The Effectiveness of Experiential Learning Strategy in Achieving Science Subject Competence Among Fifth Grade Elementary School Students

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Abstracts

This study investigates the effectiveness of experiential learning strategies in enhancing science subject competence among fifth-grade elementary students in Anbar Governorate, where traditional teaching methods dominate. Prior research indicates a lack of engagement and critical thinking among students, emphasizing the need for pedagogical approaches that promote active learning and real-world experiences. Employing a descriptive and experimental design, this research included two groups: an experimental group receiving instruction through experiential learning and a control group taught via traditional methods. The sample consisted of 65 fifth-grade students from Al-Mu'min Primary School, chosen to ensure representativeness. Pre-experimental assessments ensured equivalence in variables such as age, intelligence, and previous academic achievement. The study's impact was evaluated using a post-test composed of 40 multiple-choice questions aligned with the science curriculum. Statistical analysis revealed a significant difference in mean achievement test scores between the groups, with the experimental group achieving a higher average score of 29.90 compared to the control group's 22.55. The calculated t-value was 10.11, surpassing the critical t-value of 2.00 at the 0.05 significance level, indicating strong evidence for the effectiveness of experiential learning strategies. Furthermore, the effect size measured using eta squared ($\eta^2 = 0.63$) confirmed a large impact on student achievement. The findings signify that experiential learning strategies substantially enhance science subject competence among elementary students, fostering greater engagement and understanding of scientific concepts. These results advocate for the integration of experiential learning methodologies in science education, reflecting a shift away from traditional teaching practices to more effective, student-centered approaches that promote critical thinking and real-world application of knowledge.

Keywords: Experiential Learning, Science Education, Elementary Students, Student Achievement, and Active Learning.

Introduction

In the context of teacher training and development, it is evident that there is a discrepancy between the recommended guidelines and the actual teaching practices observed among science teachers and supervisors in Anbar Governorate. The findings reveal a prevalent use of traditional teaching methods characterized by teacher-centered approaches, such as pre-prepared lessons, lecture-style delivery, and heavy reliance on question-and-answer sessions without allowing ample time for student reflection. Additionally, students are often prompted to provide answers directly from their textbooks, indicating a lack of emphasis on critical thinking and independent problem-solving skills [1]. This discrepancy underscores the importance of aligning teacher training programs with modern pedagogical approaches that prioritize student engagement, critical thinking, and active learning strategies to enhance the quality of science education in the region. The studies by Covitt et al. and Greenall & Bailey emphasize the importance of moving away from traditional teaching methods in science education to enhance students' learning outcomes. Covitt et al. highlight the significance of engaging students in three-dimensional learning experiences to promote scientific sensemaking and cognitive apprenticeship [2], while Greenall & Bailey advocate for the integration of Traditional Ecological Knowledge (TEK) into classrooms to increase Indigenous student belonging and inclusivity in biology education [3]. Additionally, McQueen & Colegrave's research on quecture questions demonstrates that active learning interventions, such as metacognitive reflection through student-generated questions, can significantly improve student engagement and performance, particularly benefiting low-scoring students [4]. These findings collectively underscore the necessity of adopting experiential and student-centered approaches in teaching to cater to diverse learning styles, foster critical thinking, and enhance cognitive growth, aligning with the principles of expert learning strategies. Incorporating experiential learning into the academic curriculum, as highlighted in various studies [5-6-7], can significantly enhance students' educational outcomes and personal growth by connecting classroom learning with real-world experiences. By integrating transdisciplinary learning approaches, such as those focusing on transformative change and biodiversity conservation [8], educators can create a more engaging and immersive learning environment for students. Furthermore, utilizing innovative tools like extended reality (XR) can provide students with hands-on experiences that foster a deeper understanding of scientific concepts related to the human body, health, matter, energy, power, and Earth's resources [6]. This approach not only caters to diverse learning styles but also addresses challenges like low science achievement among primary students, offering a pathway to more interactive and effective science education [9]. The experiential learning model has shown effectiveness in improving science education outcomes for elementary school students. Multiple studies have demonstrated its positive impact on various aspects of learning. Implementation of this model led to increased student understanding and achievement in science subjects (Hariri & Yayuk, 2018 [10]; Aprilia, 2016 [11]). It also enhanced students' motivation to learn science (Zuhryzal & Fatimah, 2019 [12]) and improved overall learning quality (Aprilia, 2016 [11]). The model's application resulted in higher average test scores and a greater percentage of students meeting competency standards (Hariri & Yayuk, 2018 [13]). Additionally, it improved teachers' instructional skills (Aprilia, 2016 [11]). A systematic literature review of 15 studies further confirmed the model's positive influence on elementary school science learning, highlighting improvements in curiosity, achievement, motivation, understanding, and competence (Susiloningsih et al., 2023) [14]. These findings collectively support the effectiveness of experiential learning in enhancing science education for elementary students.

Research Methodology

The researcher employed a descriptive research approach to develop research tools and adapted the experimental method with modifications to conduct a partial experiment, aligning with the chosen research methodology. The selection of the experimental design involved fixed random partial adjustment along with a post-test administration, deemed suitable for the nature and requirements of the current study. The experimental design with partial adjustment was implemented across two groups: a control group and an experimental group, with a post-test evaluating achievement outcomes. Details of this approach are provided in figure (1).

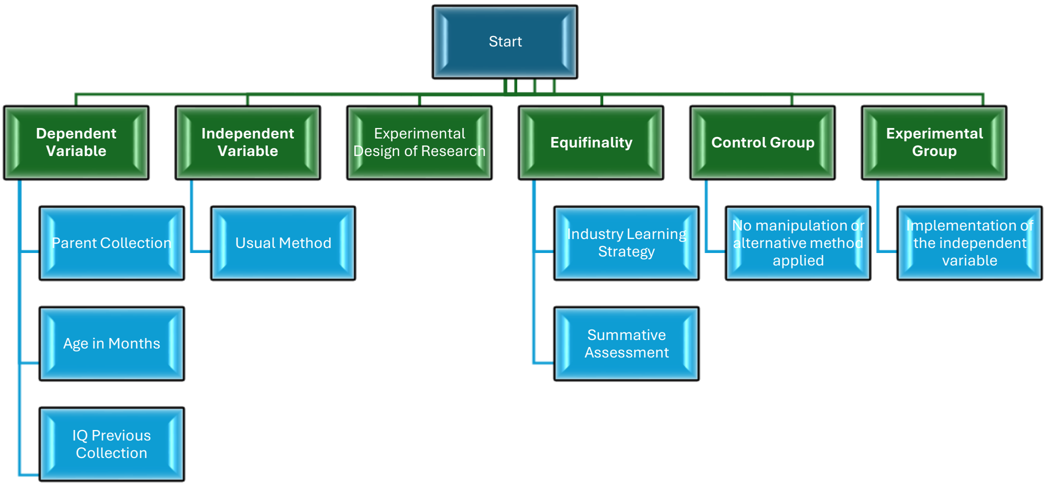

Figure (1): Experimental design of research.

1.1. Study Community

The study community encompasses primary schools in the Ramadi district, located at the heart of Anbar Governorate. This comprises a total of (228) schools catering to both boys and girls, with (148) schools designated for boys and (80) schools for girls.

a) Selection of Sample Schools: To ensure the sample selected is as representative as possible of the original community, the researcher deliberately opted for the primary school Al-Mu'min for boys. This school was chosen for its compatibility with the study's objectives in establishing two student groups - one experimental and the other control. The school administration collaborated to facilitate the experiment.

b) Student Sample: Within the fifth grade of primary school, which is divided into three sections, Division A was randomly chosen to represent the experimental group, and Division C to represent the control group. The total number of students across both groups amounted to (65) pupils, with (33) pupils in Division A and (32) pupils in Division C. Failed students from the previous year were excluded from statistical analysis while still being present in the classroom during the experiment to ensure continuity in the school system without impacting the experiment results. The number of repeating students in both groups totaled (3) pupils in Division A and (1 pupil) in Division C, totaling (32) pupils engaging in the research across the experimental and control groups.

1.2. Equivalence of the two research groups

To ensure internal validity and minimize the impact of extraneous variables on the research outcomes, the researcher identified potential factors that could influence the results. In the pursuit of achieving comparability between the students in the experimental and control groups, the researcher conducted a parity process focusing on factors that could affect the experiment's variables. These factors included intelligence levels, previous academic performance in science (from the fourth primary level), age in months, and the academic achievement of parents. By addressing and accounting for these variables, the research aimed to establish a level playing field between the two groups, allowing any differences observed between the experimental and control groups to be attributed to the independent variable being studied, rather than external or confounding factors. This approach enhances the research's integrity and ensures that any observed effects can be confidently linked to the independent variable under investigation.

a) Age: The researcher calculated the age in months by referencing the birthdates of each student within the research sample obtained from school records.

b) Intelligence: The researcher selected the Raven test, adapted and validated for the Iraqi environment, suitable for children aged 5-11. This test comprises 36 items, with each correct answer receiving one point. The maximum achievable score is 36, while the minimum score is 0. The test administration lasts for approximately 30 minutes (Raven et al., 2018) [15].

c) Previous Academic Achievement in Science (Fourth Primary): The scores for both groups were gathered from school records, and the mean and variance of the students' scores were computed. Through the application of the t-test for two independent, equally numbered samples, it was determined that there was no statistically significant difference between the students in the two groups across the three variables at a significance level of 0.05, with degrees of freedom equal to 60.

Table 1. Comparison of Experimental and Control Groups on Key Variables: Age, IQ, and Academic Achievement.

Groups / Variables	Experimental group		Control group		Value(V) at (0.05)	
	average	Variance	average	Variance	Tabular t-value	Calculated t-value
Chronological Age	129	663	128	10		1.103133
IQ	19.45161	0.2	935	1.60874		1.38478

Previous Academic Achievement	7.967742	1.7732	0.7	1.92092	2.00 at 60 df	1.034955

Parental Academic Achievement: A form was distributed to students in both research groups to assess the academic achievements of their parents, aiming to ensure parity in this variable. The collected information was summarized, and the statistical method employed was the Chi-square ($\chi 2$) test to establish parity, with some cells combined to ensure a minimum frequency of at least 5. The data analysis revealed no statistically significant differences between the two groups in terms of parental educational achievement.

1.3. Research requirements

The scientific material that will be taught to students during the trial period in the first three semesters of the science textbook for the fifth primary grade for the academic year (2022-2023AD), which was studied in the first semester of the year, according to the Ministry of Education's annual and daily approved courses for teachers. Teaching plans have been prepared for both groups (experimental, which is taught according to the learning experience and the control, which is taught according to the method set) necessary to apply the experiment at a rate of (30) daily study plan for each group divided into (12) weeks by three sessions per week.

1.4. Research tool

The process of summative assessment involves several critical steps aimed at evaluating the achievement of fifth-grade primary students concerning the scientific content outlined in the first three units of the science textbook. The primary objective of the assessment is to measure the impact of the independent variable on student achievement. To achieve this, the educational material is clearly identified, focusing specifically on the units in question, which will be referenced throughout the assessment. Additionally, a comprehensive review of the general and specific educational objectives associated with the science curriculum has been conducted. This review led to the formulation of multiple behavioral objectives, totaling 90, which are aligned with the components of the subject matter and categorized according to Bloom's taxonomy. This classification distinguishes between three minimum cognitive levels: knowledge, comprehension, and application.

To ensure the validity and reliability of these behavioral objectives, a panel of subject matter experts was consulted to assess the content's coverage, formulation quality, and appropriate classification. The feedback from these experts yielded a high approval rate, with over 90% of the objectives receiving favorable evaluations. However, five objectives fell short of the desired consensus percentage. Based on the experts' recommendations, subsequent revisions were made, resulting in the establishment of 85 validated behavioral objectives distributed across the three cognitive levels. These findings are depicted in detail within Table 3, which illustrates the alignment of the objectives with the educational content and their empirical support through expert review. This robust foundation ensures that the summative assessment effectively measures student learning and the influence of the independent variable on achievement.

Table (2). Distribution of behavioral purposes on the academic content (the three modules.

odules and their eme	Chapters	Learning subject?	Memory	Understanding	Applicability	Total
rst: Classification d Diversity	The first	flowering plants, and	7	5	3	15
	Second	Vertebrate and invertebrate animals	7	6	4	17
econd: The human dy and its health	third	Circulatory and respiratory systems	7	4	3	14
	Fourth	Gastroenterology & Urology	7	5	3	15
hird: Article	Five	Items	6	4	2	12
	Six	Compounds and mixtures	6	4	2	12
tal			40	28	17	85

The academic content designated for students during the trial period includes the initial three units of the fifth-grade science textbook for the academic year 2022-2023, specifically aligned with the first semester curriculum. This content is consistent with the Ministry of Education's approved curriculum, which serves as the foundation for the annual and daily instructional plans crafted by educators. By adhering to this regulated framework, the content ensures that all instructional activities meet the established educational standards and objectives set forth by the ministry. To facilitate the execution of the experiment, comprehensive teaching plans have been meticulously developed for both the experimental and control groups. The experimental group receives instruction based on experiential learning methodologies, while the control group is taught using traditional pedagogical approaches. Each group adheres to a structured 30-day study plan, which is organized into 12 weeks, with each week comprising three instructional sessions. This systematic approach allows for a consistent and controlled educational environment in which the effectiveness of the differing teaching methods can be assessed.

1.5. Preparing the specification

The formulation of the achievement test involved the creation of a set of 40 multiple-choice questions, each providing four alternatives, with only one correct answer. This structure is designed to assess the knowledge and understanding of the fifth-grade students regarding the relevant academic content. By utilizing a standardized format, the test allows for an objective evaluation of student performance, ensuring consistency in scoring and assessment criteria across all test-takers.

Table (3). Specification for Educational Materials: Content and Behavioral Aspects.

Chapters	Pages	Percentage	Level of performance			Total
			47%	33%	20%	100 %
Suspension	14	16%	3	2	1	6
Second	16	19%	4	3	2	9
third	14	16%	3	2	1	6
Fourth	13	15 %	3	2	1	6
Five	15	17%	3	2	1	6
Six	15	17%	4	2	1	7
Total	87	100 %	20	13	7	40

To ensure the test's content validity, a specification table was developed that aligns the test items with the academic content and the behavioral objectives specified for the curriculum. This alignment enhances the credibility of the test, affirming its relevance and appropriateness for the intended educational purpose. Consequently, the current test is deemed to possess a high level of truthfulness in terms of content accuracy and representation, thus supporting its role as a reliable instrument for measuring student achievement.

Instructions for the test were articulated by Brother Tabar and included clear guidelines regarding the types of questions, the method for providing answers, and the time constraints for completing the test. A standardized answer key was established for all questions, based on Brother Tabar's directives. Scoring was straightforward; correct answers were awarded one point, while incorrect answers and unattempted questions received zero points. Therefore, the total possible score for the test ranged from 0 to 40 points, enabling a clear quantification of student performance.

A pilot study was conducted to assess the test's clarity and the time necessary for students to complete it. This study involved a sample of 30 fifth-grade students who were not part of the primary research sample. The findings indicated that the average time required to respond to the questions was approximately 35 minutes, within a range of 30 to 40 minutes. Additionally, all participants reported that the instructions provided were clear and easy to comprehend. Following this, a comprehensive statistical analysis of the test items was carried out, focusing on individual responses to identify potential strengths, weaknesses, or ambiguities in question wording. The researcher administered the test to a sample of 100 students from three different schools to evaluate item difficulty, discriminatory power, and the effectiveness of the answer choices. The scores were sorted to retain the top and bottom 27% of responses, ensuring optimal differentiation and analysis, as recommended by Al-Abadi (2020) [16].

The difficulty levels of the test items were identified to range between 0.407407 and 0.648148. It is suggested by Bloom that a test is considered sound and valid when the difficulty coefficients of its items fall within the range of 20% to 80%. An item's ability to discern between individuals in the upper and lower performance groups improves as its difficulty coefficient approaches 50% (Abu Atwan and Shaaban, 2019: 155) [17].

Discrimination refers to a question's aptitude to differentiate among individuals, indicating its capacity to distinguish between excellent, good, average, and weak students, validating its measure of proficiency (Al-Abadi, 2029: 109) [16]. Following the computation of the discrimination coefficient for each item, it was determined that all test items demonstrated the ability to differentiate among the sample students, with discrimination coefficients ranging from 0.3333333 to 0.481481. This indicates that the test items exhibit satisfactory discriminatory power, as items are considered valid if their discrimination coefficients are 0.30 or higher (Abu Atwan, Shaaban, 2019: 159) [17].

An incorrect alternative is deemed effective when it garners more responses from students in the lower performing group than from those in the higher performing group compared to the correct alternative. Therefore, the more negative the value associated with the incorrect alternative, the stronger it is considered (Al-Zuhairi, 2017: 212) [18]. Upon applying the equation evaluating the effectiveness of alternatives to assess responses from both the upper and lower groups for each test item, it was evident that the incorrect alternatives attracted a greater number of students from the lower group than the upper group, leading to negative results. This indicates the effectiveness of these alternatives in drawing responses, leading to the decision to retain them unchanged.

Various methods can be employed to assess test stability, and in this case, the researcher opted for the return method, the half-partition method, and the retest method, commonly used to evaluate stability. The stability coefficient resulting from this process is known as the stability coefficient. This method involves re-administering the test to a sample after a two- or three-week interval, followed by calculating the correlation coefficient between the test scores (Al-Rimawi, 2017: 127). A subset of 12 pupils from the analysis sample took the test again after 15 days, resulting in a total stability coefficient of 0.970574. Additionally, test stability was calculated using the half-split method, where the test is administered to the sample and the test items are divided into two sections: the first containing odd-numbered items and the second comprising even-numbered items. Subsequently, the scores for each section are assessed, and the correlation coefficient between the two sections is computed (Bahi, 2017: 229) [19].

The scores of 12 students from the second survey sample were utilized. After dividing the test into individual paragraph scores and even paragraph scores, the researcher employed the Pearson correlation equation, resulting in a half stability coefficient of 0.970574. Subsequently, after adjusting with the Spearman-Brown formula, a stability coefficient of 0.95201 was obtained, which is considered a satisfactory and acceptable coefficient for unstandardized tests, as a stability coefficient is deemed good if it reaches 0.68 or higher. Following the verification of reliability and consistency indicators and the statistical analysis of the items, the achievement test is now deemed ready for implementation.

Results

The results of the t-test, as presented in Table 4, reveal a significant difference in the mean scores between the experimental and control groups on the achievement test. The experimental group, comprising 31 students, achieved an arithmetic mean score of 29.90 with a variance of 6.47. In contrast, the control group, also with 31 students, obtained a mean score of 22.55 and a variance of 9.41. The calculated t-value for the experimental group is 10.11, which significantly exceeds the tabular t-value of 2.00 at a significance level of 0.05. This substantial difference indicates a statistically significant effect, suggesting that the instructional method utilized in the experimental group positively impacted student achievement when compared to the traditional methods employed in the control group. Therefore, it can be concluded that the experimental intervention was effective in enhancing the students' performance on the achievement test.

Table (4). Results of the t-test determine the significance of the difference between the mean scores of the experimental and control groups in the achievement test.

Group	Number	Arithmetic Mean	Variance	T test		Significance at a level 0.05
				Calculated	tabular	
Experimental group	31	29.90323	6.474506	10.10791	2.00	
Control group	31	22.54839	9.408949			significant

Based on Table (4), it is evident that statistically significant differences exist, specifically in the average achievement scores of the experimental group compared to the control group, with results favoring the experimental group. This suggests that students in the experimental group, following the experiential learning strategy, outperformed their counterparts in the control group, who were taught using traditional teaching methods, in the achievement test. Consequently, the null hypothesis is rejected in favor of the alternative hypothesis.

There are no significant differences, at the 0.05 level of significance, between the average scores of the experimental group and the control group in their responses to the post-achievement test items. However, upon scoring the responses of both groups based on the model answers, a disparity in the averages of the two groups relative to their expected means is apparent, as illustrated in the following figure (2).

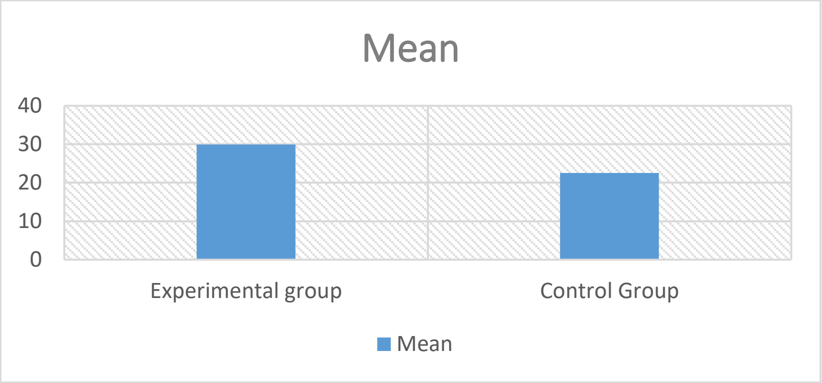

Figure (2) The difference in the means of the two groups in the achievement test compared to the hypothetical mean.

1.1. Effect Size Calculation

The effect size for the achievement test was evaluated using the eta squared coefficient (η^2) to determine the magnitude of the difference between the experimental and control groups. The calculation was carried out using the formula for eta squared derived from the t-test results:

$$\eta^2 = \frac{t^2}{t^2+df} = \frac{(10.10791)^2}{(10.10791)^2+60} = 0.63$$

Given this calculation, the eta squared value is 0.63. According to the reference provided in Table 5 for interpreting effect size levels, this value indicates a **large effect size**.

1.2. Interpretation of Effect Size

The interpretation of effect size is critical for understanding the practical significance of the study's findings. Based on the criteria outlined in Table 5, where a small effect is represented by 0.01, a medium effect by 0.06, and a large effect by 0.14, the calculated eta squared value of 0.63 suggests that the intervention not only had a statistically significant impact on student achievement but also represents a substantial effect in educational terms. This strong effect size reinforces the conclusion that the instructional method used in the experimental group effectively enhanced student performance in the achievement test.

Table (5). Reference for determining impact size levels for coefficient(η^2)

Effect size	Small	Medium	Large
Effect value	0.01	0.06	0.14

Discussion

The results from the t-test indicate a noteworthy difference in the mean scores between the experimental group and the control group, with the experimental group demonstrating significantly higher achievement test scores. Specifically, the experimental group, employing an experiential learning strategy, achieved an average score of 29.90, while the control group, taught through traditional methods, scored an average of 22.55. The calculated t-value of 10.11 far exceeds the tabular t-value of 2.00 at a 0.05 significance level, leading to the rejection of the null hypothesis and confirming that the alternative hypothesis holds. This finding aligns with previous research advocating for the effectiveness of experiential learning approaches in enhancing student engagement and understanding in science subjects (Hariri & Yayuk, 2018; Aprilia, 2016) [10].

The effect size, calculated using the eta squared coefficient (η^2), reinforces the significance of these results. The eta squared value of 0.63 suggests a large effect size, indicating a substantial impact of the experiential learning intervention on student achievement. According to the reference provided in Table 5, effect sizes are categorized as small (0.01), medium (0.06), and large (0.14). The large effect observed in this study not only demonstrates the statistical significance of the results but also illustrates the practical implications of the instructional method utilized. As supported by the work of Mehmet Küçük and Salih Çepni (2015) [1], effective teaching strategies that engage students in active learning processes can lead to improved educational outcomes.

Despite the success of the experimental group, it is essential to recognize that no significant differences were found between the groups in their responses to certain post-test items. While the data indicates higher average scores for the experimental group, discrepancies related to some specific test items suggest that further investigation is needed to understand the nuances of these responses. The participants' perspectives on the clarity of instructions and their engagement with the material can also provide valuable insights into how experiential learning can be fine-tuned to maximize its effectiveness (Brady et al., 2023 [5]; Covitt et al., 2023) [2]. Figure 2 further illustrates the differences between the groups in relation to the hypothetical mean, highlighting the areas where performance diverged significantly.

The positive outcomes of this research align with existing literature advocating for the implementation of experiential learning models in science education (Zuhryzal & Fatimah, 2019 [12]; Susiloningsih et al., 2023) [14]. The findings confirm that integrating active learning strategies leads to better student retention and understanding of scientific concepts, thereby promoting a more profound and lasting educational experience. As such, these results advocate for a broader adoption of experiential learning methodologies in teaching practices across educational settings, particularly in science courses designed for primary education.

Conclusion

In summary, the findings of this study provide compelling evidence for the effectiveness of experiential learning strategies in enhancing student achievement in science education. The significant difference in the mean scores between the experimental and control groups underscores the positive impact of active learning methodologies, with the experimental group achieving an average score substantially higher than that of the control group. The statistical analysis, highlighted by a t-value of 10.11, supports the rejection of the null hypothesis, indicating that the instructional methods employed in the experimental group were more effective than traditional approaches.

Moreover, the calculated eta squared value of 0.63 signifies a large effect size, further validating the profound influence of the experiential learning intervention on student performance. This strong effect size aligns with existing literature that emphasizes the role of engaging teaching strategies in fostering improved educational outcomes. However, the lack of significant differences in some post-test responses suggests that further exploration is warranted to assess specific areas where experiential learning could be optimized. Considering students' perceptions and the clarity of instructional materials could enhance the framework within which experiential learning is implemented.

The alignment of this study's results with prior research indicates a broader trend toward incorporating active learning models in primary science education. The data reinforces the notion that experiential learning not only aids in retaining knowledge but also deepens student understanding of complex scientific concepts. Consequently, this research advocates for the widespread adoption of experiential learning strategies across educational settings, emphasizing their potential to transform educational practices and improve student engagement, retention, and overall academic performance.

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