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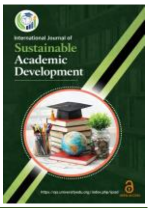

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Comparative effects of inquiry, problem-solving and lecture methods on academic achievement and retention of Physics students in Delta North Senatorial District, Delta State, Nigeria

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Abstract

This study investigated the comparative effects of inquiry, problem-solving and lecture methods on the academic achievement and retention of Physics students in Delta North Senatorial District, Delta State, Nigeria. The study also examined the moderating effect of sex. Two research questions and two corresponding null hypotheses guided the study, tested at the 0.05 level of significance. A pretest, posttest, delayed posttest, quasi-experimental planned variation design was adopted. The population comprised 16,473 Senior Secondary II Physics students in Delta North Senatorial District, from which a sample of 345 students was drawn from six public co-educational secondary schools using simple random sampling. Data were collected using a 50-item Physics Achievement Test (PAT) developed from past West African Examinations Council (WAEC) questions, validated by three experts, and possessing a reliability coefficient of 0.72 (Kuder-Richardson Formula 21). Data were analysed using mean, standard deviation, t-test, Analysis of Variance (ANOVA). Results showed that students taught with inquiry teaching strategy recorded the highest achievement gain (31.39 points) and retention rate (94%), followed by problem-solving strategy (28.26 points; 93% retention), while the lecture method recorded the lowest achievement gain (5.26 points) and retention rate (87%). No significant difference was found between male and female students' achievement or retention scores. The study concluded that inquiry and problem-solving strategies are more effective than the lecture method in enhancing achievement and retention in Physics, regardless of students' sex, and recommended their wider adoption in secondary school Physics instruction.

Keywords: Inquiry learning strategy; problem-solving strategy; lecture method; academic achievement; retention; Physics education.

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Introduction

Physics is a branch of science concerned with the study of matter, energy, and their interactions, providing the foundation for understanding how the universe works. As one of the core science subjects at the senior secondary level, Physics underpins technological and scientific development and provides the basic understanding necessary for advances in engineering, medicine, and other applied fields. Izunwa (2011) described Physics as the "queen of sciences" that has opened up vistas of human understanding, from the inner workings of the atom to the dynamics of the cosmos. In recognition of its centrality to national development, the National Policy on Education (Federal Republic of Nigeria, 2013) identifies Physics as a foundation for technological and economic growth and mandates its study as a core subject for science students at the senior secondary level.

Despite its recognised importance, students' academic achievement in Physics has remained persistently unsatisfactory in many secondary schools, including those in Delta North Senatorial District of Delta State. A major factor often implicated in this trend is the continued dominance of the conventional lecture method, a teacher-centred approach that emphasises content coverage and rote memorisation with minimal opportunity for students to engage actively with scientific concepts. Scholars have increasingly advocated for more effective, learner-centred instructional strategies, such as the inquiry learning strategy and the problem-solving strategy, which shift the focus of instruction from teacher-led delivery to student-driven exploration and reasoning.

The inquiry learning strategy engages students in observation, questioning, experimentation, and the drawing of conclusions, placing them in the role of scientists who investigate questions and analyse data to construct their own understanding (Bybee, 2014). Research suggests that inquiry-based instruction fosters higher-order thinking and long-term retention of scientific concepts (Hmelo-Silver et al, 2007). The problem-solving strategy similarly requires students to analyse authentic problems, plan strategies, and apply prior knowledge systematically to arrive at logical conclusions, thereby promoting deeper understanding than rote memorisation. Both strategies are rooted in constructivist principles, which hold that learners actively construct knowledge through engagement with their environment rather than passively receiving information from a teacher.

While the theoretical advantages of inquiry and problem-solving strategies over the lecture method have been well established, there remains limited empirical evidence directly comparing the effects of all three approaches on students' academic achievement and retention within Delta North Senatorial District. It is against this background that this study sought to determine the comparative effects of inquiry, problem-solving, and lecture methods on the academic achievement and retention of Physics students in the District, while also examining whether sex moderates these effects.

Statement Of Problem

Despite Physics' importance for technological growth, SSII students in Delta North demonstrate poor achievement and weak problem-solving skills. Evidence suggests inappropriate teaching methods contribute to this trend. Although inquiry and problem-solving strategies are theoretically superior to lecture methods, most studies have not comparatively tested all three methods on Physics achievement in Delta North, nor investigate whether effects differ by gender. Therefore, the purpose of this study is examine the comparative effects of inquiry, problem-solving, and lecture methods on the academic achievement and retention of Physics students in Delta North Senatorial District , with gender as a moderating variable. The study will benefit teachers and students who can utilize the teaching methods for effective teaching and learning process in Physics.

Research Questions

1. What is the effect on inquiry, problem-solving, and lecture methods on the academic achievement among Physics students?
2. What is the mean difference in the achievement scores between male and female students taught with the inquiry method?
3. What is the mean retention score among students taught with inquiry, problem - solving and lecture methods?

Hypotheses

1. There is no significant difference in the effect of inquiry, problem-solving, and lecture methods on the academic achievement among Physics students
2. There is the mean difference in the achievement scores between male and female students taught with the inquiry method
3. There is no significant difference in the mean retention scores among physics students taught with inquiry, problem -solving and lecture methods.

Theoretical framework

This study is anchored on two theories of learning that emphasise active engagement in the construction of knowledge. The Constructivist Learning Theory, associated with Piaget (1972), Vygotsky (1978), and Bruner (1961), posits that learners actively construct knowledge through interaction with their teachers, peers and environment rather than passively receiving it from an instructor. Piaget emphasised the individual learner's cognitive construction of knowledge through direct experience, Vygotsky highlighted the social and collaborative dimension of learning in which guided interaction scaffolds understanding, while Bruner emphasised discovery learning, in which learners arrive at knowledge through their own exploration and inquiry. These perspectives collectively support instructional strategies, such as inquiry and problem-solving, that require students to explore, question, and reason rather than simply receive information.

The second theoretical anchor is Ausubel's (1968) Theory of Meaningful Learning, which holds that learning becomes meaningful when new information is deliberately connected to a learner's existing cognitive structures, rather than memorised in isolation. This principle aligns closely with inquiry and problem-solving strategies, both of which encourage learners to relate new physics concepts to prior knowledge through reasoning, questioning and experimentation, in contrast to the lecture method, which tends to promote rote learning with little connection to what students already know.

Empirical evidence generally supports the superiority of learner-centred strategies over the conventional lecture method. In a meta-analysis of 225 studies, Freeman et al. (2014) found that active learning approaches significantly improved student performance in science, engineering and mathematics courses compared with traditional lecturing. Within the Nigerian context, Ebokaiwe et al (2024) reported that the 5E guided inquiry approach produced significantly higher achievement among Physics students in Delta State than the lecture method, while Ovuworie and Ajaja (2024) found that Polya's problem-solving strategy significantly improved Physics students' achievement and retention in the same state. Similarly, Okeke and Ramaila (2025) demonstrated that a cognitively guided inquiry-based instructional approach significantly enhanced students' academic achievement in Physics. These studies provide a strong empirical basis for the present investigation, which extends this line of research by directly comparing inquiry, problem-solving and lecture methods within a single study and examining the moderating role of sex, an area in which comparative, locally grounded evidence remains limited in Delta North Senatorial District.

Methodology

Research Design

The study adopted a pretest, posttest, delayed posttest, quasi-experimental planned variation design. A quasi-experimental approach was considered appropriate because intact classes, rather than individually randomised students, were used for the three treatment groups. The study had three levels of the independent variable (inquiry teaching strategy, problem-solving strategy, and lecture method), two dependent variables (academic achievement and retention), and one moderating variable (sex).

Population and Sample

The population comprised all 16,473 Senior Secondary II (SS II) Physics students in public secondary schools across the nine Local Government Areas of Delta North Senatorial District, Delta State, during the 2025/2026 academic session. A sample of 345 students was drawn from six public co-educational secondary schools, two schools each from the Asaba, Agbor and Obiaruku education zones, using simple random sampling by balloting with replacement. Only co-educational schools were selected to allow for comparison between male and female students. The final sample comprised 162 male and 183 female students, distributed across the inquiry (n = 115), problem-solving (n = 111), and lecture method (n = 119) groups.

Instrumentation, Validity and Reliability

Data were collected using Physics Achievement Test (PAT), a 50-item multiple-choice instrument drawn from past West African Examinations Council (WAEC) questions covering Heat Energy and Gas Laws (Boyle's Law, Charles' Law, Pressure Law, and the General Gas Law), topics taught over six weeks at four periods of forty minutes each per week. The same instrument, reshuffled between administrations, was used as the pretest, posttest, and delayed (retention) posttest.

The face validity of the PAT was established by three experts — one physics teacher, one science educator, and one expert in measurement and evaluation — all of whom confirmed its appropriateness for the study. Content validity was established using a table of specification that distributed items across Bloom's (1956) cognitive levels of knowledge, comprehension, application, analysis, synthesis and evaluation. The reliability of the instrument was determined using the Kuder-Richardson Formula 21 following a pilot administration to 40 SS II Physics students in a school outside the study sample, yielding a reliability coefficient of 0.72, indicating an acceptable level of internal consistency.

Treatment Procedure

Six physics teachers in the selected schools served as research assistants, two rfor each treatment group. Teachers for inquiry and problem-solving groups received three days of training on the theoretical basis, procedures, and classroom implementation of their respective strategies, while teachers in the lecture group required no additional training. All groups were pretested a day before treatment commenced. The treatment lasted six weeks, after which a posttest was administered a day after treatment ended, followed by a delayed posttest four weeks later to assess retention. Research assistants, rather than the researcher, delivered instruction in order to minimise the Hawthorne effect, and standardised lesson notes were provided to reduce variation in delivery across schools.

Method of Data Analysis

Data collected were analysed using mean, standard deviation, and percentages to answer the research questions. Hypothesis one was tested using paired-samples t-test, while hypotheses two was tested using one-way Analysis of Variance (ANOVA) All hypotheses were tested at the 0.05 level of significance.

Results

Research Question 1: What is the effect of inquiry learning strategy, Problem-Solving strategy and Lecture methods on the achievement of Physics in Delta North Senatorial district, Delta State?

Table 1: Mean (X) and Standard Deviation (SD) of Pretest and Posttest Achievement Scores of Students Taught Physics Using Inquiry Teaching Strategy (ITS) Problem-Solving Strategy (PSS) and Lecture Method (ML)

Group	N	Pre-test Mean (x)	SD	Posttest Mean(x)	SD	Mean gain
ITS	115	39.93	3.91	71.32	2.16	39.39
PSS	111	39.74	2.20	68.00	1.79	28.26
LM	119	39.58	2.51	44.84	4.41	5.26

Table 1 shows the effects of inquiry teaching strategy (ITS), Problem Solving Strategy (PSS) and the Lecture Method (LM) on students achievement in Physics. For ITS, the Pretest mean was 39.93 with a SD of 3.91, while the posttest mean increased to 71.32 and a SD of 2.16, resulting in mean gain of 39.39. The PSS group had a pretest mean of 39.74 (SD = 2.20) and a posttest mean of 57.96 (SD=1.79) with a mean gain of 28.26. The LM groups pretest mean was 39.58 (SD = 2.51) and the posttest mean increased to 44.84 (SD = 4.41), yielding a mean gain of 27.11. All three methods led to improvement in students mean scores, with ITS showing the highest mean gain (39.39), followed by PSS (28.26) and LM (5.26). This implies that Inquiry Teaching Strategy, problem- solving strategy and lecture method have positive effect on student achievements scores in Physics.

Hypothesis One: There is no significant difference in the effects of Inquiry Teaching Strategy, problem solving strategy and Lecture Methods) on the achievement of Physics in Delta North Senatorial district, Delta State.

Table 2: Paired sample t-test comparing the pretest and Posttest Achievement scores of students taught Physics using Inquiry Teaching Strategy (ITS), Problem-Solving Strategy (PSS) and Lecture Method (LM).

Strategies	N	Pre-test Mean	SD	Posttest Mean	SD	df	t-cal.	Sig. (2-tailed)
ITS	115	39.93	3.91	71.32	2.16	1.11	79 .474	.000
PSS	111	39.74	2.20	68.00	1.79	101	103.327	.000
LM	119	39.58	2.51	44.84	4.41	118	11.084	.000

$P< 0.05$

Table 2 shows the paired sampled t-test comparing the pretest and posttest achievement scores of students taught Physics using Inquiry Teaching Strategy (LTS), problem-solving strategy and Lecture Methods (LM). For ITS, with 115 students, t-value was 79.474 and p-value was 0.000, which is less than 0.05, leading to rejection of the null hypothesis (HO1). The same result occurred for PSS, with 111 students where the t-value was 103.327 and p-value was 0.000, also rejecting HO1. For the LM group with 119 students, the t-value was 11.084 and the p-value was 0.000, again rejecting HO1. These results indicate that there is a statistically significant effect of all three teaching strategies on student's achievement in Physics as all p-value are less than 0.05.

Research Question Two: What is the difference in mean achievement scores between male and female physics students taught with inquiry, problem - solving and lecture methods in Delta North Senatorial district, Delta State?

Table 3: Mean (X) and Standard Deviation (SD) of Posttest Achievement Scores of Male and Female Students Taught Physics Utilizing Inquiry, Problem --Solving and Lecture Method Mean Scores by Instructional Strategy and Sex

Instructional Strategy	Sex	N	Mean	Difference
Inquiry Strategy	Male	58	71.29	—
	Female	57	71.35	0.06
Problem-solving	Male	55	68.25	—
	Female	56	67.75	0.50
Lecture	Male	49	45.42	—
	Female	70	44.42	1.00

Table 3 shows the mean Posttest achievement scores of male and female students taught Physics using inquiry teaching strategy, problem --solving strategy and lecture method. The result indicates that male students taught using inquiry had a mean score of 71.29 (SD=2.21), while female students had a mean score of 71.35(SD=2.13), resulting in a mean difference of 0.06 in favour of the females. The result also shows that male students taught using problem - solving strategy had a mean score of 68.25(SD=1.88), while female students had a mean score of 67.75(SD=1.68), resulting in a mean difference of 0.50 in favour of the male. Consequently, the result indicates that male students taught using lecture method had a mean score of 45.42(SD=3.47), resulting in a mean difference of 1.00 in favour of the male. The observed disparity implies that inquiry teaching strategy and problem-solving are effective for both sexes, which could be attributed to higher participation levels or greater confidence in science - related problem --solving activities. However, the statistical significance of this difference is further determined in Table 4.

Hypothesis Two: There is no significant difference in the mean achievement scores between male and female physics students taught with the inquiry , problem - solving and lecture methods in Delta North Senatorial district, Delta State.

Table 4: **Independent Sample t-test of Mean Achievement Scores of Male and Female Students Taught Physics Utilizing Inquiry, Problem - Solving and Lecture Methods.**

T-Test Analysis of Instructional Strategy by Sex

Instructional Strategy	Sex	N	Std	t-value	Df	p-value
Inquiry	Male	58	2.21	-0.15	113	.881
	Female	57	2.13			
Problem Solving	Male	55	1.88	1.48	109	.142
	Female	56	1.68			
Lecture Method	Male	49	45.42	1.30	117	.196
	Female	70	44.42			

Table 4 shows the independent Sample t-test comparing the Posttest mean achievement scores of male and female students taught physics using inquiry teaching strategy, problem --solving strategy and lecture method. The result indicates a t-value of -0.15 with a significance level of p=0.881, for inquiry teaching strategy. Result also shows a t-value of 1.48, with a significance level of p=0.142 for problem --solving strategy and a t-value of 1.30, with a significance level of p=0.196 for lecture method. There is no significant difference among the mean achievement scores of male and female students taught physics using inquiry teaching strategy, problem --solving strategy and lecture method since all the p-values are greater than 0.05level of significance. Therefore, the null hypothesis is not rejected.

Research Question Three: What is the mean retention score among students taught with inquiry, problem - solving and lecture methods?

Table 5: Mean(X) and Standard Deviation (SD) of Retention scores of Students Taught Physics Utilizing Inquiry Teaching Strategy (ISS), Problem–Solving Strategy (PSS) and Lecture Method (LM)

Posttest and Delayed Test Performance Analysis

Group	N	Posttest (Mean)	Posttest (SD)	Delayed Test (Mean)	Delayed Test (SD)	Mean Lost	(DTM/PM) x 100
ITS	115	71.32	2.66	67.10	2.66	0.78	94.08
PSS	111	68.00	1.79	63.24	1.71	0.24	93.00
LM	119	44.84	4.41	40.84	4.29	3.03	86.62

DTM=Delayed Test Mean, PM=Posttest Mean

Table 5 shows the mean retention scores of students taught physics using inquiry teaching strategy, problem - solving strategy and lecture method. The result indicates that students taught with inquiry teaching strategy had a Posttest mean of 71.32(SD=2.16) and a delayed test mean of 67.10(SD=2.66) resulting in a mean loss of 0.78 and a retention rate of 94%. Students taught with problem --solving strategy recorded a Posttest mean of68.00(SD=1.79) and a retention test mean of 63.24(SD=1.71), with a mean loss of 0.24 and a retention rate of 93% These results indicates that inquiry teaching strategy produced the highest retention, closely followed by problem --solving strategy, while the lecture method had posttest score of 44.84,a delayed test mean of 40.84 and least retention rate of 86.64. This means that active learners - centered Instructional does not only enhance immediate achievement but also promote long- term retention of knowledge more effectively than the conventional lecture method.

Hypothesis Three: There is no significant difference in the mean retention scores among physics students taught with inquiry, problem -solving and lecture methods.

Table 6: ANOVA Comparing the Difference between the Retention Mean Scores of Students Taught Physics Utilizing Inquiry Teaching Strategy, Problem --Solving Strategy and Lecture Method .

ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	39755.220	2	19877.610	2058.154	.000
Within Groups	3303.029	342	9.658		
Total	43058.249	344			

$P(0.000) < 0.05$, H_{03} is rejected.

Table 6 shows the result of the one -way ANOVA Comparing the retention mean scores of students taught Physics using inquiry, problem-solving and lecture methods. The analysis showed a statistically significant difference among the three groups (F(2,344) =2058.154, p=.000).Since p< 0.05, the null hypothesis was rejected. This finding indicates that the Instructional strategies influenced students' retention in physics . This suggests that the difference in retention rates observed in table 8 are not by chance rather they are attributable to the type of teaching method employed. Consequently, a post -hoc analysis Table 7 is necessary to identify the specific Instructional strategies that accounted

Table 7: Scheffe Post- hoc Analysis on Direction of Difference in Retention Among Groups

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Post-Hoc Comparisons: Instructional Strategies

(I) Instructional Strategy	(J) Instructional Strategy	Mean Difference (I-J)	Sig.	Lower Bound	Upper Bound
Inquiry Strategy	Problem-solving	3.32174*	.000	2.3247	4.3188
Inquiry Strategy	Lecture	26.48140*	.000	25.5016	27.4612
Problem-solving	Inquiry Strategy	-3.32174*	.000	-4.3188	-2.3247
Problem-solving	Lecture	23.15966*	.000	22.1709	24.1484
Lecture	Inquiry Strategy	-26.48140*	.000	-27.4612	-25.5016
Lecture	Problem-solving	-23.15966*	.000	-24.1484	-22.1709

The asterisk (*) indicates that the mean difference is significant at the 0.05 level.

Table 7 shows the Scheffe post -hoc analysis comparing the retention scores of students taught Physics using Inquiry instructional strategy, problem --solving strategy and lecture method. The result indicates that inquiry Teaching Strategy significantly outperformed Problem--solving with a mean difference of 3.322 (p=0.000) and the lecture method with a mean difference of 26.481(p=0.000). Similarly, problem – solving strategy significantly outperformed the lecture method with a mean difference of 23.160 (p=0.000). These findings confirm that inquiry teaching strategy is the most effective instructional strategy for enhancing knowledge retention, followed by problem - solving strategy, while the lecture method is the least effective. This reinforces the conclusion that learner- centered strategies promote better long- term retention of knowledge compared to teacher - centered strategies.

Discussion of findings

The finding that inquiry teaching strategy produced the highest achievement gain, followed by problem-solving strategy, while the lecture method was least effective, agrees with Ovuworie and Ajaja (2024), who found that Physics students taught with guided inquiry recorded significantly higher achievement than those taught with conventional lecture methods in Delta State. It also corroborates the meta-analytic finding of Freeman et al. (2014), which showed that active learning approaches significantly improve academic performance in science, engineering and mathematics relative to traditional lecturing. The finding that the lecture method produced the lowest achievement gain is further consistent with Achor, Gyuse, and Shikaan (2017), who observed that teacher-centred approaches are less effective than learner-centred approaches in promoting conceptual understanding in science. The superiority of inquiry and problem-solving strategies may be attributed to their emphasis on active engagement, questioning, and reasoning, which are consistent with the constructivist principle that learners construct knowledge more effectively through direct experience than through passive reception of information.

Similarly, the finding that inquiry and problem-solving strategies produced considerably higher retention rates than the lecture method supports Hmelo-Silver et al (2007), who reported that inquiry-based instruction promotes higher-order thinking and long-term retention of concepts. This may be explained by Ausubel's (1968) theory of meaningful learning: because inquiry and problem-solving strategies require students to relate new concepts to existing knowledge through active reasoning, the resulting learning is more meaningfully anchored in students' cognitive structures and therefore more resistant to forgetting than content acquired through rote memorisation under the lecture method. The absence of a significant difference between male and female students' achievement and retention scores, suggests that inquiry and problem-solving strategies benefit male and female students equally. This finding indicates that adopting these learner-centred strategies will be favourable to both sex, and that any observed gap in Physics achievement between male and female students will be attributed to the instructional approach used than to sex itself.

Conclusion

This study set out to compare the effects of inquiry, problem-solving and lecture methods on the academic achievement and retention of Physics students in Delta North Senatorial District, Delta State, while also examining the moderating role of sex. The findings showed that inquiry teaching strategy was the most effective in enhancing both achievement and retention, followed by problem-solving strategy, while the conventional lecture method was the least effective on both measures. Sex was not found to significantly influence students academic achievement indicating that both male and female students benefited equally from each teaching method. The study therefore concludes that learner-centred strategies, particularly inquiry teaching strategy and problem-solving strategy, are superior to the conventional lecture method in promoting meaningful learning and long-term retention of Physics concepts among secondary school students, regardless of sex.

This study contributes to knowledge by providing empirical, locally grounded evidence on the comparative effectiveness of inquiry, problem-solving and lecture methods in Delta North Senatorial District in Delta State; by demonstrating that instructional method, rather than sex, is the primary determinant of achievement and retention in Physics; and by producing a validated 50-item Physics Achievement Test that can serve as a resource for future research and classroom assessment in the study area.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. Physics teachers should adopt the inquiry learning strategy as a primary instructional approach, while schools should encourage the use of problem-solving techniques across science subjects.
2. Regular training and workshops should be organised for teachers on the practical classroom implementation of inquiry and problem-solving strategies.
3. Schools should be provided with instructional materials that facilitate active, learner-centred engagement in Physics lessons.
4. The use of the lecture method should be reduced or combined with more interactive, learner-centred strategies.
5. Curriculum developers should incorporate greater emphasis on activity-based learning approaches within the Physics curriculum.

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