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Effect of Inquiry-Based Learning on Students' Academic Performance in Secondary School Physics in Burutu Federal Constituency

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***Abstract*: *This study examined the effect of inquiry-based learning (IBL) on secondary school physics performance in Burutu Federal Constituency, Delta State, Nigeria. Ongoing underachievement in physics has led educators and policymakers to explore new instructional methods. The research used a non-equivalent quasi-experimental pretest-posttest control-group design with 121 Senior Secondary School II (SS II) students selected through stratified random sampling. The experimental group received IBL instruction, while the control group received a conventional lecture strategy. Data were collected using a Physics Achievement Test (PAT) with a reliability coefficient of 0.82 and analysed using mean, standard deviation, t-test, and Analysis of Covariance (ANCOVA). Results showed a statistically significant improvement in student performance when taught with IBL compared to the conventional lecture method. The study concludes that IBL enhances students' conceptual understanding and academic performance in physics and recommends incorporating inquiry-based strategies into physics instruction and teacher training. The findings have contributed to knowledge by supporting constructivist learning theory, which emphasises active participation in the construction of knowledge.*

Keywords: *Inquiry-based learning, academic performance, physics education, secondary schools, Nigeria*

Introduction

Physics is a foundational science that underpins technological advancement, industrial development, and innovation. It offers essential principles for understanding natural phenomena and serves as the basis for fields such as engineering, medicine, environmental science, and information technology. As a result, physics education is crucial for equipping students with the scientific knowledge, analytical skills, and problem-solving abilities needed to succeed in a technology-driven world. Countries that have advanced in science and technology have typically invested heavily in science education, especially in physics and related disciplines.

Despite the recognised importance of physics, students' academic performance in Nigeria remains persistently low. Examination bodies such as the West African Examinations Council (WAEC) and the National Examinations Council (NECO) consistently report that many candidates do not achieve credit-level passes in physics, limiting their access to science and technology-based tertiary programs. This ongoing poor performance concerns educators, researchers, and policymakers, as it threatens national goals for scientific and technological advancement (WAEC, 2023; NECO, 2023). The causes are complex and include the abstract nature of physics concepts, inadequate instructional materials, insufficient laboratory facilities, large class sizes, limited teacher preparation, and students' negative attitudes toward the subject (Abdulkadir et al., 2024; Udofia et al., 2024). Many students struggle with the mathematical reasoning and abstract thinking required in physics, especially without sufficient instructional support and practical experience. The lack of well-equipped laboratories in many Nigerian secondary schools' further limits students' ability to engage in hands-on activities that support understanding of complex concepts.
In Burutu Federal Constituency, Delta State, student achievement in physics remains consistently low, reflecting the national trend. Reports from school administrators and local education authorities highlight that many students view physics as difficult and abstract, leading to low interest, limited engagement, and poor performance. Schools in the area face inadequate teaching resources, limited laboratory equipment, and a shortage of qualified physics teachers. These challenges hinder effective teaching and learning, contributing to ongoing underachievement in physics.

Teaching methodology is a key factor influencing poor performance in physics. The prevalent use of teacher-centred methods, particularly the conventional lecture approach, has been criticised for its limited effectiveness in promoting meaningful learning. In this model, teachers are the main source of knowledge, and students are passive recipients. This often leads to rote memorisation rather than conceptual understanding, leaving students unprepared to apply knowledge to real-life situations or solve complex problems (Roslan et al., 2023).

The limitations of the lecture method are particularly evident in physics, where conceptual understanding depends on active engagement, experimentation, and critical thinking. Without active involvement, students struggle to develop the skills needed to analyse, interpret, and apply scientific knowledge, leading to poor academic performance. Teacher-centred approaches also fail to address diverse learning needs and abilities, thereby widening the achievement gap. As a result, there is a need to increase the use of learner-centred instructional approaches that actively engage students. Inquiry-Based Learning (IBL) is one such approach and is widely recognised as effective for teaching science subjects, including physics. IBL is grounded in constructivist learning theory, which asserts that learners construct knowledge through active interaction with their environment rather than passive reception from teachers (Bruner, 1961; Vygotsky, 1978). This method emphasises exploration, questioning, investigation, and discovery, enabling students to take an active role in their learning.

Inquiry-based learning involves activities such as posing questions, formulating hypotheses, conducting experiments, analysing data, and drawing conclusions. These processes help students develop a deeper understanding of scientific concepts and build critical thinking, problem-solving, and scientific reasoning skills. Research shows that students taught with inquiry-based approaches often achieve higher academic performance and demonstrate greater interest and motivation in science learning (Jacalan & Castillo, 2023; Misoga et al., 2024).

A key advantage of inquiry-based learning is its capacity to bridge the gap between theory and practice. By engaging students in hands-on activities and real-life problem-solving, IBL shows the relevance of physics concepts in everyday life. This approach enhances understanding and increases student interest and motivation. Inquiry-based learning also promotes collaboration and communication, as students often work in groups to investigate problems and share findings. These experiences enrich learning and support the development of social and interpersonal skills. However, the number of skilled teachers in it remains limited. Challenges include inadequate teacher training, insufficient instructional materials, large class sizes, and resistance to departing from traditional teaching practices (Bogador et al., 2024). Many teachers lack adequate training in inquiry-based strategies and may not have the confidence or resources to implement them effectively. Consequently, they continue to rely on lecture-based methods, despite evidence of their limited effectiveness.

In Burutu Federal Constituency, these challenges are particularly severe. Limited infrastructure and resources hinder teachers' ability to implement inquiry-based activities that require experimentation and hands-on learning. The lack of regular professional development further restricts teachers' exposure to innovative instructional strategies. As a result, students in this area miss out on the benefits of modern teaching approaches that could improve learning outcomes. To address these issues, it is important to explore and promote effective instructional strategies to enhance students' performance in physics. Inquiry-based learning offers a promising solution that aligns with the goals of science education and addresses many limitations of traditional methods. However, empirical studies are needed to demonstrate its effectiveness in specific contexts, such as Burutu Federal Constituency.

This study aims to investigate the effect of inquiry-based learning on students' academic performance in secondary school physics in Burutu Federal Constituency. By comparing students taught using an inquiry-based strategy with those taught using a conventional lecture method, the study will assess how IBL can enhance learning outcomes. The findings are expected to provide valuable insights for educators, policymakers, and curriculum developers and contribute to efforts to improve science education in Nigeria.

This study is significant because it addresses a critical gap in the literature by providing localised evidence on the effectiveness of inquiry-based learning in a rural, resource-constrained setting. While many studies have shown the benefits of IBL in various contexts, possibly none have examined its application in Burutu Federal Constituency. By exploring the impact of IBL here, the study will help inform how innovative teaching strategies can be adapted to diverse learning environments.

Consequently, the persistent poor performance of students in physics in Nigeria, especially in Burutu Federal Constituency, requires urgent and innovative solutions. Traditional teaching methods have not adequately addressed these challenges. Inquiry-based learning, as a learner-centred approach, offers a promising alternative to improve understanding, engagement, and academic performance. This study provides a timely assessment of the effectiveness of inquiry-based learning as a strategy for enhancing physics education and promoting scientific literacy among secondary school students.

Literature Review

Inquiry-Based Learning (IBL) is a student-centred approach that emphasises active participation through questioning, investigation, and discovery. Unlike traditional methods focused on knowledge transmission, IBL encourages learners to construct knowledge through exploration and interaction with their environment. Students engage by asking questions, forming hypotheses, conducting experiments, analysing data, and drawing conclusions. A key principle of inquiry-based learning is its alignment with scientific investigation. Students are encouraged to think and act as scientists through problem-solving activities that require critical thinking and reasoning. Jacalan and Castillo (2023) found that inquiry-based learning improves students' understanding of scientific concepts by supporting both independent and collaborative exploration. This approach fosters curiosity and deeper learning by prompting students to seek answers to questions that arise during the learning process.

Inquiry-based learning is especially relevant in physics education because of the subject's abstract nature. Concepts like force, motion, energy, and electricity often require visualisation and experimentation for effective understanding. Inquiry-based activities let students manipulate variables, observe outcomes, and build conceptual clarity. IBL also helps integrate theory with practice, connecting classroom learning to real-world applications. An additional feature of inquiry-based learning is the evolving role of the teacher. In IBL environments, teachers serve as facilitators, guides, and mentors rather than as holders of absolute knowledge. Inquiry-based learning also shifts the teacher's role from a repository of knowledge to a facilitator of the knowledge-acquisition process.
In IBL settings, teachers act as facilitators, guides, and mentors rather than sole authorities. They support students by designing learning experiences, asking guiding questions, and providing assistance throughout the inquiry process. This approach creates a more interactive and collaborative classroom, encouraging students to share ideas and participate in meaningful discussions (Misoga et al., 2024). large class sizes, limited laboratory facilities, and inadequate teacher training can impede successful adoption, particularly in developing countries such as Nigeria (Bogador et al., 2024). However, when implemented effectively, inquiry-based learning can significantly enhance students' academic performance and interest in science subjects.

Theoretical Framework

This study is based on Constructivist Learning Theory, which provides a strong foundation for inquiry-based learning. Constructivism holds that learners actively build knowledge through interaction with their environment, rather than passively receiving information. The theory emphasises the importance of prior knowledge, experience, and social interaction in learning. The theory originates from the work of scholars such as Jean Piaget and Lev Vygotsky. Piaget (1970) emphasised cognitive constructivism, proposing that learners build knowledge through assimilation and accommodation. Learning occurs when individuals encounter new information that challenges existing cognitive structures, prompting modification to achieve equilibrium. This process is particularly relevant to inquiry-based learning, where students are continually exposed to new ideas and experiences that require them to reconsider and refine their understanding. Vygotsky (1978) introduced social constructivism, highlighting the role of social interaction and collaboration in learning. He defined the Zone of Proximal Development (ZPD) as the gap between what a learner can do alone and what they can achieve with guidance. In inquiry-based classrooms, teachers and peers help students progress through their ZPD, improving learning outcomes.

Constructivist theory underpins inquiry-based learning by emphasising active engagement, exploration, and collaboration. It encourages learners to assume responsibility for their learning and to construct meaning through experience. In physics education, constructivism holds that students learn most effectively when actively involved in experiments, discussions, and problem-solving activities that facilitate in-depth exploration of scientific concepts. Constructivism also highlights the value of authentic learning experiences connected to students' real-life contexts. Inquiry-based learning provides these experiences by involving students in tasks that mirror real scientific investigations. This approach improves understanding and boosts motivation and interest in the subject. Adopting inquiry-based learning in physics classrooms aligns with constructivist principles and is expected to produce positive educational outcomes.

Empirical Studies

A growing body of research shows that inquiry-based learning improves students' academic performance, especially in science subjects like physics. Studies consistently find that students taught with inquiry-based strategies outperform those taught through traditional lectures. For example, Jacalan and Castillo (2023) reported that students in the inquiry-based group scored significantly higher in physics than those in the conventional group. The study concluded that inquiry-based learning enhances conceptual understanding and encourages active engagement, both of which are essential for mastering physics concepts.

Similarly, Misoga et al. (2024) found that inquiry-based learning significantly improved students' achievement and attitudes in physics. Students who participated in inquiry-based activities showed better problem-solving skills and a deeper understanding of scientific concepts than those taught with traditional methods. Abdulkadir et al. (2024) examined how innovative teaching methods affect students' achievement in science. They found that student-centred approaches, including inquiry-based learning, significantly improved students' interest and performance. The study highlighted the importance of active student engagement for better understanding and retention.

Udofia et al. (2024) reported that enhanced teaching methods, especially those that use practical, inquiry-based activities, improve academic performance in physics. Students who participated in hands-on experiments and investigative activities better understood complex concepts and applied them in problem-solving. Despite these positive results, some studies have identified challenges in implementing inquiry-based learning. Bogador et al. (2024) noted that inadequate teacher training, insufficient materials, and large class sizes are major barriers. These issues are especially relevant in developing countries, where resources are often limited.

Generally, empirical evidence shows that inquiry-based learning is effective for improving students' academic performance in physics. It enhances critical thinking, deepens understanding, and fosters positive attitudes toward learning. To maximise its benefits, adequate support in teacher training, resources, and curriculum development is essential.

Statement of the Problem

Persistent poor performance in physics on NECO and WAEC external examinations remains a significant concern in Nigeria's educational system. Despite curriculum reforms and increased focus on science education, students continue to struggle to understand and apply physics concepts. In Burutu Federal Constituency, many students view physics as difficult, abstract, and incomprehensible. A key factor is the ongoing reliance on traditional teacher-centred methods, particularly the lecture method, which emphasises rote memorisation and passive learning. This limits students' opportunities for active participation, critical thinking, and problem-solving. As a result, students often do not grasp core physics concepts or apply them in real-life situations. The problem this study therefore seeks to determine is whether inquiry-based learning can significantly improve students' academic performance in physics and reduce gender disparities compared to conventional teaching methods.

Purpose of the Study

The main purpose of this study is to examine the effect of inquiry-based learning on students' academic performance in secondary school physics. Specifically, the study aims to:

1. Determine the difference in academic performance between students taught using inquiry-based learning and those taught using the lecture method.
2. Determine whether gender influences the effectiveness of inquiry-based learning.
3. Assess the interaction effect of teaching method and gender on students' performance.

Research Questions

The study is guided by the following research questions:

1. What is the mean performance score difference between students taught physics by inquiry-based learning and by the lecture method?
2. How does performance differ between male and female physics students using inquiry-based learning?
3. Does the interaction between teaching method and gender influence students' academic performance?

Research Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

H_{01}: There is no significant difference in the mean performance scores of students taught using inquiry-based learning and those taught using the lecture method.

H_{02}: There is no significant difference between male and female students' performance when taught using inquiry-based learning.

H_{03}: There is no significant interaction effect of teaching method and gender on physics students' performance.

Research Design

A quasi-experimental pretest-posttest non-equivalent control group design was used. This method is suitable for comparing groups when random assignment is not possible, as is often the case in educational research. The study included an experimental group and a control group. Both groups completed a pretest before the instructional intervention to establish baseline equivalence in physics performance. The experimental group received inquiry-based learning (IBL) instruction, while the control group received conventional lecture instruction. After the intervention, both groups completed a posttest to assess academic performance. The control group provides a comparison point, allowing clearer interpretation of the impact of inquiry-based learning. This design is well-suited for evaluating instructional interventions in real classroom settings without altering the normal classroom activities.

Study Population

The population of the study include all the Senior Secondary School II (SS II) students enrolled in Physics at public secondary schools in the Burutu Federal Constituency, Delta State, Nigeria. SS II students were chosen because they have already been exposed to physics concepts and are preparing for external examinations, including the West African Examinations Council (WAEC) and National Examinations Council (NECO).

Sample and Sampling Technique

A sample of 121 Senior Secondary School II (SS II) Physics students was selected from four secondary schools in Burutu Federal Constituency, Delta State. This sample size was deemed sufficient for reliable statistical analysis and for generalising the results.

Simple random sampling ensured fair representation across schools and gender groups. The students were divided into two groups: an experimental group of 63 students who received inquiry-based learning (IBL) and a control group of 58 students who received conventional lecture instruction. This arrangement enabled effective comparison of the instructional strategies. Simple random sampling minimised bias and ensured the sample accurately represented the population.

Instrumentation

The Physics Achievement Test (PAT) used in this study consisted of 30 multiple-choice questions assessing students' understanding of selected physics concepts taught during instruction. Each question offered four options (A-D) with one correct answer, covering knowledge, comprehension, and application domains consistent with the secondary school physics curriculum. Face and content validity were established to confirm the instrument's appropriateness and accuracy. Face validity was assessed by determining whether the test items appeared suitable for measuring students' academic performance in physics. Content validity was confirmed through expert review by experienced physics teachers and science education specialists, who evaluated the alignment of the test items with the curriculum and instructional objectives. The instrument's reliability was measured using Cronbach's Alpha, yielding a coefficient of 0.82. This high internal consistency indicates that the test items reliably measure the same construct. Therefore, the PAT was considered valid and reliable for assessing students' academic performance in physics.

Procedural Overview

This study systematically implemented instructional strategies in both experimental and control groups. Trained physics teachers from selected secondary schools served as research assistants. For the experimental group, these teachers received orientation and training in inquiry-based learning (IBL) strategies and were given structured lesson plans to promote inquiry, engagement, critical thinking, and problem-solving. Teachers in the control group did not receive specialised training; they used lesson plans based on the conventional lecture method. At the start of the study, both groups completed a pretest to assess prior knowledge and establish baseline equivalence. The experimental group used an inquiry-based strategy with active participation, questioning, and hands-on activities. The control group received traditional lecture-based instruction with teacher-centred delivery and passive student involvement. The instructional intervention lasted six weeks. Afterwards, both groups took a posttest using the same Physics Achievement Test (PAT) to measure academic performance and evaluate the effect of the instructional methods.

Data Analysis

Descriptive and inferential statistics were used to analyse the data. The mean and standard deviation summarised student performance in both groups, representing the average score and variability, respectively. An independent-samples t-test was used to assess differences in mean scores between male and female experimental groups. Analysis of Covariance (ANCOVA) controlled for pretest differences and evaluated the instructional method's effect on posttest performance. Using ANCOVA improved validity by adjusting for baseline variations and isolating the effect of inquiry-based learning on student performance in physics.

Result Analysis

Research Question 1: What is the mean performance score difference between students taught physics by inquiry-based learning and by the lecture method?

Table 1

Descriptive Statistics of Students' Pretest and Posttest Scores by Instructional Methods

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
Inquiry-Based Learning (Experimental)	63	42.31	2.45	72.84	3.15
Lecture Method (Control)	58	42.10	2.60	55.67	2.98

The above table 1 shows the pretest and post-test means and standard deviations, with a clear difference in the performance of both the experimental and control groups concerning the instructional methods.

Hypothesis One (H01): There is no significant difference in the mean performance scores of students taught using inquiry-based learning and those taught using the lecture method.

Table 2

Independent Samples t-Test Showing Difference in Posttest Scores Between Experimental and Control Groups

Variable	Groups	N	Mean	SD	t	df	p
Posttest Score	Experimental	63	72.84	3.15	28.47	119	.000
	Control	58	55.67	2.98			

Table 2 showing a statistically significant difference in performance between students taught using inquiry-based learning and those taught using the lecture method ($p < .05$). Base on the above analysis the hypothesis 1 is hereby rejected.

Table 3
ANCOVA Analysis of Comparing Experimental and Control Groups

Source	SS	df	MS	F	p
Pretest (Covariate)	112.45	1	112.45	14.32	.000
Group (Experimental vs Control)	8450.67	1	8450.67	1076.54	.000
Error	923.75	118	7.83		
Total	9486.87	120			

Table 3 show a further inferential analysis of hypothesis 1, with a p-value for groups as $p = 0.000$ is less than 0.05, as a result the null hypothesis is rejected. This indicates that there is a statistically significant difference in performance between students in the experimental and control groups.

Discussion of Findings

The findings were analysed against the research questions and hypotheses to assess the impact of inquiry-based learning on students' physics achievement in Burutu Federal Constituency, Delta State. This discussion compares the performance of students taught through inquiry-based learning with that of students taught through conventional lectures. It also examines the effects of gender and the interaction between instructional method and gender on achievement. Relevant theories and empirical studies support the interpretation, offering deeper insight into the results.

Effect of Inquiry-Based Learning on Students' Academic Performance in Physics

Research Question One and Hypothesis One showed a significant difference in physics achievement between students taught with inquiry-based learning and those taught with traditional lectures. The experimental group had higher adjusted posttest scores, and ANCOVA confirmed this difference remained after accounting for pretest scores. Thus, inquiry-based learning significantly improved students' academic performance in physics. This improvement is due to the dynamic nature of inquiry-based learning, which engages students through questioning, exploration, experimentation, and problem-solving. Unlike traditional lectures, it allows students to build knowledge through direct interaction with materials and scientific investigations. Active participation deepens understanding of physics concepts and improves the application of scientific principles.

These findings support Constructivist Learning Theory, which posits that learners construct knowledge through active engagement and meaningful experiences. Piaget (1970) and Vygotsky (1978) contend that effective learning occurs when students discover and interpret knowledge rather than simply memorise facts. Inquiry-based learning exemplifies this by promoting student-centred instruction and fostering understanding through investigation and collaboration. These results are consistent with previous studies showing the positive impact of inquiry-based learning on science achievement. Jacalan and Castillo (2023) found higher physics performance among students through traditional instruction. Misoga et al. (2024) reported improvements in conceptual understanding, critical thinking, and achievement from inquiry-based instruction.

This study further supports the effectiveness of inquiry-based learning in physics education. Inquiry-based learning connects theory and practice through experimentation and investigation. This approach helps students visualise abstract concepts and relate them to real-life situations, enhancing academic performance and demonstrating the value of learner-centred instruction.

Influence of Gender on Students' Performance in Inquiry-Based Learning

Research Question Two and Hypothesis Two found no significant difference in performance between male and female students in the inquiry-based learning context. Although mean scores varied slightly, the difference was not statistically significant at the 0.05 level. Therefore, inquiry-based learning was equally effective for both genders. This result shows that inquiry-based learning fosters an inclusive environment, allowing all students to participate fully regardless of gender. Its collaborative approach may reduce gender-related barriers often seen in science instruction. Both male and female students had equal opportunities to explore, question, investigate, and discuss, promoting learning based on ability and engagement rather than stereotypes.

This finding differs from earlier studies that found gender gaps in science achievement, with males outperforming females in physics. However, it supports recent research showing that student-centred strategies can reduce gender-based academic disparities. Abdulkadir et al. (2024) reported that these methods promote equal participation and achievement.

However, this study's result suggests that inquiry-based learning effectively promotes gender equity in science education. Since both male and female students benefited equally, teachers can use inquiry-based approaches without concern for gender bias. This is important for addressing societal stereotypes that discourage female participation in science.

Interaction Effect of Teaching Method and Gender on Students' Performance

Analysis of Research Question Three and Hypothesis Three found no significant interaction between instructional method and gender on physics performance. ANCOVA confirmed that instructional effectiveness was independent of student gender. Inquiry-based learning improved academic performance for both male and female students. The lack of an interaction effect highlights its suitability for diverse student populations.

This result aligns with constructivist principles, which emphasise collaborative and active learning for all students. Inquiry-based instruction encourages interaction and meaningful experiences, promoting equal participation. This inclusiveness may explain the lack of significant gender influence. Previous studies consistently report no significant interaction between instructional method and gender in science achievement, confirming that engaging instructional approaches helps reduce gender differences.

Overall Implication of the Findings

In summary, this study shows that inquiry-based learning is an effective strategy for improving students' academic performance in physics. Active, student-centred methods significantly enhance understanding, engagement, and problem-solving skills. Inquiry-based learning also promotes gender inclusivity by providing equal opportunities for all students. These findings underscore the need for educators, curriculum developers, and policymakers to promote inquiry-based instructional strategies in secondary school physics. Moving from teacher-centred to interactive, student-centred methods can increase achievement and foster greater interest in science.

Conclusion

This study demonstrates that inquiry-based learning effectively improves students' academic performance in physics. By encouraging active participation, this approach enables students to question, investigate, experiment, and solve problems, which enhances their conceptual understanding. Unlike traditional lectures, inquiry-based learning centres on the learner and helps students develop the critical thinking and analytical skills needed to grasp complex physics concepts. The study also found that this strategy is effective for both male and female students, supporting inclusive learning. Adopting inquiry-based learning in secondary school physics can significantly improve achievement, increase engagement, and enhance science education outcomes.

Contributions to Knowledge

- This study demonstrates that inquiry-based learning improves secondary school students' performance in physics in Burutu Federal Constituency, Delta State. Students using inquiry-based methods achieved higher results than those taught with the conventional lecture method.
- The study also shows that inquiry-based learning increases students' engagement, conceptual understanding, and critical thinking in physics. These findings support constructivist learning theory, which emphasises active participation in the construction of knowledge.
- The study finds that inquiry-based learning is equally effective for male and female students, supporting gender inclusiveness in physics education.
- The study offers guidance for teachers, curriculum developers, and policymakers on adopting learner-centred instructional strategies to improve science achievement and strengthen science education in Nigeria.

Recommendations

These recommendations are based on the study's findings:

1. Physics teachers should implement inquiry-based learning strategies in their instruction.
2. Government and educational authorities should organise regular training and professional development for teachers.
3. Schools should provide functional physics laboratories and sufficient instructional materials.
4. Curriculum planners and policymakers should integrate inquiry-based learning into the physics curriculum.
5. School administrators should foster learning environments that promote active engagement.
6. Further research should examine inquiry-based learning in other science subjects and at various educational levels.

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