerOr remembers information without understanding. (Al-Harbi, 2015).

Levels of engineering thinking

The following is a description of Van Hiele's levels of engineering thinking, which passes through five successive levels: (Khasawneh,2007; Saeed, 2007; Groth,2005).

1. Visual recognition level (Visual Level)

At this level, the learner can observe a geometric shape and name it through its general appearance, and can distinguish it from a group of shapes that appear similar to it, without being aware of or perceiving the characteristics of the shape. He perceives it visually but does not realize its specificity. Thus, the learner uses the sense of sight to draw a comprehensive picture. In his mind to distinguish objects or shapes.

2. Analytical level (Analysis Level)

At this level, the learner can observe and describe the properties of geometric shapes without linking them to each other, whether at The level of the properties of one shape or the properties of different

shapes. The learner can use oral language to express properties that are not apparent to students of the previous level, and the learner tests those properties by analogy, but It is unable to identify the critical features that make up a geometric figure, i.e., the defining components of that figure, or distinguish them from secondary features, but rather it describes all distinguishable properties.

3. Ordinal level (informal inference) (Ordering Level)

At this level, the learner can give an accurate definition of the geometric concept, find relationships between the properties of the same shape or different shapes, and prove their validity without proof. Where the relationships are not clear to students of the previous level, it becomes an area for thinking at the current level.

4- Deductive level (formal reasoning) (Deduction Level)

It is characterized by the learner's ability to abstract and reason by constructing proofs, understanding the role of theory, definition, and axioms, and the ability to explain and justify the steps of proof, as axioms, definitions, and theories are elements of students' thinking at this level.

5- Abstract level (extreme precision) Rigor Level)

It is considered the highest level in engineering thinking, as it is characterized by the learner's ability to understand the origins of relationships to build geometric axioms and theories, the ability to distinguish between Euclidean, non-Euclidean, neutral and projective geometry, and discover geometric axioms by making a comparison between various systems, in addition to understanding proof based on logic and using non-Euclidean proof. Direct.

Geometric concepts represent an elementa It is important in teaching and learning mathematics at different educational stages, especially the basic stage, which is considered one of the components of mathematical knowledge that contributes to organizing mental experience, and is a goal. Essentially! One of the goals of teaching and understanding mathematics, and the basis on which students build their previous experiences, and those who follow the teaching and learning of mathematics in general and engineering in particular sense some difficulties and problems such as perceptions and ideas that revolve in the minds of students about some engineering concepts and ideas that are not consistent with sound scientific interpretation (Morsi et al.,2020)

The results of the study of Kalia and Bana Jyots (Kallia & Panagiotis (2010) stated that there are difficulties in learning basic engineering concepts, and recommended the need to pay attention to them and give students more definitions and explain them more clearly. Therefore, the inability of students to acquire and comprehend engineering concepts has an impact.aIt's clearHahaIn acquiring new knowledge, and linking it to previous learning. (Al-Khatib,2018).

Over the past decades, educators have invested effort and attention in searching for methods and models of learning that resemble a dynamic and social process,Encourages learners to acquire new knowledge,The result of active interaction and effective participation with the surrounding environment. (Wing-Mui-So, 2002)

Therefore,Learning in light of constructivist theory depends on the assumptions that this learning occurs when there is a change in theaThe ideas available to the learner, either by adding new information, or reorganizing what is known from previous experiences, by focusing on the learner's internal structures and processes under the influence of context and social interactions (Appleton,1997).

AndConsequentlyConstructivist learning and teaching models seek to provide an atmosphereThe semester thatEncourages students to discuss theaIdeas and their development; To build new ideas with their teachers and classmates, that's whatYou confirm itPrinciples of School Mathematics issued by the National Council of Teachers of Mathematics Which emphasizes the learner's active movement

and interactive role. (NCTM,2000).

Social constructivist theory descends from constructivist theory, which emphasizes the role of others in constructing the individual's knowledge an fruitful social interactions between the Individuals help in the growth of their cognitive structure, and work to develop it constantly, as Vygotsky believes that interaction plays a fundamental role in the development of cognition, and shows the extent of the individual's cultural development on the individual and social levels, and this includes evolutionary attention, logical memory and the formation of concepts. (Mustafa,2001).

Therefore, it is necessary to activate the use of teaching strategies in teaching and learning mathematics, allowing the learner to practice different skills, discover different aspects of knowledge for himself, and deduce the relationships between them. Teaching strategies that rely on constructivist theory care about the learner and make him the focus of the educational process, and educational scaffolding is considered one of the learning strategies. Which emerges from the social constructivist theory he presented Vygotsky(Vygotsky, And Which contributes to providing a participatory learning environment that supports and facilitates the educational process, she confirms on That learning takes place through Participation and interaction with others, especially since interaction directly affects the development of the way of thinking, And Interpretation of situations It is one of the educational applications of constructivist theory (Al-Harbi and Ben Jabal,2020 (.

In the opinion of Eve et al(Eva et al, 2019) that educational scaffolding is a collective interactive process between the teacher and the learners with the aim of facilitating the learners' learning by providing guidance and advice to them, and meeting their needs in mathematical problems, as the main idea of educational scaffolding crystallizes in the student's need for help at the beginning of his learning, and then diminishes. The student gradually adopts this aid, and bears responsibility for his own learning, just like the scaffolding used by construction workers in order to complete it. This is what is called the gradual move towards independence. The teacher in this system is the cornerstone in providing educational scaffolding, as he is the one who determines when, how, and what. It will be used as educational scaffolding within the school. (Abdul Hamid, 2019).

Educational scaffolding is defined as the model that provides support to the learner to the extent that allows him to perform the skill successfully. The teacher provides support in various forms, including: dividing the skill into partial skills, modifying difficult questions to make them easier, and providing learners with examples and hints that lead them to the correct answer. It should not take This assistance is a form of direct indoctrination, but should be provided in the form of support to the learner to help him cross the gap between what he knows and what he does not know (Zaytoun, 2003).

The importance of educational scaffolding is to make abstract concepts concrete, through which students can learn about new concepts, facilitate access to science and make it available to students. Contribute to providing social support to students during teaching, and require tasks that challenge abilities, so that they push the student to accomplish meaningful tasks, encourage him to generate ideas, ensure his continuity in learning, and help students to be independent when performing their activities, which increases their ability to interact and engage in an educational environment. Stimulating creativity, while building and developing knowledge. (Doering & Veietsiaianos, 2007)

One of the teaching models that can be supported by learning scaffolds is the Appleton model (Appleton Model, which was developed by Ken Appleton in 1997 and is one of the models based on the constructivist philosophy that stems from the ideas of both Piaget in cognitive constructivism and Vygotsky in social constructivism, where Piaget believes that the process of acquiring knowledge is an active and continuous constructive process, which It is done by addressing the learner's cognitive structures through the processes of representation, alignment, and organization, while

Vygotsky asserts that the acquisition of knowledge takes place through social communication between the teacher and his students on the one hand and between the students themselves on the other hand. The model is also based on the views of Claxton ((Kakston, Howard (Haward) about how adaptation occurs between previous and subsequent knowledge within the individual's cognitive system, especially school experiences within the societal environment, which Vygotsky emphasizes (Al-Kabani, 2008, Attia, 2015).

And Appleton knew Appleton (1997) His model is: one of the models based on the constructivist philosophy of education, through which students' learning processes are described and analyzed. The basis of teaching in this model is to put them in real situations or problems, arrive at meaning, and help them to fully understand, and it consists of four stages. The main areas are sorting the ideas held by the learner, processing information, mining information, and the societal context. He showed that his model focuses on the learner as part of the educational group within the classroom. This model is based on the theories of cognitive constructivism and social constructivism, which provide insight into the conceptual learning of learners.

Stages of Appleton's model.

When using the Appleton model in teaching, it goes through a set of stages (Appleton, 1997; (Olive and Olive, 2003)

1- Sorting the ideas that the learner has (Existing Ideas: This stage represents the starting point in constructivist thought, where previous experiences are known through concept maps and the learner's verbal expressions of knowledge, and an attempt is made to organize those experiences, structures, and internal processes of the learner, in the form of ideas, concepts, and cognitive systems. Giving the learner a comprehensive and clear picture of the world around him, and stimulating his memory to associate it with new stimuli, to try to search for the best idea to explain the new situation.

At this stage, the educational scaffolding was reinforced by asking questions, hints, discussions, cooperative work, and using presentations to display shapes, and visual aids that help the students remember the prior learning of the lesson, such as an educational tool that shows the students the types of angles.

2- Information processing (Processing of information: The learner uses what he remembers about the situation, until he finds the most appropriate explanation that can be used to build meaning around the new information. Information is processed at this stage in several ways, such as representation and matching, so that he receives information from the environment through tangible manifestations, or conducting experiments. Or doing different activities, or comparing. Either the new knowledge is identical with the idea that the learner has, so he feels a state of satisfaction, or he has a partial or complete difference with the new knowledge, then the learner tries to search for more details about the new knowledge.

The educational scaffolding was reinforced at this stage by dividing the full skill into a partial skill through investigative worksheets, using similes and images, asking questions, instructions and directions, interpretation, analysis, and cooperative work, and geometric models and cartoon models of shapes, such as prism and pyramid models of different types, and models Triangles, quadrilaterals, etc.

3- Information mining ((Seeking Information: In this stage, information is searched for through multiple sources, such as presentations made by the teacher or direct educational materials, or examples similar to the course, the use of audio-visual means, and the ideas of the teacher and colleagues, or what the teacher may present in the lesson or Similar lessons: These are methods used by the teacher to encourage students to come up with the answer, so they are under complete control of the teacher who represents their guide and support.

Educational scaffolding was used at this stage through various visual means, such as types of triangles according to the lengths of their sides and angles, types of quadrilaterals, a cartoon model that explains the relationships between quadrilaterals, and a cuneiform tablet that helped in forming the different types of polygons and distinguishing between regular and irregular polygons. Drawings and pictures through the book and the interactive board (Smart board), models and geometric shapes, in addition to exchanging ideas and cooperative work.

4-Social context ((The Social Context: This stage takes multiple forms, such as the teacher's verbal or non-verbal hints and the use of ideas similar to what is present in memory, while noting everything related to the situation, which helps students think flexiblely when expanding the concept through different experiences and activities..

Here, this stage was enhanced with educational scaffolding by asking questions, providing feedback, using verbal and non-verbal reinforcement, clarifying and expanding ideas and concepts, and using technological applications such as using an application.Geo-boardTo ensure that students are able to distinguish between polygons and non-polygons, and regular and irregular polygons, in addition to modifying questions that carry a level of difficulty to be easier.

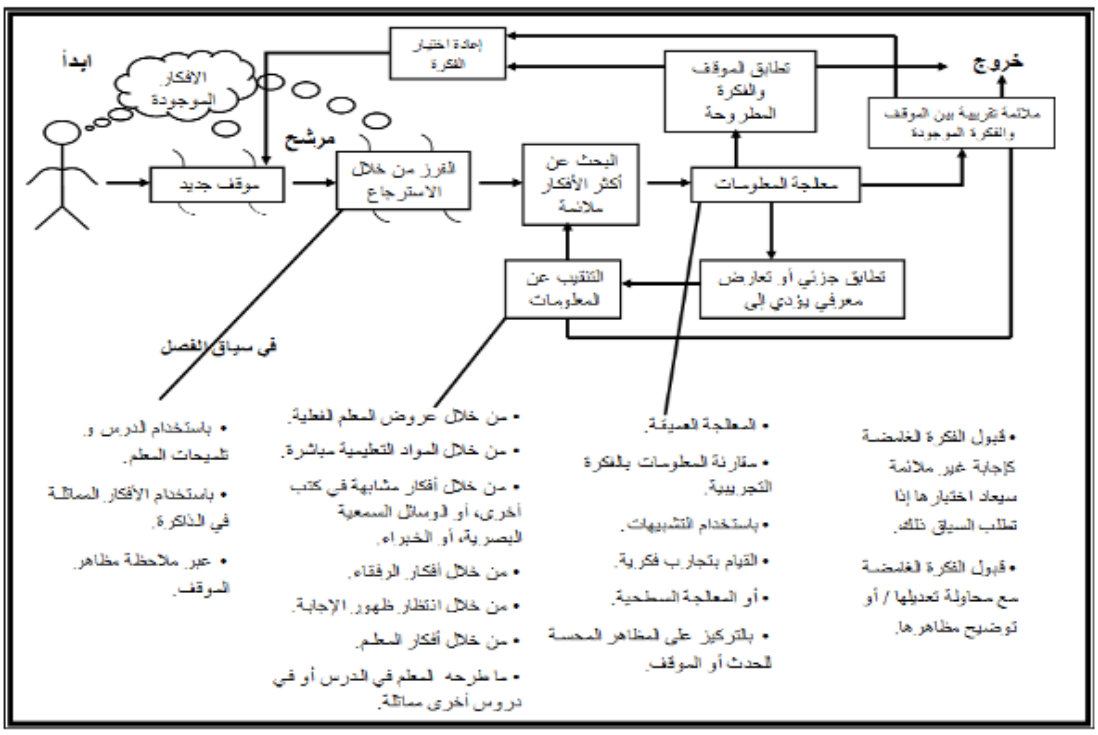

Figure (1) The four stages of the structural analysis model (Appleton) (Olive and Olive,2003,214)

Based on the previous figure, it is clear to us that the Appleton model consists of several stages that are implemented sequentially within the classroom, beginning by sorting information and previous experiences, by using various strategies such as brainstorming and advanced organizations, in order to process and organize that information. Then it progresses to research and exploration for more in-depth information, as this takes place in an organized classroom environment and an integrated community context.

The Appleton model is characterized by several features, including: making the learner the focus of the educational process by activating his role in searching for information, giving the learner an opportunity to develop his positive attitudes towards science and society regardless of its problems and issues, and providing the learner the opportunity for discussion and dialogue with his colleagues or with the teacher, which contributes to Developing the language of sound dialogue in him, and making him an active learner. The model also contributes to providing the opportunity for the learner to practice thinking in its various styles and think of the largest possible number of solutions to one problem, which stimulates the use of creative thinking and its development in them. Learning in the Appleton model is contextual, as he learns The learner learns through what he knows, what he believes, what he agrees with and what he rejects(Al-Binaa, 2015).

The role of the learner in the Appleton model is highlighted by making him the focus of the educational process in the Appleton model, as Zaitoun pointed out2007) that the learner Plays a role! Effective! In acquiring knowledge and understanding it himself, that is, his role must be positive! He participates in questions, discusses, explores, debates, and assumes instead of being a listener. The learner must be social in that he deals with knowledge socially. He does not obtain knowledge individually, but rather socially through discussion and social dialogue with his peers. His role is also to be Creative and innovator of knowledge and understanding.

The role of the teacher in the Appleton model is also represented by the facilitator and guide of the learner's path in the Appleton model, as Zaitoun mentioned ((2007) that the role of the teacher is to provide an active classroom environment, so that he encourages students to talk, discuss, review, compare, and interact with each other on the one hand and with him on the other hand. The teacher is also keen to provide an educational context and teaching practices that develop individual and group thinking skills, and develop the principle of cooperation And give them confidence in solving problems, constructive criticism, brainstorming, exchanging experiences and self-evaluation, and it must help in employing the prior knowledge of the learners in the educational situation and linking it to new knowledge, in order to build the new acquired knowledge in a way that produces distinctive learning.!In the cognitive construction of the individual, his role is to know the characteristics of students, and to provide means, activities and learning situations that suit these characteristics and develop them, to build new learning situations that lead to opening horizons. New to learning, accepting the learner's personality and initiatives, and giving him the opportunity to express them completely freely without any fear of criticism.

Based on Appleton (Appleton, 1997). Sample It is used as a means of showing and analyzing the cognitive progress of learners during learning. It is also used to provide teachers with previous experience on how learners arrive at solutions to the problems they face during lessons, and to correct alternative perceptions stuck in the minds of some learners, in addition to using it in developing teaching strategies that enhance learning opportunities. Learners as much as possible, and evaluate their learning.

In light of what was mentioned previously about the Appleton model, it became clear to us that the learner's prior knowledge is considered the basic foundation and starting point for achieving and developing new knowledge for him. It also became clear to us that the Appleton model focuses on simplifying, organizing, and discovering knowledge by the learner in order to reach the best results.

And because Tn Mathematical thinking is one of the most important goals of teaching mathematics, and to help students develop their thinking regarding geometry, they need educational opportunities and experiences to develop their thinking in geometry, so this study came to investigate the effect of using the Appleton model (Appleton) supported by educational scaffolds in developing geometric thinking among fifth-grade female students.

By reviewing previous literature related to Appleton's model, it was found that there islackIn studies

that examined its impact on mathematics in general and on engineering thinking in particular, ABRgStudies that examined its effect on thinking:

Saidiya study ((2017) which aimed to reveal the impact of the Appleton model on the acquisition of statistical concepts and statistical thinking among tenth grade female students. The study sample consisted of 50 tenth grade female students at Saham Secondary School for Girls, and they were divided into two groups: experimental and control, and two tools were used. To achieve the objectives of the study, which are: testing the acquisition of statistical concepts and testing statistical thinking. The results showed that there were statistically significant differences in the test of acquiring statistical concepts and statistical thinking in favor of the experimental group due to the teaching method.

Hassan and Al-Sidawi conducted itAL Sydawy & Hassan, 2019) A study aimed at identifying the impact of the Appleton model on critical thinking in mathematics among fifth grade students. The study sample consisted of 67 fifth grade students in the middle school in Dhi Qar District in Iraq, and they were distributed into two control groups. Experimental, and a critical thinking test was used to investigateaFor the purposes of the study, andaThe results showed that there were statistically significant differences in favor of the experimental group due to the teaching method.

And building!Upon reviewing previous research and studies on Appleton's model of structural analysis, it was found that the model was used in multiple topics, all of which proved the effectiveness of using the model, such as the study of history, the study of Shinawa and Al-Amir (2017) which aimed to reveal the effectiveness of the Appleton model in achievement and deductive thinking among second-year middle school female students. The researchers used the experimental method and prepared a test of achievement and deductive thinking to achieve the objectives of the study.

The effectiveness of the Appleton model has been investigated in other subjects such as biology, English language, psychology, geography, chemistry, curricula and teaching methods on various dependent variables such as: achievement, problem solving, productive thinking, creative thinking and others. The researchers also noted the lack of studies and research that The Appleton model was used in teaching mathematics.

Most studies focused on the importance of the Appleton model for structural analysis and its role in the educational process. Most studies of this model followed the experimental approach, and previous studies were benefited from in building the theoretical framework and formulating the problem of the study. This study agreed with some studies such as: the study of Hassan and Al-Sidawi ((2019 and Al-Saeedia study 2017)) What will distinguish this study is that it deals with variables on which the effectiveness of the Appleton model has not been studied before.

The study Problem

The problem of the study emerged based on the results of the research and studies that were revealedThere is a weakness among students in engineering thinking in terms of acquiring engineering concepts and skills, such as (Al-Absi,2007, Khasawneh, 2007).

asTouch Finderthe firstthroughHis work in the field in teaching theIn the basic stage, there is weakness in engineering thinking among female students, and a low level of their academic achievement in engineering.Where this was shownn through classroom activities thatIt was practiced with female students, as he feltThe first researcherThere are negative attitudes and trends towards engineering, due to the inability of female students to employ engineering concepts and generalizations in solving engineering problems, in addition to the inability of female students to translate engineering problems into shapes and drawings and justify the steps for solving engineering problems, and the inability to link engineering concepts to the students' daily lives, in addition to Monthly and quarterly test results.

That is why this study came to address this problem, by employing a teaching model that contributes to the development of engineering thinking among female students, due to its importance and the extent to which female students need it in all fields of knowledge.

Study questions

1. What is the effect of using the Appleton model (Appleton) supported by educational scaffolds in developing geometric thinking and each of its levels (visual, analytical, ordinal) among fifth grade female students?

Study hypotheses

1- There are no statistically significant differences at the significance level ($\alpha = 0.05$) between the arithmetic averages of the performance of female students in the experimental group and the control group on the geometric thinking test and for each of its levels (visual, analytical, ordinal) due to the teaching method (Appleton model supported by educational scaffolding, regular).

The importance of studying

The importance of the study lies in its treatment of the Appleton model (Appleton), which is considered one of the modern constructivist models, and supporting this model with educational scaffolding and researching its impact on geometric thinking in mathematics in the engineering unit among fifth-grade female students in Jordan, which contributes to the development of different teaching strategies and methods for mathematics. The importance of the study also lies in its presentation. It is a model that teachers benefit from and directs their attention towards constructivist models and their role in the educational process. Educational supervisors also benefit from it in terms of learning about applications to mathematics of modern constructivist models.

Study limitations and limitations

This study was applied during the second semester2023/2024, and the study sample was limited to fifth grade female students in one of the schools affiliated with the Directorate of Education for the Bani Kenanah District in Irbid Governorate. The study was also limited to the geometry unit from the mathematics book for the fifth grade, in addition to the study tools being limited to testing geometric thinking at its levels. (Visual, analytical, ordinal). The generalization of the study results depends on the extent to which the sample represents the population and the validity and reliability of its tools.

Procedural terms and definitions

Appleton model(Appleton) supported by educational scaffolding: an organized method for a set of procedures employed by the teacher for fifth-grade female students in the geometry unit of the mathematics book, in which the learner builds his own knowledge in light of previous experiences and is represented by four successive procedural steps: sorting the information that the learner possesses, processing the information. Information mining and interactive context, and the model was supported with educational scaffoldsAs stated in the introduction.

Engineering thinking:A pattern of mathematical thinking related to engineering concepts and applications to them, and depends on a set of mental procedures that are represented by the ability of fifth-grade female students to perform a set of...aThe functions required to achieve The levels of engineering thinking as defined by Van Hiel, STThe current study deals with only the first three levels in light of the Van Hiele model (visual, analytical, and ordinal) and is measuredaGradually!The score the student obtains in the engineering thinking test prepared for this study.

Study personnel

The study population consisted of54 fifth-grade female students at Hartha Basic Mixed School in the

Directorate of Education of the Bani Kenana District, in the second semester of 2023/2024. The school was chosen intentionally.Where was chosen 27 female students from the fifth grade of basic B as an experimental group, and 27 female students from the fifth grade of basic A as a control group. The experimental group and the control group were chosen randomly using a lottery.

Study tool

To answer the study questions, theaThe following tool:

Engineering Reasoning Test:

Based onexaminingBased on previous literature such as the study of repentance (2015), Done Prepare test questions in accordance with the scientific material presented in the geometry unit for the fifth grade in the second semester, and the test consists of25 multiple-choice items asking students to justify Answerthe questionTo find out why students chose to For an answer And the ability to determine their level of engineering thinking. The items were distributed into the first three levels of engineering thinking according to the Van Hiele model, based on the researcher's assumption.yen. The inability of fifth-grade students to reach the stage of constructing geometric proofs and understanding the role of postulates and theorems in various applications, and they did not reach the stage of accuracy in understanding Euclid's geometric structure. The test preparation went through the following steps:

1- Determine the purpose of the test

The geometric thinking test aims to measure the geometric thinking of fifth-grade female students in its first three levels according to the Van Hiele model.

2- Designing test questions

The number of test items was determined for each of the first three levels within the traits and characteristics included under eachlevel. Two marks are calculated for each paragraph; One mark was awarded for the question and one mark for the justification of the answer. And the table (1) It shows the distribution of the items on the three levels of geometric thinking, the number of items for each, the grades for each level, and the total score for the test as a whole.

Table 1: Distribution of the number of items in the geometric thinking test on the first three levels

The level	Number of paragraphs	The number of paragraphs belonging to The level	Total marks
Visual	8	1-8	16
Analytical	9	9-17	18
Informal inference	8	18-25	16
the total	25		50

Validity of the geometric reasoning test

The validity of the geometric thinking test was verified by presenting it to a number of arbitrators specialized in mathematics, curricula and methods of teaching mathematics, and educational supervisors in the Ministry of Education, to take their opinions into account in terms of the suitability of each question to measure the desired goal, verify the soundness of the linguistic formula, and the suitability of the paragraphs to The levels of geometric thinking. The appropriate modifications were made by deletion or addition in light of their comments and the test was reached in its final form.

Reliability of the geometric reasoning test

To ensure the reliability of the test, it was verified using the test-retest method (test-retest) by applying the test, and re-applying it two weeks later to a group from outside the study sample consisting of (20) female students, and then the Pearson correlation coefficient was calculated between their estimates the two times, reaching (0.86) for the test as a whole.

Table 2: Replay stability of levelsaccording toPearson correlation coefficient

Levels	**Replay stability**
Visual	0.82
Analytical	0.83
Informal inference	0.81

The time required to test engineering thinking

The time to answer the test was determined by calculating the arithmetic average of the time it took the students in the survey sample to answer the test, which was fair.Approximately45minute.

Educational material

The educational material that was applied was prepared To the experimental group to explain how to teach the topics of the geometry unit from the mathematics book for the fifth gradeSecond semester (2023/2024), using the Appleton model supported by educational scaffoldingAs stated in the introductionSeveral steps were followed to prepare the unit and analyze its contents , Determine the objectives of teaching the unit and the outcomes that students are expected to achieve.

It was planned to implement the learning using the Appleton model supported by educational scaffolding, defining all the educational and learning procedures used to achieve these outcomes, focusing on the role of both the teacher and the student, and proceeding according to the steps of the model represented by: sorting the ideas that the learner possesses, processing information, mining for information, and societal context. In addition to preparing the general framework for the teacher's guide to implement the lessons of the engineering unit for fifth-grade students, the framework included the introduction, general objectives, content, number of proposed classes, educational procedures and methods, and the lesson implementation plan, which included:(Lesson title, general objectives, number of classes, lesson plan, and educational methods used). The guide included the following components:

1- An introduction that included talking about the importance of the guide and its objectives.

2-A brief overview of the Appleton model and how to use it in teaching.

3- A list of the lessons included in the unit and the time plan for teaching them.

4-Analysis of engineering content.

5- The general objective of the lessons And Behavioral objectives that emerge from the overall goal.

7-The educational means used.

8-Methods and activities used to achieve goals And Calendar methods.

Evidence arbitration. The validity of the educational material was verified by presenting it in its initial form to a group of experienced and specialized arbitrators in a number of Jordanian universities, and supervisors of the Ministry of Education, with the aim of verifying the extent to which it achieves the set objectives, and ensuring its comprehensiveness and compatibility with the educational model. The necessary amendments were made in light of their suggestions and observations.

Study procedures

To achieve the objectives of the study, the following was done:

- Obtaining official approvals and letters related to the study application.

- Determining the educational content represented in the study unit (Geometry) in the second semester of mathematics for the fifth grade.

- Review of educational literature and previous studies related to the Appleton model (Appleton) and geometric thinking and their benefit in the current study

- Preparing what is necessary to teach the content of the educational unit according to the Appleton model supported by educational scaffolds, such as worksheets related to each lesson and using the interactive board in teaching.

- Designing the teacher's guide according to the Appleton model (Appleton) supported by educational scaffolding, presented it to specialized arbitrators, and put it in its final form after taking into account their comments and suggestions.

- Preparing the study tool, ensuring its validity and reliability, and obtaining approval for its application

- Applying the study tool (the geometric thinking test) to the exploratory sample before starting to apply the experimental treatment.

- Applying the study tool (engineering thinking test) to the study sample before teaching the academic content (engineering unit)

- Training fifth-grade female students in the experimental group on how to implement the steps of the Appleton model supported by educational scaffolding for two sessions on two consecutive days.

- Teaching the educational content of the selected unit to the experimental group using the Appleton model (Appleton) supported by educational scaffolding, and for the control group in the usual way.

- Applying the study tool (engineering thinking) to the sample members after completing teaching the academic content (engineering unit)

- Correcting the test, entering data into the computer, and analyzing it using a program SPSS, and use the necessary processors.

- Discussing the results and presenting the most important recommendations regarding them.

Curriculum

The research was based on the quasi-experimental approach with two groups, one of which was an experimental group that taught the geometry unit using the Appleton model supported by educational scaffolding, and the other was a control group that was taught in the usual way. A pre-post design was used for two equal groups, in order to achieve the goal of the research, which is to identify the effectiveness of the Appleton model supported by Educational scaffolding in developing engineering thinking.

Study variables:

It was formed. The study variables are as follows:

1- The independent variable, which is: the teaching method, has two levels:

Teaching method using the Appleton model (Appleton) supported by educational scaffolding and the usual method.

2- The dependent variable, which is engineering thinking at its three levels: the visual, analytical, and ordinal levels.

RESULTS

This study aimed to identify the effectiveness of Appleton's model(Appleton)Supported by educational scaffolding in developing geometric thinking among fifth-grade female students, the following are the results reached by the study:

Study question: What is the effect of using Appleton's model? (Appleton) **Supported by educational scaffolds in developing geometric thinking and each of its levels (visual, analytical, ordinal) among fifth grade female students?**

To answer this question From which the following hypothesis emerged: There are no statistically significant differences at the significance level ($\alpha = 0.05$) between the arithmetic averages of the performance of female students in the experimental group and the control group on the geometric thinking test and for each of its levels (visual, analytical, ordinal) due to the teaching method (Appleton model supported by educational scaffolding, regular). HSat arithmetic means, standard deviations, and adjusted arithmetic mean of scores Fifth grade students taking a test Geometric thinking in the pre- and post-measurements according to the group (experimental, control), as shown in Table No. (3):

Table 3: Averages Arithmetic And deviations Standard and average Arithmetic the average To degrees Fifth grade students Basic on testing Engineering thinking As a whole For both measurements Tribal And the distance By group (experimental, control)

the group	the number	Pre-measurement*		Dimensional measurement		Average Arithmetic the average	The error Standard
		Arithmetic mean *	standard deviation	Arithmetic mean*	standard deviation		
Experimental	27	12.44	3.896	27.93	8.119	28.517	.927
Officer	27	13.48	3.251	19.63	3.553	19.038	.927

* Total score for the test (50)

It is clear from the table (3) There are apparent differences between the arithmetic means and the adjusted arithmetic mean of the grades of fifth-grade female students on the geometric thinking test

in the pre- and post-measurements according to the group (experimental, control). To find out whether these apparent differences are statistically significant, the accompanying one-way analysis of variance (One) was used. method ANCOVA) for the post-measurement of the geometric thinking test as a whole according to the group (experimental, control) after neutralizing the effect of the pre-measurement on them. The following is a presentation of these results as shown in the table (4):

Table 4: Results analysis Unilateral contrast Attendant(One way ANCOVA)To measure Al-Baadi To degrees Fifth grade students Basic on testing Engineering thinking as a whole According For group (experimental, control)after Neutralize Effect Measurement Tribal They have

Source of variance	Sum of squares	Degrees of freedom	Mean sum of squares	value F	Significance level	ETA squareη 2
Pre-measurement	871.283	1	871.283	37.951	.000	
the group	1187.349	1	1187.349	51.718	.000	.503
The error	1170.865	51	22.958			
Total	2971.333	53				

It is clear from the table (4(There are statistically significant differences at the significance level)α= 0.05) in the grades of fifth-grade female students on the geometric thinking test according to the group (experimental, control), the value of (F) reached (51.718) with a statistical significance of (0.000), which is a statistically significant value, and the differences were in favor of the experimental group who were exposed to using the Appleton model.(Appleton)supported by educational scaffolds compared to members of the control group.

As shown in the table (4) that value Eta square (η2)To measure the size of the effect of the teaching method ((0.503, This means that(50.3%) of the explained (predicted) variance in the dependent variable, which is the geometric thinking test The difference between female students in the experimental and control groups may be due to the teaching model that was used.

The means, standard deviations, and adjusted arithmetic mean were also calculated for the pre- and post-measurements of the dimensions of the geometric thinking test according to the group (experimental, control), as shown in the table (5).

.**Table 5: The circles Arithmetic And deviations Standardization The adjusted arithmetic mean of the two measurements Tribal And the distance For dimensions** a test Engineering thinking **According For the group**

Dimensions	the group	the number	Measurement Tribal		Measurement Al-Baadi		Average Arithmetic the average	The error Standard
			the middle* Arithmetic	standard deviation	the middle* Arithmetic	standard deviation		
Visual	Experimental	27	7.96	2.862	12.15	2.699	12.218	.415
	Officer	27	7.30	2.053	9.89	1.826	9.819	.415

Analytical	Experimental	27	3.30	2.053	10.59	4.449	11.001	.530
	Officer	27	4.44	1.908	6.44	2.207	6.036	.530
Inference Informal	Experimental	27	1.19	1.039	5.19	1.922	5.373	.284
	Officer	27	1.74	1.130	3.30	1.171	3.109	.284

* Total score for visual level (16), and for the analytical level ((20, and The level of informal inference)14)

Note from the table (5) There are apparent differences between the arithmetic means and the adjusted arithmetic mean in the pre- and post-measurements of the dimensions of the geometric thinking test resulting from the difference in the group (experimental, control). In order to verify the significance of the apparent differences, a one-way and multiple concomitant analysis of variance was applied.(One way MANCOVA). This is as shown in the table (6).

Table 6: Analysis variance Accompanying mono Multimeter (One way MANCOVA)For effect the group By analogy Al-Baadi for every Dimensions of testing Engineering thinking After neutralization Effect Measurement Tribal They have

Source variance		Sum of squares	Degree of freedom	Mean sum of squares	F	Probability of error	Effect size η2
Visual tribal (accompanying)	Visual after me	45.711	1	45.711	10.641	.002	
Analytical tribal (accompanying)	Analytical after me	101.957	1	101.957	14.591	.000	
Inference The pre-formal (conjunctive)	Inference Non-formal after me	.251	1	.251	.125	.725	
the group	Visual after me	66.487	1	66.487	15.477	.000	.240
hotelling=.996	Analytical after me	285.048	1	285.048	40.792	.000	.454
h=.000	Inference Non-formal after me	59.237	1	59.237	29.524	.000	.376
The error	Visual after me	210.499	49	4.296			
	Analytical after me	342.404	49	6.988			
	Inference Non-formal after me	98.312	49	2.006			

Corrected kidney	Visual after me	344.981	53				
	Analytical after me	873.481	53				
	Inference Non-formal after me	179.870	53				

It appears from the table (6(There are statistically significant differences at the significance level) α≤0.05) according to the effect of group (experimental, control) in all Levels, And The differences were in favor of the experimental group members who were exposed to Using Appleton's model (Appleton) supported by educational scaffolding Compared to members of the control group, note that the effect size of the dimensions ranged between (24%-45.4%).

DISCUSSION

This part aims to discuss the research results that were reached in light of the theoretical framework and previous relevant studies, and the following is a presentation of that: The results showed that there were statistically significant differences at the significance level (α≤0.05) according to group effect (experimental, control) in all dimensions, and the differences were in favor of the experimental group members who were exposed to using the Appleton model(Appleton Model) supported by educational scaffolds compared to members of the control group.

This result is attributed to the importance of using constructivist teaching models in general, especially the Appleton model (Appleton Model), as it is one of the most important models that facilitate the student's access to information, specifically with regard to conceptual knowledge, which reflects the recognition of new concepts, as this model, with its connection to educational scaffolding, is considered an important teaching method based on the acquisition of knowledge in a continuous, active, constructive process. Through cognitive structures, which the teacher uses in activities related to teaching mathematics, through which he includes mathematical concepts and mathematical operations, so that students understand them within the mathematics class, using the processes of representation, alignment, and organization, and this is confirmed by researchers and scientists such as Kakston and Howard, who They praised the ability of the Appleton Model to provide the student with new concepts, as it combines cognitive constructivism and social constructivism, which enables the teacher to give conceptual knowledge to his students in mathematics, through social communication between him and his students on the one hand, and between the students themselves on the other hand. This enables the teacher to make a kind of agreement and harmony between the student's previous knowledge and link it to later knowledge, within a knowledge system full of educational school experiences and experiences of the community environment, to employ them in acquiring mathematical conceptual knowledge, which contributes to expanding the students' perceptions and developing their geometric thinking.

By reviewing the teacher's guide, and working papers, Appleton's model has been supported(Appleton Model) with educational scaffolding, which provided support for students to perform engineering skills successfully. It was noted through the activities that the support provided to the student was in different forms, such as dividing the full skill into partial skills, and this made it easier for the students to access information. This is also observed through the worksheets. In addition to the examples that served as a guide and the beginning of a path leading the students to the correct answer, the questions that carried a level of difficulty were modified to be easier, and this highlighted the role of the teacher as a supervisor, mentor, and guide for the students, to reach correct

geometric thinking, and this led to To link students' previous knowledge through conceptual maps, accompanied by hints, examples, and verbal expressions as a guide to knowledge.

It is noted from the activities how useful the Appleton model is(Appleton Model) supported by educational scaffolding, through the images used in presenting this model during the development of engineering thinking, which drew students' attention in order to link them to their ideas and concepts, and form their own cognitive systems, which leads to better stimulation of students' memory to understand new situations. , where use is noteda. The method of discussion in presenting issues related to geometric shapes, which stimulate geometric thinking, such as the activity related to distinguishing the shapes of angles, and measuring angles using a protractor, and reliance was placed on sorting ideas. Among the procedures were: (asking questions, cooperative work, brainstorming), and one of the exercises In which the teacher develops through the educational scaffolds included according to the Appleton model(Appleton Model) is an activity that detects an error by presenting an example and asking students to justify the answer.

This is what Zaytoun (2007) stated that the role of the teacher is in accordance with the Appleton model (Appleton Model), is considered a facilitator and guide for students' progress, by providing an active classroom environment and encouraging them to speak, discuss and interact with each other, by providing an interactive social environment, and providing teaching practices that develop individual and group thinking skills, as educational scaffolding is based on developing the principle of cooperation, active learning and brainstorming. Mentally, this raises levels of mathematical thinking within mathematics classes in the engineering unit, and when presenting activities and exercises related to including the Appleton Model.

We see that in the lesson on triangles, for example, according to the Appleton model and by imparting the skill of the side lengths of triangles, the teacher used asking questions within cooperative work groups and stimulating geometric thinking by requesting interpretation and analysis of the triangle's shapes and angles. There was an explanation of the teacher's use of illustrative drawings of the types of triangles in order to facilitate the access of the information to All students.

The effectiveness of Appleton's model is due to The Appleton Model, being constructivist, begins with describing and analyzing the concept to be taught, which prompts the teacher to place the students while explaining the class so that they are immersed in situations that carry a real problem that needs to be helped in solving it by describing it and arriving at a clear meaning and understanding of it.

That's what It was done through A Using the steps and stages of Appleton's model (Appleton Model) with educational scaffolding, which had (4) main stages: (sorting the ideas held by the teacher, processing information, prospecting for information, and social context) (Appleton, 1997).

The interpretation of the current result is in favor of the experimental group by relying on the effect of the Appleton model(Appleton Model), which is based on educational scaffolding, enhances the logical implicit comparison with old traditional teaching models and methods within the usual strategies, by focusing on them and trying to replace them among mathematics teachers, especially because they have proven their low feasibility and effectiveness in teaching and imparting geometric thinking, specifically in the mathematical geometry unit, which You need to develop the mathematical cognitive structure through participation in active learning groups, in a way that reflects positively on the student and supports the exchange of ideas and concepts with his colleagues, starting from the stages of the Appleton model, starting with the idea sorting step, ending with the social context step, which (includes enrichment exercises and problems, and verbal reinforcement). non-verbal, and feedback).

The results of these studies are consistent with the study of Al-Saeedia (2017), where he found differences on the statistical thinking test in favor of the experimental group, attributed to the teaching method according to the Appleton model.(Appleton Model), as well as the study of Hassan

& AL Sydawy (2019), which showed that there were differences in favor of the experimental group, due to the teaching method according to the Appleton Model on the critical thinking test.

The study was distinguished in this result, as it linked The level of students on the engineering thinking test and their ability to develop engineering thinking skills according to the Appleton model (Appleton) supported by educational scaffolding in mathematics, and according to the researchers' knowledge, some studies focused on other topics, such as the history study in the study of El-Shenawy and Amir (2017), the physics study, such as the study of Al-Harishawi (2019), and the study of Al-Hamza (2017), which used the science study, and in a review For the dependent variables, the current study was distinguished by reviewing the variable of engineering thinking within the subject of mathematics and by focusing on the engineering unit, and this is considered a qualitative addition within the limits of the researchers' knowledge.

Conclusions and recommendations

The study presented a main conclusion that using the Appleton model (Appleton Based on educational scaffolding at its various stages, it creates opportunities for engineering thinking at its various levels. The role played by this model is to give the teacher an active role in the learning process, by providing various activities that take into account individual differences, and through which different ideas and viewpoints are exchanged between students within the classroom, which It contributes to giving female students the opportunity to build, organize, and connect ideas, and to develop rapid thinking processes and linking ideas.

Also, learning using the Appleton model (Appleton) Supported by educational scaffolding, it helped students use their higher abilities. In the stage of sorting the ideas held by the learner, the model contributed to the formation of sound mathematical knowledge by linking previous and current learning, and this included answering the teacher's questions that stimulated thinking among the students. In the information processing stage, laws, generalizations, and characteristics of concepts, geometric shapes, and solids were deduced from Before the students, which led to an increase in their ability to summarize information, solve problems, reach conclusions, and make decisions, which in turn led to the development of engineering thinking among the students.

Moreover, the social context between the teacher and the students and among the students themselves led to motivation, enthusiasm, and the desire to solve problems through life issues, which in turn led to expanding the students' awareness of the importance of mathematics in daily life.

In addition to the above, we do not forget the importance of the educational scaffolding that was supported by the model, as the scaffolding contributed greatly to simplifying and clarifying the information for the students and making the information reach all the students, such as dividing the complete skill into a partial skill, and using various visual aids, such as a means of distinguishing the types of angles and a means of distinguishing the types of angles. To distinguish the types of triangles according to the measurements of their angles and the lengths of their sides, and to use the cuneiform tablet to form polygons and to distinguish between regular and irregular polygons, geometric figures, images and other means, which in turn worked to employ geometric shapes, delve into their properties, find relationships, similarities and differences between them, and develop appropriate interpretations to solve engineering problems, This aroused enthusiasm among the students and pushed them to discover and organize information, which helped in providing justification, explaining answers to questions, and connecting with life by discovering new applications, and all of this in turn leads to the development of engineering thinking.

Based on the above, and in light of the results reached in this study, the researchers recommend the following:

1- Taking advantage of Appleton's model (Appleton) supported by educational scaffolds in teaching mathematics, and tools prepared by the researchers because of its positive impact on its use.

2- Holding training courses and workshops to introduce the Appleton model supported by educational scaffolding and training teachers on it and using it in teaching.

3- Holding training courses for teachers on engineering thinking, its levels, importance, and how to develop it among students.

4- Paying attention to training students to use effective social interaction among themselves, and linking previous knowledge with new knowledge to build meaning.

Conducting studies similar to the current study and its impact on other variables such as algebraic thinking and proportional thinking, and dealing with different educational stages such as the secondary stages.

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