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Effectiveness of the Inquiry Wheel Model in Physics Achievement among Fifth Grad Female Scientific Students

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Abstract
This study investigate the effectiveness of the inquiry wheel model (IWM) on academic achievement in physics among fifth-grade female students, by testing the null hypothesis stated that no statistically significant difference (0.05) exists between the mean achievement scores of the experimental group (taught via the inquiry wheel model) and the control group (taught via the traditional methods). The research was conducted at Al-Safwa High School for the Girls (Al-Qadisiyah Governorate/ Afak District) during the 2024-2025 academic year, using the standard physics textbook for the fifth-grade science. A randomized sample of two intact classes (out of three) was selected, comprising 72 students evenly distributed into experimental (36), and control (36) groups. The groups were matched for age (in months), intelligence, and prior knowledge to ensure equivalence. To validate the investigation, 48 lesson plans were developed: 24 aligned with the IWM (experimental group) and 24 following pedagogy (control group). A 40-item multiple-choice achievement test was administrated, with established validity and reliability. The eight-week experiment involved three weekly sessions per group. Post-intervention data analyzed via SPSS revealed statistically gains in achievement scores for the experimental group compared to the control group (<0.05), supporting the efficacy of the IWM.
Keywords: *Secondary Education, IWM, Achievement Test, Female students, Traditional Method, SPSS,.*

I- INTRODUCTION

A. Problem Statement

The rapid advancements in scientific knowledge, particularly in physics, have positioned this discipline as a cornerstone for understanding natural phenomena and shaping modern life. Physics has driven revolutionary changes in the 21st century, influencing technology, industry, and daily human experiences. Despite its significance, the teaching of physics often remains stagnant, relying on traditional lecture-based and rote memorization methods rather than fostering critical thinking and engagement. This outdated approach has led to a lack of student interest, declining academic achievement, and frustration among both learners and educates (Al-Bati & Saad, 2018, p.87). The researcher, drawing from six years of teaching experience in physics and observations from school visits across Afak District/ Al-Qadisiyah Governorate, noted a concerning decline in fifth-grade science students physics performance. An analysis of past academic records revealed both qualitative and quantitative drops in achievement. To substantiate these observations, a survey was administrated to 20 physics teachers, yielding the following results:

1. 70% confirmed a decline in students physics achievement.
2. 80% reported limited familiarly with inquiry-based learning, particularly the IWM.

These finding underscore the urgent need for innovative, student-centered teaching strategies that align with local educational contexts. Thus, this study addresses the question:

"What is the effectiveness of the IWM in enhancing physics achievement among fifth-grade science students? "

B. Importance of the Research

We are living in an age of science and technology, where scientific discovers, theories, and their technological applications continue to accumulate, affecting the lives of all members of society, whether scientifically oriented or not. All citizens now use one or more applications of the electronic and information revolution, such as television and computers. Today, humanity faces a scientific and informational revolution that has surpassed all expectations. Knowledge is no longer fixed or defined by a starting and ending point, but has become endlessly variable. This necessitates having a solid scientific foundation that enables us to keep pace with educational challenges, the accumulation of knowledge, and

to contribute to utilizing knowledge for a better future. Practical education is the process of providing individuals with a set of scientific experiences (Knowledge, skills, attitudes) necessary to become scientifically literate and capable of keeping up with contemporary times by; focusing on understanding the nature of science, applying scientific knowledge to daily life situations, recognizing the interrelationship between science, technology and society, benefiting from scientific inquiry processes, and acquainting oneself with values and attitudes associated with science (Al-Sayyid Ali, 2009,p.19).

Given the growing emphasis on inquiry-based learning in education generally and science instruction specifically, numerous contemporary inquiry-based teaching models and strategies have emerged. Among these is the IWM a dynamic framework that illustrates how scientists practice science and demonstrates the dynamic nature of scientific inquiry. This model provides educators with effective tools for teaching and discussing authentic scientific investigation processes with students. According to this model, scientists may engage with any component of the wheel as needed during their investigating work. The IWM comprises ten activities that provide students with an authentic model of scientific inquiry as practiced by scientists, offering a more comprehensive, insightful, and expensive approach than the traditional scientific method. Inquiry may initiate from any activity, with some potentially requiring more emphasis than others. These activities include: asking questions, observing, identifying the problem, formulating questions, discovering knowledge, making predictions, conducting research, interpreting results, reflecting on findings, and communicating with others. This model is practical, creative and unconventional. It is an invitation to focus on questions as the center of the educational process. It emphasis that there is no need to follow a linear method. Instead, it opens the door to many different approaches, as questions can arise at any stage. Therefore, IW skills should be learned and applied in different contexts to enable a broad understanding of reality rather than merely being considered a means of gathering information. The term 'inquiry' has two meanings:

1. Inquiry as an understanding of content, in which students build concepts, models and meanings to interpret scientific experiments.
2. Inquiry as a term for skills and abilities, including scientifically determining appropriate questions, formulating hypothesizes, drawing conclusions from enquires, formulating scientific expansions, communicating and proving scientific evidence (Saleh and Al-Sayed, 2014: 1- 2).

C. Research Objective

The current research aims to identify the effectiveness of the inquiry wheel model in the educational engagement of fifth-grade science students in physics.

D. Research Hypothesis

In light of the research objective, the researcher formulated the following null hypothesis: there is no statistical significant difference at the 0.05 significance level between the average academic achievement scores of experimental group students learning physics according to the inquiry wheel model and control group students according to the traditional method.

E. Limitations of the research

1. Human limitations: The research was conducted by fifth-year science students at the General Directorate of Education in Al-Qadisiyah.

2. Time limitation: The second semester of the 2024-2025 academic year.

3. Spatial limitation: Government secondary and preparatory day schools for girls only, which are affiliated with Qadisiyah Education Directorate/Afak District.

4. Knowledge limitation: the approved fifth-grade science physics textbook for the 2024-2025 academic year, consisting of four chapters: Chapter 7: Circular and Rotational motion; Chapter 8: Wave Motion; Chapter 9: Electric Current; and Chapter 10: Magnetism.

F. Terminology Determination

1. IWM: Defined by; Harwood (2004) as comprising ten main activities, nine of which revolve around the center, with the tenth activity being the asking of questions (Harwood, 2004, pp.44-45). Saleh(2014) defines it as including ten main activities, with the activity of asking questions at its centre and the other nine activities arranged around it. The researcher adopts Saleh's (2014) definition as a theoretical one and defines it procedurally as follow: A model comprising a set of nine main activates centered around

the tenth activity of asking questions. These activates provide Year 6 science students with an appropriate atmosphere for exploration and investigation according to the needs of the study.

2. Achievement: defined by: Ismaili, (2011) as the total of the grade a student has obtained in a test as a result of the influence of certain inputs, namely the curriculum, teaching methods, and educational resources (Ismaili, 2011: 61). Al-Fakhri (2018) defines achievement as the information acquired by the student or gained through learning academic subjects, and achievement is obtains in an achievement test (Al-Fakhri, 2018:8). The researcher adopts Al-Fakhri (2018) theoretical definitions and defines it procedurally as follows; the outcome of what the student learn after a period of time, as represented by the grade obtained in an achievement test, in order to determine the success of the teaching strategy for physics, which was prepared by the research after confirming its validity and reliability.

II- Theoretical Background and Previous Studies

1- First IWM: Inquiry is one of the methods of learning and scientific research that contributes to preparing learners to face the problems they encounter in their lives, which they must solve. These are phenomena that they need to understand these phenomena and acquire related concepts and principles, which has a positive effect on how they develop and interact with their environment in the present and future. Scientific inquiry is considered a search for meaning that requires many mental processes to understand the experience that the individual goes through. With the tremendous advancement of knowledge, the burden placed on individuals educational process requires the selection of more effective learning, teaching methods and techniques that can meet the increasing needs of the times (Al-Qadri, 2007:220).

1.1 Steps of The IWM:

This model provides us with effective means to teach and discuss the real and actual process of scientific inquiry with students. In light of this model, scientists engage in any of the model's activities whenever necessary. The IWM includes ten main activities, nine of which revolve around the centre, with the tenth activity being asking questions. The steps of the model are detailed below:

1. Defining the Problem: In this activity, the scientific objectives to be discovered are defined. Scientists base their definition of the problem on their observations and understanding of the literature. Through their observations, they must decide which problems are testable and which contribute to scientific knowledge, while ruling out those that are false.

2. Forming the Question: This refers to the process of constructing a question that will guide the research or study.

3. Discovering Knowledge: Investigating this activity corresponds to stage of the traditional scientific method.

4. Forming Expectations: This activity from the IWM corresponds to the hypothesis stage in the scientific method.

5. Study the Out Carrying: Based on the review of literature related to the subject of investigation, as well as any predictions or hypotheses formulated.

6. Interpreting the Results: Once the data has been obtained in the previous stage, scientists being to examine what the results mean. The results may take the form of measurements, observations, statistical analyses or exploratory studies.

7. Reflecting on the Finding: This activity is different from the stage of interpreting the results. In this activity, scientists spend a sufficient amount of time thinking about the results they have obtained. What do these results mean? What is their significance? How do these results relate to existing knowledge?

8. Communication: Scientists rarely work in isolation, so during the research process they communicate with their peers and scientists in other laboratories.

9. Observing: It is evident that observation is an integral component of all activities encompassed by the IWM. Accurate recording of readings necessitates observation, a fact emphasised by scientists throughout the entire scientific inquiry process. Indeed, observation is included in both the study completion stage and the discovery of what is known stage.

10. Questions: The IWM posits that the act of posing questions constitutes the very core of any scientific inquiry, irrespective of the complexity or generality of the inquires in question. This

assertion is supported by the seminal works of (Reiff, R. et al, 2002,21) and (Harwood, W., 2004:44-45).

1.2 The Function of the Instructor in the Context of Inquiry-based learning:

Al-Fahidi, 2011 proposes a particular conception of the role of the teacher in inquiry-based learning, which is outlined as follows: firstly, in the context of an inquiry-based lesson, the teacher plays a pivotal role in preparing students for the investigative process. This involves presenting students with a problem or a perplexing question that necessitates an answer or solutions. The teacher then encourages students to engage in thought, research, and investigation to address the problem or reach a conclusion. Secondly, the provision of guidance and mentorship to students thought the educational process is paramount. This encompasses the provision of instructions and guidance, with the objective of facilitating the students attainment of solutions, including the utilization of relevant methods and tools. Thirdly, the role of the inquiry process, with the student as the focal point of the educational process, (Al-Fahidi,2011: 324-325).

1.3 The Role of the Teacher in Inquiry Based Learning

Keellow (2006) believes that this role consists of the following; firstly, participating in planning the inquiry and research. Secondly, exploring natural phenomena around them. Thirdly, cooperating and communicating with members of their group, (Keellow, 2006: 7).

2. Secondly Academic Achievement

Academic achievement is a key part of the educational process and one of the most important goals that students strive for. It is one of the general areas that has attracted the attention of parents and educators, as it seeks to provide individuals with the knowledge and skills to broaden their horizons and develop their personalities in healthy manner. In fact, the goals pursued by the education system extend beyond this. Schools and universities primarily create social cohesion and promote progress. They must instill positive values and educate people to become responsible individuals, (Ahmed, 2010: 93). The importance of academic achievement lies in its ability to create behavioral, cognitive, emotional and social change in students. This is usually referred to as learning, which is an internal and invisible process that occurs as a results of changes in the students cognitive structure. We recognise learning through academic achievement, as achievement is a product of learning and is both influential and tangible. Academic achievement is also importance because it helps students to achieve behavioral, emotional and psychomotor goals. The greater its influence on students overall developmental outcomes, the more effective and important it is improving student behavior and supporting them to interact with their environment, (Al-Samili, 2019: 49).

III- RESEARCH METHODOLOGY AND PROCEDURES

1. Research Methodology and experimental design: the researchers used an experimental methodology based on a two-group equivalent design with post-test subjects.

2. Research Community and sample: the research community refers to all individuals or objects that certain observable characteristics, and the only criterion for the community is the existence of a common character among its members. The observable characteristics of the community features, (Abu-Huweij, 2002:44). The current research community consists of all fifth-grade science students in government day secondary schools for girls affiliated with the Qadisiyah Governorate Education Department for the academic year (2024-2025) in the Afak District of the Qadisiyah Education Directorate, except for schools for gifted and talented students, where the number of schools for the academic year (2024-2025) was five, with no less than two fifth-grade science classes, the research community consisted of 461 students.

3. Equivalence of the Research Groups: before starting her experiment, the researcher was keen to ensure that, despite using a random method to select the research groups, and despite the fact that the sample consisted of female students from similar socio-economic backgrounds, studying at the same school and or the same gender, she sought to ensure statistical equivalence between the two groups in a number of variables that affect the results of the experiment in order to increase its accuracy. These variables are:

- **Chronological age calculated in months:** is represented by the age of the students calculated in months, as the experiment began on Wednesday, 5/2/2025. The average age of the students in the experimental group was (205.78) months with a standard deviation of (9.29). the average age of the students in the

control group was (206.08) months with a standard deviation of (10.45). when using the t-test for two independent samples to determine the significance of the difference between the age of the students in the two groups, the results showed that there were no statistically significant differences the two research groups in this variable, as the calculated t-value was (0.131), which is less than the tabulated t-value of (2) with a degree freedom (70) at a significance level (0.05). This indicates that the two research groups are equivalent in terms of age.

• **Prior Knowledge test:** in order to ensure parity among the research sample students in terms of prior knowledge, the researcher administrated a prior knowledge test to the research sample students (experimental and control) on Thursday, 6 February 2025, to determine their prior knowledge. The research prepared a test to measure their prior knowledge, basing the wording of the questions on the physics textbook for the previous four stages (first intermediate, second intermediate, third intermediate, fourth scientific). The test consisted of 20 multiple-choice questions. The t-value calculated for the two research groups was 1.015, which is less than the tabulated value (2). Therefore, the results show that there is no statistically significant difference at a significance level; of (0.05) and a degree of freedom of (70) between the two research groups, which confirms their equivalence in terms of prior knowledge.

• **Previous achievement:** the researcher based her findings on the physics scores achieved in the mid-year exam by students in both groups in order to ensure parity between the two groups. The arithmetic mean for the experimental group was 75.69, with a standard deviation of 17.61. As for the control group, the arithmetic mean was 74.83 and the standard deviation was 19.88. To understand the significance of the difference between these two averages, the researcher used the t-test for two independent samples. Table 9 shows that there are no differences in the previous achievement scores in physics for the students in the control and experimental groups, as the t-value is not statistically significant. The calculated t-value was 0.195, which is less than the tabulated value of 2 at a significance level of 0.05 and a degree of freedom of 70.

• **Intelligence Test (Philip Carter and Ken Russell):** to determine the equivalence of the two research groups in terms of intelligence, the researcher chose the (Flipp) test for mental abilities, which is designed for ages 11-45 and standardized for secondary school students in Iraq. It includes 40 multiple-choice questions, one of which is correct and the other incorrect. A correction standard was adopted of 1 point for a correct answer and 0 point for an incorrect answer, thus limiting the total test score to between 0 and 40. The time allocated for answering was 45 minutes. The test was administered to the two research groups (experimental and control) on Sunday, 9 February 2025, on the same day for both groups. After the test was completed, the students answer were corrected. The arithmetic mean, standard deviation, and t-test were calculated for two samples of equal size to compare the two research groups (experimental and control). There are was no statistically significant difference at the significance level of 0.05, as the calculated t-test value (0.161) was smaller than the tabulated value (2) with a degree of freedom (70). Thus, the two research groups are statistically equivalent in terms of intelligence quotient.

4. Controlling extraneous variable: Both researchers attempted to avoid the impact of certain extraneous variables that could affect the course of the experiment. No accident or unexpected circumstance occurred during the experiment, and there were no interruptions in attendance or transfers of students to other schools during this period. The researchers selected the research groups randomly to avoid individual differences between the students. The duration of the experiment was equal, lasting eight weeks, and the same subject matter was used, namely the fifth-grade science physics textbook.

5. Research requirements: These include the following:

• **Determining the scientific material:** The researchers determined the scientific material that would be taught to the two research groups during the experiment in the second semester of the academic year (2024-2025), which consisted of the last four chapters of the tenth edition of the fifth-grade science physics textbook.

• **Formulating behavioral objectives:** The researcher formulated 209 behavioral objectives from the content of the fifth-grade science physics textbook, distributed across the six levels of Bloom's taxonomy: (knowledge, comprehension, application, analysis, synthesis, evaluation). In order to ensure their validity

and relevance to the subject matter, the researcher presented them to a group of specialists in the field of education and teaching methods. After analysing the responses of the 23 reviewers, 17 behavioral objectives were deleted, bringing the final number of behavioral objectives to 192, with 58 behavioral objectives for the recall level, 38 behavioral objectives for the comprehension level, 42 behavioral objectives for the application level, 22 behavioral objectives for the analysis level, 18 behavioral objectives for the synthesis level, and 14 behavioral objectives for the evaluation level, all of which were included in the teaching plans. After analysing the specialists' responses using percentages, chi-square, degrees of freedom (1) and significance level (0.05), all were accepted, and the calculated t-value was higher than the tabulated t-value, thus making them all statistically significant.

• **Preparation of teaching plans:** The researcher prepared 24 plans for each of the experimental groups according to the inquiry wheel model, as well as 24 plans for the control group according to the usual plan. After that, a sample of these plans was presented to a group of expert judges specializing in physics teaching methods and physics sciences, as well as some physics teachers. Their comments were taken into account and the plans were modified to make them suitable for teaching in their final form.

6. Research tool: Tests are used in the field of education to reveal students' abilities, measure their achievement levels, identify their problems, and diagnose their strengths and weaknesses (Al-Najjar, 2010: 133). One of the requirements of this research is to construct an achievement test to measure the achievement of the research sample in physics. The researcher followed the following steps in constructing it:

1- Determining the purpose of the test: The purpose of the test is to measure the achievement of fifth-grade science students (the research sample) for four classes in physics for the second semester of the academic year (2024/2025) according to the behavioral objectives previously set and specified for that educational content.

2 - Determining the scientific material: The researcher determined the scientific material to be taught to the students in the two research groups during the experiment. The scientific material included the four chapters of the fifth grade science physics textbook, vol. 10, for the year 2023.

3- Formulating behavioral objectives: According to Bloom's taxonomy, the researcher determined the educational outcomes by measuring the six cognitive levels (remembering, understanding, applying, analysing, synthesizing, evaluating) from the physics textbook for the fifth grade science class for the academic year (2024-2025). The final number of behavioral objectives was 192.

4- Determining the type of test and the number of items: The researcher determined the type of test to be multiple choice and the number of test items (40) sections, each containing four alternatives, distributed across topics within the scope of the subject matter and the behavioral objectives to be measured, with the help of a number of arbitrators and specialists in science and physics teaching methods, as well as some physics teachers (Appendix 5). In light of their suggestions and opinions, (40) paragraphs remained.

5 - Preparation of the specifications table (test map): The specifications table is defined as a detailed plan that clarifies the content of the subject matter in the form of main headings, specifying the percentage of objectives and the relative weight of each topic and the number of questions allocated to each,(Al-Abadi, 137:2006). Thus, the test covered all parts of the subject matter, and each part was given its true weight in relation to the time spent teaching it and its importance. Accordingly, the specification table was prepared according to the following steps; the relative weight of the content for each of the last four chapters of the physics textbook for the fifth year of scientific studies was determined based on the number of pages in each chapter.

Table (1): Table of specifications for the achievement test

Chapters	No. of pages	Relative Importance	Percentage of Behavioral Objectives						
			Remember	**Understand**	**Apply**	**Analyze**	**Synthesize**	**Evaluate**	**Total**
			58	**38**	**42**	**22**	**18**	**14**	**192**
			30%	**20%**	**22%**	**12%**	**9%**	**7%**	**100 %**
Seventh	27	23%	**3**	**2**	**2**	**1**	**1**	**1**	**10**

Eighth	37	31%	4	2	3	2	1	1	13
Ninth	34	29%	3	2	3	1	1	1	11
Tenth	20	17%	2	1	1	1	1	0	6
Total	118	100%	12	7	9	5	4	3	40

6- Formulation of achievement test items: There are many tests classified according to their uses, and objective tests are considered one of the most important types of tests because their correction is not affected by the subjective judgment of the corrector, and they are characterized by high reliability and consistency as a result of objective correction. (Al-Kutaisi, 2007: 118). On this basis, 40 test items were formulated, with one item for each behavioral purpose identified in accordance with the specifications table. The researcher chose multiple-choice objective questions, with four alternatives for each item (one correct alternative and three incorrect alternatives).

7- Test instructions: Specific instructions and guidelines were provided on how to answer the questions, including writing the full name, class and section in the designated space, selecting one correct alternative for each item, answering all items, and the time allowed for answering.

8- Correcting test answers: After the test paragraphs were drafted, the type of test was selected, and the test was put together in its initial form consisting of 40 test paragraphs, a standard was set for correcting the answers, with one point for each correct test paragraph and zero for incorrect answers, paragraphs left blank, and paragraphs with more than one answer. and one for a question with more than one answer), As a result, the highest possible score for the achievement test was 40 points and the lowest possible score was zero:

1- Test validity: 'A test is considered valid if it measures what it was designed to measure' (Melhem, 2000: 273).
2- A measurement tool is considered valid if it measures what it is intended to measure. The researcher verifies logical or methodological validity by analysing the content of the course, extracting its characteristics, and preparing a means of measuring them from different aspects. (Al-Mahasna and Abdul-Hakim, 2013: 218).

To verify the validity of the test through two types of validity:

• **Face validity:** Face validity refers to the image that the test appears to be suitable for the purpose for which it was designed. This type of validity is evident in the initial examination of the test contents and knowing what it should measure, then matching it with the function to be measured. If the two are close, the test is face valid. (Nashwan, 2013: 165). Therefore, the researcher presented the achievement test to a group of arbitrators and specialists in physics and physics teaching methods, for the purpose of expressing their opinions and suggestions about the validity of the paragraphs, their wording, and their suitability for the specified objectives. Some of them were modified and others were reworded without deleting any items, with a level of agreement of more than 85% based on the chi-square equation. Thus, the test retained its 40 items, thereby achieving face validity.

• **Content Validity :** Al-Zamani (2007) defined it as 'the degree to which the test measures the content to be measured', (Al-Zamani, 2007: 113). This type of validity is suitable for achievement tests. In order to ensure the validity of his test in measuring achievement in a particular subject, the test designer begins by studying the content and analysing its general objectives into detailed objectives. then determines the weight of each, and then studies the content thoroughly and in detail and determines the weight of each. From these weights, the questions are determined (Al-Azawi, 2008: 93). Therefore, the researcher prepared the achievement test in light of the specifications table (test map) she designed for this purpose, and the achievement test was presented to experts and arbitrators, thereby enabling her to verify the validity and suitability of the test items.

9- Procedures for the exploratory application of the achievement test: The achievement test was applied exploratory in two stages:

First exploratory application: The researcher applied the test to an exploratory sample consisting of 30 female students in the fifth scientific grade at Al-Nourin Girls' Secondary School, affiliated with Al-Qadisiyah Education/Afak District, on Tuesday, 15 April 2025. The time required to answer the test ranged between 30 and 45 minutes, and the average time to answer was 39 minutes, which is

approximately one class period. The average time was calculated by calculating the average time taken by all students (Al-Najjar, 2010: 36).

Second exploratory application: The test was applied to a second exploratory sample after ensuring the clarity of its paragraphs and instructions and knowing the time required to answer it. The sample consisted of (100) female students from Al-Wadag Girls' Secondary School to extract the psychometric characteristics of the test. The students were informed of the test date one week before it was conducted, and the researcher supervised its application in cooperation with the subject teacher at the school. The test was administered on Wednesday, 16 April 2025. The purpose of the test was to statistically analyse the achievement test items to obtain the psychometric characteristics of the test, namely item difficulty, item discrimination, and the effectiveness of distractors.

10- Statistical analysis of achievement test items: The aim of analysing test items is to improve the test by identifying its shortcomings, revealing weak items, and addressing or eliminating those that are unsuitable. (Alam, 2006: 116). After conducting the second exploratory application, which included 100 students, the researcher corrected the answers of the exploratory sample students, giving a score for the correct answer and zero for the wrong or omitted answer, and ranking them in descending order from the highest score (37) to the lowest score (12) Appendix 13) in order to perform statistical analyses, then calculate the difficulty coefficient, discrimination power, and effectiveness of the wrong alternatives as follows:

1) Difficulty coefficient for achievement test items: The difficulty coefficient is useful in clarifying the ease or difficulty of a question in the test and is the percentage of students who answered the question correctly. (Al-Mahasna and Abdul-Hakim, 204:2013).

2) Discrimination index for achievement test items: The discrimination index is the degree to which a test item can distinguish between the answers of high-level students and those of low-level students. (Al-Zamli et al., 2013: 373).

3) Effectiveness of incorrect alternatives for achievement test items: An incorrect alternative is effective when it attracts more students from the lower group as the correct alternative than the number of students who choose this alternative in the higher group. Therefore, the more negative the value of the incorrect alternative, the better the alternative. (Majeed, 2010: 30). The effectiveness of the false alternatives for the achievement test items was calculated, and the results of applying the alternatives equation to all items were negative, ranging between (0.04- - 037-), which indicates the effectiveness of these false alternatives for the achievement test in attracting students. Therefore, it was decided to keep them unchanged.

11- Test reliability: Test reliability is one of the conditions of a good test, as it gives the same or similar results if it is reapplied to the same individuals under the same conditions, meaning that if the measurements of a single individual are repeated, they show some stability, (Melhem, 2010: 329). The researcher verified the reliability of the test in two ways:

A. Half-split method: The researcher used the answers from the second exploratory sample, which consisted of 100 answer sheets. The odd-numbered paragraphs for each student were collected on one side and the even-numbered paragraphs on the other (i.e., the scores were divided into two groups, one representing the scores for the odd-numbered paragraphs and the other representing the scores for the even-numbered paragraphs). The reliability was calculated using Pearson's correlation coefficient between the scores of the two halves of the test, which was 0.82. When corrected using the Spearman-Brown equation, it was 0.90, which is a good and reliable reliability coefficient.

B. Kuder-Richardson 20 equation: The reliability coefficient (Kuder-Richardson 20) is sensitive to measurement errors caused by content sampling. It is also a measure of vocabulary heterogeneity and can be applied when the test vocabulary scores are dichotomous, i.e., scored as 0 or 1.(Alam, 2013: 176). The stability coefficient calculated using this equation was 0.89, which indicates that it is a good and acceptable stability coefficient, and that the test is stable if its stability value is 0.70 or more (Alam, 2011: 543). Thus, its value is considered good and appropriate, and the test is therefore considered stable.

Seventh: Statistical methods: The researchers used the Statistical Package for the Social Sciences (SPSS) in the current research procedures and analysis of its results, as well as Microsoft Excel.

IV- Presentation and interpretation of results

First: Presentation of results: After applying the post-test and obtaining the scores of the two research groups, and in order to verify the first null hypothesis, which states that: (There is no statistically significant difference at the significance level (0.05) between the average scores of the experimental group students who studied physics according to the inquiry wheel model and the average scores of the control group students who studied the same subject according to the regular plan in the achievement test prepared for the purposes of this research). The mean and standard deviation of the scores of both the experimental and control groups were calculated as follows:

Table (2) shows that the average scores of the female students in the experimental group in the achievement test were (31.61) with a standard deviation of (3.68), while the average scores of the female students in the control group were (27.83) and the standard deviation was 4.83. Using the t-test equation for two independent samples, it was found that the calculated t-value (3.731) was greater than the tabulated value at a significance level of 0.05 and a degree of freedom of 70, which is equal to (2), which means that the students in the experimental group outperformed those in the control group in the post-test and rejected the first hypothesis and accepted the alternative hypothesis, which states that there is a statistically significant difference between the mean scores of the experimental group and the mean scores of the control group in favors of the experimental group.

Table (2): Arithmetic mean, variance, calculated t-value, tabulated t-value, and degree of freedom for the grades of female students in the research sample in the achievement test.

No.	Group	No. of Students	Mean	Std. Deviation	Degrees of Freedom	t-value		Statistical Significance at 0.05 Level
						Calculated	Tabulated	
1	Experimental	36	31.61	3.68	70	3.731	2	Significant
2	Control	36	27.83	4.83		-	-	

Statement of the magnitude of the effect of the independent variable on the first dependent variable (achievement): The researcher used Cohen's formula to extract the magnitude of the effect (d) of the independent variable on the dependent variable, and the magnitude of the effect was (d) was (0.89), which is an appropriate value for interpreting the magnitude of the effect and is significant for the teaching variable using the inquiry wheel model in the achievement test and in favor of the experimental group. Table (3) shows this:

Table (3) Effect size of the independent variable on the dependent variable in the final achievement test, η^2 value and corresponding d value, and effect size in the achievement test

Independent Variable	Dependent Variable	T-value	Degree of freedom	η^2 value	d value	Effect Size
IWM	Achievement	3.731	70	0.17	0.89	Large

By extracting the d value, which reflects the magnitude of the effect, which reached (0.89), and the value (η^2), which is equal to (17.0), which is a large value when interpreted in relation to the independent variable (survey model) in the dependent variable (achievement) according to the scale established by Cohen (1988), who considers the effect size to be large when it is 0.80 or more. Table 4 illustrates this:

Table (4): Impact size and effect size values according to Cohen's classification (Kiess,1996:164)

Level of Effect Size	Effect Size Guidelines				Measure
	Small	Medium	Large	Very Large	
1	0.01	0.06	0.14	0.20	η^2
2	0.2	0.5	0.8	1.10	d

Second: Interpretation of the results: The results indicated a statistically significant difference between the average scores of female students in the experimental group who studied physics using the inquiry wheel model and the average scores of the control group students who studied the same subject according

to the regular plan in the achievement variable in favor of the experimental group students. The researcher believes that this is due to the following:

1. Teaching using the inquiry wheel model led to the organization of information in a sequential and logical manner, which helped the students to store information, making it easier to retrieve and giving it meaning.

2. The effectiveness of the inquiry wheel model, which makes the students the focus of the educational process, is what the researcher did during the experiment.

3. The inquiry wheel model helps to add a social dimension to the educational process through cooperation between the students themselves and dialogue to arrive at the correct answers.

Third: Conclusions: In light of the results of the current research, the following conclusion was reached: Teaching according to the inquiry wheel model had a positive effect on raising the achievement level of fifth-grade science students in physics compared to the regular plan.

Fourth: Recommendations, Proposals: In light of the results of this research, the researcher recommends the following:

1- Adopting the inquiry wheel model for teaching physics to fifth-grade science students.

2- Introducing training courses for teaching staff, both male and female, to train them and familiarize them with how to use modern teaching strategies and methods, including the inquiry wheel model.

3- Equipping schools with modern laboratories and equipment for the purpose of using modern teaching strategies, models and methods, including the inquiry wheel model.

Fifth: Recommendations: To complement this research, we propose the following:

1- Conduct research on the effectiveness of the inquiry wheel model in the achievement and imaginative recall of preparatory stage students in physics.

2- Conducting the inquiry wheel model in the achievement of preparatory stage students in mathematics and science.

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