Ed Process Int J

www.edupij.com

ISSN 2147-0901 (Print), 2564-8020 (Online)

EDUCATIONAL PROCESS
INTERNATIONAL JOURNAL

Research Article

Cite this article: Bani Khaled, R., & Al-Omari, A. (2025). The Impact of Teaching Science Based on John Zahorek's Model on Acquiring Scientific Concepts Among Seventh-Grade Female Students. *Educational Process: International Journal, 19,* e2025539. https://doi.org/10.22521/edupij.2025.19.539

Received July 31, 2025
Accepted October 21, 2025

Keywords: John Zahorek's model, acquisition of scientific concepts, 7th grade

The Impact of Teaching Science Based on John Zahorek's Model on Acquiring Scientific Concepts Among Seventh-Grade Female Students

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Abstract

Background/purpose. This study aimed to identify the impact of teaching science based on John Zahorek's model on the acquisition of scientific concepts among seventh-grade female students.

Materials/methods. It was based on the quasi-experimental method. The study participants, comprising 58 seventh-grade students, were intentionally selected from the Kasbah Zarqa District and divided into two groups. The sample was selected from among the two divisions by random appointment, where the experimental group consisted of 30 female students in the first division and the control group (28) female students in the second division.

Results. After conducting statistical analysis through the SPSS program, the study showed a statistically significant effect at the significance level (α=0.05) of teaching science based on John Zahorek's model in acquiring scientific concepts among seventh-grade female students.

Conclusion. The study recommended a set of recommendations, the most prominent of which are: Adopting John Zahorek's model as part of science education strategies in Jordanian schools.

1. Introduction

Learning sciences mainly require possessing a robust knowledge base that qualifies the learner to comprehend science both as a discipline and as a fundamental source of knowledge. Technological advances have typically played a crucial role in introducing new pedagogical approaches that enable learners to master various scientific concepts and competencies. However, the expository method, lecture, remains the predominant teaching strategy used by science teachers. With this approach, the teacher provides knowledge to pupils who are not actively engaged in the learning process. This approach has benefits and drawbacks. For example, it functions effectively in classrooms that are too crowded for more contemporary approaches, including team-based learning.

Teachers frequently evaluate their students' academic achievement using theoretical tests. This expedites the assessment procedure. It can be challenging to monitor students' development in this setting and to comprehend their practical requirements and abilities.

The use of contemporary methods that enable teachers to manage the classroom environment efficiently has been highlighted by educational theorists as crucial for improving students' attitudes, values, and behaviors. By employing these strategies, a student-centered approach will replace the traditional teacher-centered one, providing students with opportunities to engage in meaningful, cooperative learning that considers their abilities (Abulibdeh et al., 2016).

Constructivism is a modern educational trend that has gained widespread popularity and is a growing interest in contemporary educational thought. It has evolved into an intellectual framework, a pedagogical approach, and an effective teaching method. Its applications in science education have diversified, using teaching strategies that encourage students to engage in various activities, enabling them to build interconnected knowledge and acquire practical skills that aid in problem-solving and enhance their thinking abilities (Tanous & Al-Khatib, 2019).

Zahorek's model is a constructivist teaching framework derived from the theory of constructive learning. It views knowledge not as a set of static facts but as meaning that students actively create through structured experiences. The model is implemented in multiple phases. The first phase, activating prior knowledge, involves teachers using various strategies to help students recall and connect their existing knowledge, enabling them to better engage with new information (Zahorik, 1991). As effective information processors, students approach learning while maintaining their own interpretations of historical phenomena and events, with the teacher's role limited to providing guidance and support as students process information (Zahorek, 1971).

The next stage, understanding information, requires students to identify subtle differences between new learning and previous knowledge, which allows them to reorganize and refine their understanding (Al-Asadi & Dawood, 2015). This is followed by the application phase, in which students practice and apply new concepts to real-world problems, thereby refining their cognitive schemas and embedding knowledge through experience. New experiences are gained through students' own efforts and are deepened through discussion and social interaction.

According to Zahorek (1995), knowledge is dynamic, shaped by both social and individual experiences, and constructed through active engagement (Al-Khafaji & Al-Qaisi, 2019). Zahorek identifies five basic stages of constructive teaching: activating information, acquiring information, understanding information, using information, and reflecting on information. Knowledge grows through research, exploration, and experience, as well as through the exchange of ideas with others, interaction with the environment, and feedback from these interactions.

The educational process is typically centered on key components, the most important of which is undoubtedly the students, in addition to the instructional methods used to facilitate the delivery of information more efficiently, and to achieve the objectives sought by the educational institution in a manner consistent with the content of the curricular content, whether the material is physical, skill-based, or intellectual (Sager, 2015).

Hazza (2022, p. 26) and Saleh (2024) define Zahorek's model as a set of successive steps based on the constructivist theory, starting with activating previous information, acquiring information, understanding information, using information, and thinking about information; so that the learner can activate, acquire, understand, use, and think about information; which helps him to form new cognitive structures about learning topics. In this research, it is referred to as a set of structured instructional procedures provided to seventh-grade students to acquire scientific concepts and self-reliance. It is assumed that students' learning begins with activating their knowledge by engaging in discussions with peers (recall), preparing them for acquiring new information, and deductively moving from general principles to application, as well as solving scientific problems, aiming to develop their skills in acquiring scientific concepts and developing effective study habits.

The importance of Zahorek's model lies in its emphasis on a holistic-to-analytical instructional sequence, which begins with the presentation of comprehensive concepts and then gradually breaks them down into their constituent elements. This top-down approach provides students with a broad conceptual framework before engaging with specific details, thereby supporting cognitive organization and facilitating deeper understanding. Moreover, by presenting learning as an iterative process, the model highlights the significance of refining and restructuring concepts through real-world applications. According to this theory, learners who can distinguish between previously acquired knowledge and newly presented material are better able to integrate and comprehend new information. Through this process, students gain a broader intellectual and cultural perspective while achieving conceptual reorganization, which strengthens their cognitive system and enhances their overall cognitive infrastructure (Al-Asadi & Dawood, 2015; Al-Bahadli, 2019).

John Zahorek's model is philosophically grounded in constructivist theory, which emphasizes the role of the teacher as a mentor and guide and depends on the learner's interactions with others and their surroundings through positive and active learning. Instead of passive receptacles awaiting knowledge, students must take an active role in shaping their understanding (Yassin & Raji, 2012). According to this theory, learning is a dynamic, adaptive process in which prior knowledge or experience interacts with new knowledge in the learner's mind, modifying and enhancing both prior information and new knowledge through personal and social interactions that the learner performs within the learning environment. It also highlights the learner's role in creating and shaping knowledge (Attya, 2015).

Zahorek's key assumptions about acquiring knowledge and the instructional processes include the following: The first assumption is that knowledge is not something that exists independently of the student, but instead requires the student to play an active and effective role in constructing this knowledge and incorporating it into their cognitive structures, through interaction with the mental cognitive structures of the learner experiences. This assumption has several issues related to the fact that knowledge is a constructive process, learning is an active process, and learning is a purpose-oriented process. The second premise is based on the notion that individuals create knowledge by drawing on their prior experiences as well as the most recent circumstances they have encountered.

The third assumption is that individuals acquire knowledge by making an active and diligent effort to gather facts, concepts, and information about this knowledge. The fourth assumption suggests that individuals continually construct information and acquire new experiences, implying that knowledge is not fixed. Because it is subject to reorganization within the individual's cognitive structure. Moreover, the fifth assumption assumes that knowledge grows as it is presented through activities and experiences in the classroom environment, and the sixth assumption suggests that understanding becomes stronger and deeper if it is tested through discussion and interaction

https://doi.org/10.22521/edupij.2025.19.539 Published online by Universitepark Press

between the learners themselves and with the teacher towards activities and information inside and outside the classroom (Singh & Yaduvanshi, 2015).

Zahorek's model consists of five steps, including:

1. Activation of information: At the beginning of learning a new topic, students' prior knowledge is activated and utilized (Hussein, 2020). In this stage, learners quickly scan the material to be studied, discuss what they already know about related concepts, identify familiar ideas, and connect their own experiences and knowledge from various sources to the new information (Attya, 2015).

2. Acquisition of information: Zahorek's model of information acquisition suggests that the event or situation be presented as a whole rather than as parts; that is, the general rule should be presented first, followed by the details in a deductive curve (Yassin & Raji, 2012). This is because the learner first comprehends the whole before delving into the specifics of the parts, indicating that the whole is perceived and understood before the parts (Al-Najdi & Abdul Hadi, 2005).

3. Understanding information: Learners understand new information by discovering the content of the new learning and the detailed differences and new information it contains compared to their previous knowledge, and through sharing information with others. Through this sharing, the acquired structures are refined, and the learner is prompted to compare the information they possess with the teacher's information, which provides the learner with a conscious view and begins to reorganize their information in comparison with the teacher's information (Atiyah, 2015).

4. Using information: Students are allowed to apply their knowledge in educational contexts, such as classroom discussions or activities, which refines their information and cognitive structures (Yassin & Raji, 2012).

5. Thinking about information: Following the process of comprehending and applying the information, the constructive learning process must continue to consider its supporting evidence and the necessity of understanding this evidence in relation to the information and knowledge gained. This is accomplished by giving this information more thought, which leads to the ongoing creation and advancement of knowledge that can be applied both within and outside of the classroom (Al-Najdawi, 2005).

Scientific concepts are defined as the general idea that describes a thing, event, or person, allowing for abstract thinking devoid of distracting details. Concept formation involves classifying information into meaningful categories, which requires experience with both positive and negative examples of the concept. Individuals acquire concepts through learning or forming rules. Concepts vary between associative, relational, and disjunctive (Bruna et al., 2025).

Scientific concepts are also referred to as the outcomes of the process of organizing meaningful information, constituting a pivotal element in the acquisition of scientific information in the classroom (Harahsheh, 2019, p. 215).

According to Faraj et al. (2024, p. 219), scientific concepts are one of the levels of classification in cognitive construction; they organize an individual's thoughts, perceptions, and data about phenomena. Concepts are fundamental to increasing an individual's ability to learn an unlimited number of cognitive basics. The essence of a concept lies in defining objects, phenomena, and events that are relevant to it. Al-Mutairi (2023) described scientific concepts as everything that learners form through understanding and meaning, which they use to connect different and familiar facts, phenomena, and situations in an organized manner when studying a unit from their prescribed textbook. Scientific concepts are operationally defined as the results that students obtain from learning scientific concepts in a science course. These results can be verbal, symbolic, or mental, or they might be represented by a collection of objects that ignore certain traits while sharing others.

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Methods of teaching concepts have received significant attention, given the pivotal role concepts play in the learning process. Numerous studies have emphasized the effectiveness of teaching concepts (Artino, 2008; Saleh, 2011), as they help learners move beyond a static state and acquire new concepts and knowledge. Artino (2008) emphasized that learners must develop themselves independently to adapt to a changing world and remain interactive with others. In this way, he will be able to solve real-life problems in relevant tasks.

According to Al-Rababa'ah (2019), students must develop their knowledge and scientific skills at all educational levels. He clarified that relying solely on memorization and ignoring activities, educational resources, and innovative techniques results in a lack of mastery of the educational process, which in turn lowers learners' critical thinking and scientific development. For the learner's role to be active, positive, effective, and participatory in the classroom with the teacher and their colleagues, it is necessary to help motivate teachers to adopt modern teaching methods and move away from traditional ones, with a focus on the learner. This can be achieved by utilizing new models that make learning scientific concepts more engaging and effective.

Mastropieri and Scruggs (2014) list several essential tactics for successful concept acquisition, including daily review of prior lessons, introducing new concepts clearly through illustrative methods, providing guided exercises tailored to students' abilities, practicing repeatedly to master a skill, and using short-term performance assessments to identify progress and correct deficiencies. Numerous factors, including the nature of the concept and the teaching strategies employed, typically influence the process of acquiring scientific concepts. This process has garnered significant attention from educators, who intend to overcome the challenges of learning concepts and ensure the integrity of their understanding among students (Al-Omari, 2020).

Through the researcher's systematic observation as a science teacher, she identified a weakness in students' performance levels on standardized, national, and international science exams, as well as a decline in their success rates over previous years. She also observed a weakness in students' classroom interactions, which could be attributed to the traditional instructional methods employed by teachers. The results of Jordanian students in the International Student Trends in Mathematics and Science Study (TIMSS) demonstrate a decline in students' science scores by 23 points from 2011 to 2019. Jordan ranked 33rd out of 39 participating countries in the TIMSS Science Test, and it is considered one of the four countries with the most declining performance relative to participating countries, according to the global classification of the test (Ghazala, 2020).

In the same context, Martin, Mullis, and Foy (2018) reported several common characteristics among students in countries that ranked low on the TIMSS tests. These features include a marked weakness in understanding scientific concepts, weak skills in the real-life applications of these concepts, the ability to provide scientific explanations, and the capacity to conduct scientific exploration. Thus, it is necessary to examine which teaching strategy would help seventh-grade female students acquire scientific concepts in science. The problem of the current study was to attempt to answer the following question:

"Are there statistically significant differences at the α=0.05 level between the mean scores of scientific concepts level attributable to the teaching method (John Zahorek model, traditional)?"

The study hypothesis is:

‘’There are no statistically significant differences at the significance level (α = 0.05) between the mean scores in the level of scientific concepts that can be attributed to the teaching method (Zahorek’s model vs. the traditional method).’’

This study is considered one of the few, to the researchers' knowledge, that addresses Zahorek's model for teaching science. The aim of this study aligns with global educational trends that emphasize

https://doi.org/10.22521/edupij.2025.19.539 Published online by Universitepark Press

the use of varying strategies and models to enhance scientific concepts. It also provides a tool with appropriate psychometric properties for measuring the acquisition of scientific concepts in science, which teachers and researchers can utilize to their benefit. It is hoped that theoretical literature and the studied variables (John Zahorek's model and scientific concepts) can serve as a reference for researchers and scholars.

This study highlights the potential benefits that science teachers and supervisors may gain from its results in enhancing teaching practices, particularly using Zahorek's model. It is hoped that the study will help teachers incorporate these scientific practices into the curriculum, utilizing John Zahorek's model. This contributes to the development of science teaching strategies and methods to enhance their students' scientific concepts. Furthermore, the findings may inform professional development initiatives within the Ministry of Education, supporting the design and implementation of training workshops that equip teachers with the pedagogical tools necessary to improve their instructional performance.

The findings of this study are limited to the scope of its implementation. The study was conducted with a sample of seventh-grade female students from Al-Al-Mukhaizin Secondary School for Girls in the Qasaba Al-Zarqa District during the second term of the 2024/2025 academic year. The tested material was Unit 9 ‘Behavior and Adaptation’ from the seventh-grade science textbook. The study aimed to investigate the impact of science teaching based on John Zahorek's model on the acquisition of scientific concepts among seventh-grade female students. The generalizability of the results depends on the accuracy, honesty, and objectivity of the study sample in responding to the study instrument.

2. Literature Review

Numerous investigations have been conducted on the learning of scientific concepts and the teaching of science, for instance. Abulibdeh et al. (2016) examined the effect of two constructivist teaching models on students’ motivation to learn science using a questionnaire. The study sample comprised 211 eighth-grade students divided into three groups: an experimental group taught using the Bybee model (n = 71), a second experimental group taught using the Zahorek model (n = 70), and a control group taught using the traditional method (n = 71). The results showed statistically significant differences across all dimensions of the overall motivation scale attributable to the teaching model. These differences favored both experimental groups, with the Bybee group outperforming the Zahorek group. In addition, there were statistically significant gender differences on the overall motivation scale, with females demonstrating higher motivation than males.

Tameh and Muhammad (2019) investigated the effectiveness of John Zahorek's model on higher-order thinking skills among fourth-grade science students in biology, conducting a two-month experiment. The study selected Al-Najah Preparatory School for Boys using a random assignment method. Using a straightforward random assignment approach, the 71 fourth-grade science students were allocated into two groups: the experimental group consisted of 35 students, while the control group consisted of 36 students. Variables such as chronological age, intellect, biology first-course grades, and the pre-test of higher-order thinking skills were used to compare the two groups. For two equal groups (experimental and control), the study used a largely controlled experimental design. Additionally, the unimportant variables were managed. The experiment was used during the second semester of the 2017–2018 school year. The t-test for two independent samples was used to analyze the results statistically once the experiment was completed. Higher-order thinking skills demonstrated a statistically significant difference in favor of the experimental group.

Using the experimental approach, Al-Khafaji and Al-Qaisi (2019) investigated the effect of Zahorek’s model on developing reflective thinking among second-grade middle school students. The study randomly selected two schools: Hassan Al-Sumaidaie Intermediate School, representing the experimental group employing Zahorek's model (n=30), and Al-Naziheen Intermediate School, representing the control group, using the traditional method (n=34). Findings demonstrated statistically significant differences between the groups in the reflective thinking test, favoring the experimental group. Zahorek's model has been proven to effectively develop the reflective thinking of second-grade middle school students in Islamic education.

Yousif (2021) examined the effect of using two constructivist teaching models on motivation towards learning science. Two hundred eleven eighth-grade students participated. Three three-group design was employed: two experimental groups, the first using the Bybee model (n= 71); the second group (n= 70) using the Zahorek model; and the third group (the control group), which consisted of 71 students, was taught using the traditional teaching method. The researchers used a 35-item questionnaire to measure students' motivation towards learning science. Statistically significant differences on the motivation scale were found to be attributable to the influence of the teaching model, with these differences favoring the two experimental groups over the traditional group. The study also favored the first group, which was taught using the Bybee model, compared to the group taught using the Zahorek model. There were also statistically significant differences on the overall motivation scale attributed to the influence of gender, with the differences favoring females.

Muhammad's (2021) study aimed to identify the effectiveness of Zahorek's constructivist model in correcting scientific misconceptions and developing imaginative thinking skills and scientific sense among second-year middle school students. A student booklet and a teacher's guide were prepared to study the content of the science curriculum for the unit "Reproduction and Persistence of Species". The researcher developed a tool to collect data. A total of 40 students were recruited for each of the control and experimental groups. Findings revealed statistically significant differences between the average scores of the experimental and the control group in the post-test scores of the misconceptions test and the imaginative thinking and scientific sense test, favoring the experimental group. These findings were interpreted using statistical equations to highlight the significance of applying Zahorek's constructivist perspective. Students found it easier to comprehend and analyse the unit subjects because they were studied in a variety of ways.

Al-Hamdani (2022) studied the effect of John Zahorek's constructivist model on the achievement of 63 third-grade middle school students in mathematics and the development of their lateral thinking. The experimental group consists of 33 students, while the control group comprises 30. A statistically significant difference was observed between the experimental group, who studied using Zahorek's constructivist model, and the control group students (traditional method) in the achievement test, in favor of the experimental group. Furthermore, the experimental group outperformed the control group on the lateral thinking test, with a statistically significant difference between the two groups.

Finding an educational model based on constructivist theory that considers the development of students' cognitive abilities, accounts for individual differences, and promotes positive learner participation during lessons was of importance. According to constructivist theory, the Zahorek model is a good example that provides a framework for planning and structuring the learning process. Furthermore, this model provides a comprehensive framework for teachers to utilize when creating lessons, offering a thorough description of the educational process through a series of steps linked to enhancing students' capacity to construct knowledge. This study aimed to identify the effect of science teaching based on John Zahorek's model on the acquisition of scientific concepts among seventh-grade female students.

3. Methodology

3.1. Study Methodology

This study employed a quasi-experimental design since it investigates causal relationships in real-world settings where intervention effects can be studied without artificially manipulating variables, and this aligns with the goal of this study, which is identifying the impact of science teaching based on John Zahorek's model on the acquisition of scientific concepts among seventh-grade female students.

3.2. Study Population and Sample

The study sample comprises 58 female students, who were intentionally selected from seventh-grade female students in the Qasaba Zarqa District and are divided into two groups. One group was randomly selected to represent an experimental group (n=30), and the second group represented a control group (n=28).

3.3. Study Instruments

The test for acquiring scientific concepts was developed based on the targeted study unit of the seventh-grade science curriculum (*Behavior and Adaptation*). The items were constructed as multiple-choice questions with four alternatives, totaling 20 items, and were designed in accordance with Zeitoun's (2013) standards for measuring science learning. These standards include identifying verbal meaning, discovering the scientific concept, interpreting observations, applying the practical concept to problem-solving, and using the scientific concept in reasoning and generalization, as presented in Table 1.

Table 1. Distribution of Test Items According to the Dimensions of Measuring Learning of Scientific Concepts, According to Zaytoun (2013)

Dimensions of concept learning	Items	N	Total score
Verbal meaning identification	*17 ،12 ،10 ،7 ،1*	*5*	*10*
Scientific concepts discovery	*19 ،13 ،9 ،8 ،3*	*5*	*10*
Observations interpretation	*14 ،4*	*2*	*4*
Problem solving	*18 ،15 ،11 ،5*	*4*	*8*
Reasoning and generalizing	*20 ،16 ،6 ،2*	*4*	*8*
Total		*20*	*40*

As presented in Table 1, the maximum score of the test is 40. Each correct answer is awarded two points; in contrast, wrong answers are awarded zero points.

3.4. Psychometric Characteristics of the Test

To determine the psychometric characteristics of the test, the indices of difficulty, discrimination, reliability, and validity were calculated.

3.5. Face Validity of the Test

To verify the face validity of the test, it was initially presented to a group of experts and specialists in the field of curricula and teaching methods. They were asked to provide feedback on the clarity of the questions, their ability to measure scientific concepts, and to note any observations regarding the test items. This process aimed to ensure the soundness of the test, its scientific and linguistic accuracy, its alignment with the dimensions of measuring scientific concept learning, the relevance of the items to the unit topics and the students' level, the appropriateness of the content being measured, and the suitability of the distractors and alternatives. Based on the feedback from the reviewers, the wording of some items was modified, and specific alternatives were replaced. The items were distributed across the dimensions of measuring scientific concept learning, with the majority achieving an agreement rate of 80% or higher.

3.6. Difficulty and Discrimination Indices

To calculate the difficulty and discrimination indices of the test items, the test was administered to a pilot sample of 20 seventh-grade students outside the main study sample. The results are presented in Table 2.

Table 2. Values of the Difficulty and Discrimination Indices for the Items of the Scientific Concepts Test According to the Test Dimensions

Dimension	Item	Difficulty coefficient	Discrimination coefficient
Verbal meaning identification	1	0.50	0.40
	7	0.25	0.60
Scientific concepts discovery	10	0.50	0.40
	12	0.55	0.40
	17	0.45	0.80
	3	0.40	0.40
	8	0.45	0.40
Observations Interpretation	9	0.45	0.80
	13	0.40	0.60
	19	0.35	0.80
	4	0.45	0.60
	14	0.50	0.80
problems solving	5	0.30	0.60
	11	0.25	0.60
	15	0.45	0.80
	18	0.45	0.80
reasoning and generalization	2	0.45	0.60
	6	0.40	0.60
	16	0.45	0.60
	20	0.40	0.60
Total		0.42	0.61

Table 2 shows the following:

1. The difficulty coefficient values for the test questions ranged between 0.25 and 0.55, which are considered acceptable values, as the best difficulty coefficient for test items is 50% or around it.

2. The discrimination coefficient values for the test questions ranged between (0.40-0.80), which are considered acceptable values, as the discrimination coefficient values are considered appropriate when they range between 30%-75% (Awda, 2010).

3.7. Construct Validity of the Scientific Concepts Acquisition Test

The construct validity of the Scientific Concepts Acquisition Test was verified by applying the test to the previously mentioned survey sample. Correlation coefficients for each question were extracted with the test as a whole, with the dimension to which it belongs, and with the test as a whole. Table 3 illustrates this.

Table 3. Correlation Coefficients of the Scientific Concepts Acquisition Test Questions with the Dimension and the Overall Test

Verbal meaning identification			Scientific concepts discovery		
Question	With dimension	With test	Question	With dimension	With test
1	0.736 **	0.637 **	3	0.602 **	0.598 **
7	0.491 *	0.496 *	8	0.652 **	0.663 **
10	0.794 **	0.748 **	9	0.713 **	0.679 **
12	0.784 **	0.778 **	13	0.665 **	0.582 **
17	0.754 **	0.695 **	19	0.686 **	0.654 **
Total		0.965 **	Total		0.957 **
Observations Interpretation			**Problem solving**		
Question	With dimension	With test	Question	With dimension	With test
4	**0.866	**0.695	5	**0.706	**0.549
14	**0.867	**0.685	11	**0.697	*0.496
			15	**0.701	**0.711
			18	**0.622	**0.679
Total		0.796 *	Total		0.902 **
Reasoning and Generalizing					
Question	With dimension	With test			
2	0.778 **	0.631 **			
6	0.620 **	0.566 **			
16	0.633 **	0.711 **			
20	0.768 **	0.598 **			
Total		0.895 **			

***Statistically significant at the significance level (α≤0.01).*

**Statistically significant at the significance level (α≤0.05).*

Table 3) shows that all correlation coefficients between the test questions and the dimension to which they belong, and the test as a whole, were statistically significant, which indicates the acceptance of the construct validity of the test.

The test's duration was determined by averaging the amount of time each student in the survey sample needed to complete each question. The test had a 43-minute time requirement. The test instructions were read for an additional two minutes, bringing the total duration to the proper forty-five minutes.

The Scientific Concepts Acquisition Test was used and reapplied to the previously indicated survey sample to confirm its reliability. Correlation coefficients were extracted between the two administrations, and Cronbach's alpha coefficient was calculated for internal consistency reliability. Results are detailed in Table 4 below.

Table 4. Test-Retest Correlation Coefficients and Internal Consistency, Cronbach's Alpha for the Scientific Concepts Acquisition Test

Dimension	Test-retest correlation coefficients	Cronbach's alpha
Verbal meaning identification	0.791 **	0.738
Scientific concepts discovery	0.775 **	0.782
Observations interpretation	0.756 **	0.769
Problem solving	0.815 **	0.711
Reasoning and generalizing	0.837 **	0.753
Total	0.761 **	0.926

Statistically significant at the significance level ($\alpha \le 0.05$).

All correlation coefficients between the two administrations of the dimensions of the scientific concepts acquisition test were statistically significant at the $\alpha \le 0.05$ level. Similarly, all correlation coefficients using the Cronbach alpha method were higher than 0.70, which is considered an acceptable value for this study.

3.8. Teacher's Guide for Teaching Science Using the John Zahorek Model

The researcher developed a teacher's guide for teaching science using the Zahorek model, following these procedures:

- Reviewing prior theoretical literature on designing teacher guides.
- Defining the subject matter: Unit 9 of the seventh-grade science textbook, "Behavior and Adaptation." It was selected because it is the most appropriate for applying the Zahorek model. It includes three lessons (Animal Behavior, Adaptation and Extinction, and Fossils).
- Defining the purpose of the guide: The guide was designed to assist in achieving the current study's objective of acquiring scientific concepts and fostering self-reliance among seventh-grade female students, as well as supporting teachers in implementing the Zahorek model.
- The lessons for the unit were presented through the guide as activities involving the teacher's implementation of the five stages of the Zahorek model, as follows:

1. Information Activation: In this stage, students' prior information is taken into account. The teacher begins teaching a new topic, considering their prior information as the criterion for testing the new information.

2. Information Acquisition: In this stage, information is presented comprehensively, without fragmentation. The general rule is presented deductively.

3. Information Understanding: In this stage, the teacher asks students to explore and examine the nuances of new concepts thoroughly. The teacher assists the student by expanding activities and increasing discussions, which helps provide the student with insight.

4. Information Use: In this stage, information and cognitive structures are refined, providing students with the opportunity to apply practical knowledge effectively.

5. Thinking about information: In this stage, students consider how to apply the information they have learned to practical life, both at school and outside of school.

- Developing an Introduction to the Guide: The significance of John Zahorek's approach and its influence on education generally, and on learning scientific concepts and self-reliance in particular, were highlighted in the introduction to the handbook. Along with outlining the anticipated period for executing the courses, it also described the processes for implementing the educational process utilizing John Zahorek's methodology. It also described the techniques for assessment that should be applied during teaching.

- Establishing the validity of the Guide and the Implementation Methods: The guide was presented to a group of experienced faculty members specializing in curriculum and teaching at universities, as well as science specialists, including supervisors and teachers. They were asked to provide suggestions on the following points:

1. The degree of sequencing of the steps for teaching the study unit using John Zahorek's model.

2. The degree to which the results correspond with the designated instructional subjects

3. The extent to which the activities, educational resources, and worksheets prepared for the lesson topics presented are appropriate and consistent with the students' cognitive, skill, and emotional abilities, as well as their previous experiences.

4. The linguistic and scientific accuracy of the information contained in the guide.

5. In addition, any amendments, suggestions, recommendations, and other comments deemed appropriate by the reviewers.

6. The final version of the guide was developed in response to the reviewers' suggestions.

3.9. Procedures of the Teacher's Guide for Teaching Science Using John Zahorek's Model

After obtaining official approvals from the relevant authorities at Yarmouk University to conduct the study, the pilot and primary study samples were selected, and the study participants were identified as seventh-grade students. The scientific concepts pre-test was administered before teaching using Zahorek's model. The experimental group was then taught using the strategy by the science teacher, who had been trained on the implementation of the instructional strategy and provided with the teacher's guide and worksheets in advance. The control group, on the other hand, was taught using the traditional teaching method by the same teacher.

The researcher attended all sessions of both the experimental and control classes to observe and monitor the implementation of the new teaching strategy. After completing the instructional period, the scientific concepts post-test was administered to both the experimental and control groups to measure learning outcomes.

3.10. Study Variables

The study included the following variables:

1. Independent variable: Teaching method, including Zahorek's model and the traditional method.

2. Dependent variable: Acquisition of scientific concepts.

3.11. Study Design

This study used a quasi-experimental design, with pre- and post-measurements for two groups: experimental and control. The current study design is as follows:

EG: O1 X O1 CG: O1 – O1

The symbols denote:

EG: Experimental group, CG: Control group

O1: Test of scientific concepts

X: Teaching using Zahorek's model - Teaching using the traditional method.

3.12. Normality Test

Table 5 presents the results of the normality test, showing that all study variables follow a normal distribution, based on the values of the One-Sample Kolmogorov-Smirnov Test and their associated significance levels. Since all significance values in the table are greater than 0.05, this indicates that the variables in the current study conform to a normal distribution.

Table 5. Normality Test Using the Shapiro-Wilk Test

Test Value	Significance Level
0.744	0.637

As shown in Table 5, the study data follow a normal distribution, indicating that parametric statistical tests can be applied to examine the differences between mean scores.

3.13. Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) program was used. Descriptive analysis was computed to address the study question. Means, standard deviations, and adjusted means were calculated for the combined performance of the control and experimental groups on the scientific concept acquisition test. The ANCOVA was used to investigate the significance of variations in dimensional means based on the teaching method variable. The effect size of the instructional strategy was calculated using Eta square. The performance of the two study groups on each dimension of acquiring scientific concepts was also evaluated, and the means, standard deviations, and adjusted means were computed. Eta Square was used to calculate the effect size of the teaching technique, and a multiple-way analysis of variance (MANCOVA) was performed to assess the significance of the mean differences according to the teaching method variable.

4. Results

In order to answer the research question, that is, “Are there statistically significant differences at significance level (α = 0.05) between the mean scores in the learning of scientific concepts caused by the teaching method (John Zahorek model vs. traditional”?

’There are no statistically significant differences at the significance level (α = 0.05) between the mean scores in the level of scientific concepts that can be attributed to the teaching method (Zahorek’s model vs. the traditional method).’’

Averages, means, and standard deviations for experimental and control groups for the total score and sub-dimensions of scientific concept acquisition were measured. Results are shown in Table 6.

Table 6. Means Scores and Variability in Scientific Concept Acquisition (Experimental and Control)

Group	Treatment type	Acquisition of scientific concepts	Pre-test		Post-test		Adjusted mean	SE
			M	SD	M	SD		
Experimental	Zahorek's model	Verbal meaning identification	1.83	0.99	3.23	1.07	3.23	0.21
		Scientific concepts discovery	1.57	0.82	3.77	1.10	3.77	0.20
		Observations interpretation	0.80	0.66	1.43	0.57	1.43	0.11
		Problem solving	1.17	0.83	2.63	1.03	2.63	0.18
		Reasoning and generalizing	1.83	1.09	2.73	0.87	2.73	0.15
		Scientific concept test	7.20	2.66	13.80	2.71	13.80	0.48
Control	Traditional	Verbal meaning identification	1.64	0.99	2.25	1.27	2.25	0.23
		Scientific concepts discovery	2.04	1.37	2.61	1.17	2.61	0.24
		Observations interpretation	0.82	0.86	1.07	0.72	1.07	0.14
		Problem solving	1.14	0.80	1.57	1.14	1.57	0.22
		Reasoning and generalizing	1.79	0.99	1.89	0.96	1.89	0.17
		Scientific concept test	7.43	2.87	9.39	3.68	9.39	0.71

M= mean, SD= standard deviation, SE= standard error

Table 6 demonstrates significant differences in the mean scores between the two groups on the dimensions of the Scientific Concepts Acquisition Test. The mean score of the overall test experimental group was 7.20 for the pre-test and 13.80 for the post-test. By contrast, the control group's average score increased from 7.43 during the pre-test to 9.39 in the post-test.

These differences were tested for statistical significance by performing an analysis of covariance (ANCOVA) on the post-test scores of the study sample, with the pre-test scores as a covariate, to account for any initial differences in performance. The results of this test are shown in Table 7.

Table 7. Results of ANCOVA for the Scores of the Subjects on the Scientific Concepts Post-Test

Source of variance	SS	DF	MS	F	Sig	Eta square
Teaching method	281.297	1	281.297	*27.208	0.000	0.331
Pre-Test (Covariate)	8.848	1	8.848	0.856	0.359	0.015
Error	568.630	55	10.339			
Total	8761.000	58				
Adjusted total	858.776	57				

SS=Sum of Squares, DF=degree of freedom, MS=Mean Square

*Statistically significant at the significance level ($\alpha = 0.05$).

Analysis in Table 7 shows that the calculated F-value for the entire Scientific Concepts Acquisition Test was 27.208, indicating statistically significant differences at $\alpha = 0.05$. This reveals that there are statistically significant differences between the post-test scores of the experimental and control groups. Inspection of the adjusted means also shows that these differences point in the positive direction for the experimental condition. In particular, the adjusted mean engaging activities score among the experimental and control groups was 13.80 and 9.39, respectively.

Eta squared (η^2) was computed to ascertain the impact size of the John Zahorek teaching approach on the learning of scientific concepts, and the result was 0.331. This indicates that the use of the John Zahorek model accounts for about 33.1% of the variation in post-test performance. Additionally, using pre-test scores as a covariate, a multivariate analysis of covariance (MANCOVA) was performed to investigate the differences between the two groups on the sub-dimensions of the Scientific Concepts Acquisition Test. The analysis's findings are shown in Table 8.

Table 8. Results of MANCOVA for Dependent Variables, On the Post-Test Means of the Subject's Scores On the Scientific Acquisition Concepts Test

Source of variance	SS	DF	MS	F	Sig	Eta square	Source of variance
Group	Verbal meaning identification	14.004	1	14.004	10.453*	0.002	0.170
	Scientific concepts discovery	19.472	1	19.472	14.545*	0.000	0.222
	Observations interpretation	1.897	1	1.897	4.299*	0.043	0.078
	Problem solving	16.331	1	16.331	12.855*	0.001	0.201
	Reasoning and generalizing	10.231	1	10.231	12.649*	0.001	0.199
Pre-test	Verbal meaning identification	1.376	1	1.376	1.027	0.316	0.020
	Scientific concepts discovery	0.148	1	0.148	0.111	0.741	0.002

Source of variance	SS	DF	MS	F	Sig	Eta square	Source of variance
	Observations interpretation	0.365	1	0.365	0.827	0.368	0.016
	Problem solving	0.028	1	0.028	0.022	0.883	0.000
	Reasoning and generalizing	0.261	1	0.261	0.323	0.572	0.006
Error	Verbal meaning identification	68.324	51	1.34			
	Scientific concepts discovery	68.278	51	1.339			
	Observations interpretation	22.503	51	0.441			
	Problem solving	64.794	51	1.27			
	Reasoning and generalizing	41.248	51	0.809			
Total	Verbal meaning identification	532	58				
	Scientific concepts discovery	688	58				
	Observations interpretation	117	58				
	Problem solving	343	58				
	Reasoning and generalizing	371	58				
Adjusted total	Verbal meaning identification	90.621	57				
	Scientific concepts discovery	91.517	57				
	Observations interpretation	25.121	57				
	Problem solving	82.155	57				
	Reasoning and generalizing	56.776	57				

*Statistically significant at the significance level (α=0.05)

Table 8 presents the results of a MANCOVA, showing that there are statistically significant differences in the sub-dimensions of the scientific acquisition concepts test as follows:

Verbal Meaning Identification: The value of F, 10.453, was statistically significant at α=0.05, indicating an increase in the level of verbal meaning identification favoring the experimental group. The adjusted mean for the experimental group was 3.23, while it was 2.25 for the control group. The value of partial eta squared was 0.170, indicating that the use of John Zahorek's model in teaching explained 17.0% of the variance between the experimental and control groups in the scores on this dimension.

Scientific Concepts Discovery: The F-value was 14.545, which was significant at the 0.05 alpha level. The experimental group significantly scored higher than did the control group as well, with a mean adjusted score of 3.77 relative to 2.61. The partial eta-squared was 0.222, indicating that the use of John Zahorek's model in teaching explained 22.2% of the variance in scores between the experimental and control groups on the scientific concept discovery dimension.

Interpreting Observations: The experimental group's adjusted mean was 1.43, whereas the control group's was 1.07, and the partial eta square was 0.078, indicating that the experimental group's use of John Zahorek's model in instruction explained 7.8% of the variance between the experimental and control groups in the scores on the dimension of interpreting observations. The value of (F) (4.299) was statistically significant at the significance level ($\alpha=0.05$), indicating that the experimental group had an increase in the degree of interpreting observations.

Using The Practical Concept in Solving Problems: At the 0.05 level, the F-value of 12.855 was statistically significant. The experimental group outperformed the control group, with an adjusted mean of 2.63 as opposed to 1.57. The John Zahorek model accounted for 20.1% of the variation, according to the partial eta squared value of 0.201.

Using the Practical Concept in Reasoning and Generalization: At the 0.05 level, the F-value of 12.649 was likewise statistically significant. The control group scored 1.89, while the experimental group's adjusted mean was 2.73. The partial eta squared value was 0.199, indicating that the teaching strategy accounts for 19.9% of the variance in this dimension.

5. Discussion

This result can be attributed to the role of the John Zahorek model in building students' scientific thinking skills. The model offers a structured and interactive learning environment that guides students through a progressive sequence of stages: introduction, presentation, practice, application, and evaluation. This approach promotes a deeper understanding of scientific concepts. These stages help strengthen critical skills, such as analysis, interpretation, and application, which are essential for effective learning in science. These outcomes are also influenced by the beneficial aspects of Zahorek's five-stage strategy, which includes motivation, investigation, interpretation, expansion, and evaluation. Students are encouraged by this framework to go beyond memorization and instead focus on comprehending concepts. By appropriately interpreting natural events and utilizing scientific language to convey them, it also helps students connect scientific concepts to real-world situations.

Notably, Zahorek's model places a strong emphasis on active learning, in which students are encouraged to conduct research and exercise critical thought while participating in practical activities. This method promotes the development of scientific thinking and analytical skills in students, enhances classroom engagement, and boosts students' self-confidence when tackling scientific subjects. Additionally, it encourages the integration of scientific and intellectual tasks, which facilitates students' understanding and retention of abstract concepts. The researchers noticed that students in the experimental group had a comparatively high level of flexibility when interacting with practical topics during the model's implementation. Their exposure to the various learning modes included in the model — visual, auditory, and kinesthetic — may have accommodated individual learning preferences and improved comprehension overall, which could be the cause of this. Additionally, by encouraging greater levels of cooperation and teamwork among students, the John Zahorek model promoted social learning, making it easier for people to share ideas and knowledge. The use of self-assessment and continuous review procedures also facilitated the development of metacognitive thinking by empowering students to monitor their comprehension, reflect on their learning approaches, and make informed adjustments to improve their performance.

This result can be attributed to the fact that the experiment created a more inclusive and stimulating learning environment for all students at various levels. This positively impacted their motivation to learn, reduced anxiety associated with science, and made the classroom environment more interactive and engaging, which indirectly contributed to higher achievement. This result can also be explained by the fact that students who studied using John Zahorek's model were better able to use scientific concepts in new situations, indicating effective and sustainable learning, which is consistent with the constructivist learning theory promoted by the model.

Furthermore, the researcher explains that the John Zahorek model's efficacy stems from its capacity to support students' articulation of ideas and mental processes while they study scientific subjects. This method encourages deeper comprehension as opposed to rote memorization. This approach aligns with the tenets of constructivist learning theory, which emphasizes how students actively construct knowledge through engagement with course materials. Utilizing the John Zahorek model also provides students with opportunities to practice critical scientific thinking skills, including hypothesis testing, interpretation, and prediction. As students advance from passively absorbing information to actively processing it, the classroom activation of these abilities not only enhances the educational process but also helps students perform at greater levels.

Additionally, these results lend credence to the idea that teaching science to seventh-grade female students using the John Zahorek model is an effective pedagogical strategy for developing a thorough and cohesive understanding of science. The model is a promising approach to enhancing educational outcomes in science education, as it effectively integrates the cognitive, skill-based, and affective aspects of learning.

These results are consistent with the findings of Abulibdeh et al. (2016), which indicated the existence of statistically significant differences in the acquisition of concepts among students in the experimental group, attributed to Zahorek’s model. This outcome also aligns with the studies of Mohamed (2021), Mastropieri and Scruggs (2014), and Al-Ruba’ah (2019), which demonstrated the effectiveness of teaching using Zahorek’s model.

Based on the above, the alternative hypothesis is accepted, which states that there are statistically significant differences at the 0.05 significance level ($\alpha = 0.05$) between the mean scores in scientific concept levels attributable to the teaching method (Zahorek’s model versus the traditional method).

6. Conclusion

Although the study faced some challenges, such as limited access to technology—not all students had the devices or internet connectivity required to watch educational videos outside of class—and insufficient support from the school administration and parents, the results indicate that the use of John Zahorek’s model significantly enhanced the acquisition of scientific concepts among seventh-grade female students in the experimental group, compared to their peers taught using the conventional method. The researcher attributes this outcome to the fact that teaching with Zahorek’s model effectively captures students’ attention and interest. This model positions the student at the center of the learning process, with the teacher’s role being to guide and facilitate progress toward the intended educational objectives. Furthermore, the model enabled students to connect prior knowledge with real-life applications, allowing them to construct a logically organized mental representation of the concepts studied and relate them to their own experiences, thereby taking greater responsibility for their own learning.

7. Suggestion

Based on the study findings, the authors recommend the following:

- Adopting the John Zahorek model as part of science education strategies in Jordanian schools.
- Holding structured training for teachers on the practical implementation of this model.
- Developing future studies to evaluate the model's impact on various scientific concepts and at other educational levels.

Declarations

Author Contributions. Designing a test to identify the impact of teaching science based on John Zahourek's model on the acquisition of scientific concepts among seventh-grade female students.
Conflicts of Interest. The authors declare no conflict of interest.
Funding. The authors received no Financial support for this study.
Ethical Approval. The Ethical committee of Yarmouk University, Jordan, has granted approval for this study on 30 January 2025 (Ref. No. IRB/2025/005)
Data Availability Statement. Data Availability Statement. The data can be supplied by the corresponding author upon request.

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