EFFECT OF 7E-LEARNING INSTRUCTIONAL STRATEGY ON GENDER AND STUDENTS' MATHEMATICAL ABILITY IN PHYSICS PRACTICAL ACHIEVEMENT IN LAGOS STATE

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Abstract

The research assessed the effectiveness of the 7E-Learning instructional approach in minimising gender-related gaps and differences in mathematical ability affecting physics practical achievement in Lagos State. A quasi-experimental research framework was utilised for the study, comprising 372 respondents selected from six schools using stratified and simple random sampling methods within six educational districts of Lagos State. Reliability was determined through the test–retest procedure, producing reliability coefficients of 0.84 and 0.72 respectively. Data were analysed through mean scores, standard deviation, and inferential statistics (ANCOVA). The results indicated that female students in the Experimental Group obtained higher mean scores than their male counterparts within the same group. In addition, a statistically significant variation existed in the mean achievement scores of learners exposed to the 7E-Learning instructional strategy compared with those instructed through the conventional teacher-centred demonstration approach. The study concluded that the 7E-Learning instructional strategy considerably improves students' performance in physics practical activities, with female students showing greater gains. The study further suggested that physics instructors integrate the 7E-Learning instructional strategy into classroom practice to promote learner-centred and constructivist teaching environments while reducing gender disparities in achievement. Moreover, curriculum development agencies should organise professional development programmes aimed at providing educators with the competencies required for the effective application of the 7E-Learning instructional strategy during practical lessons.

Keywords: gender, physics practical, achievement, 7e-learning instructional strategy

Introduction

Constructivist learning theory has greatly influenced modern science education, including physics practical instruction, by highlighting learners' direct participation in the development of understanding through experiential learning. Recent research highlights the relevance of this approach in fostering deeper understanding and skill development. Constructivists advocate for a learning strategy that empowers and engages learners, addressing not only epistemological concerns but also broader educational goals (Tadesse & Gillies, 2020). The theory posits that individuals build knowledge through hands-on interactions and reflective engagement with their environment, making learning unique to each individual (Aljohani, 2017). Constructivist learning environments prioritise active participation, encouraging students to engage meaningfully in their learning process (Salam et al., 2022). Various instructional strategies have been developed to align with this philosophy. Early frameworks like the 3E Learning Cycle (Explore, Explain, and Expand) supported foundational skills, while the 4E model added Evaluate to foster reflection. The widely adopted 5E Learning Cycle (Engage, Explore, Explain, Elaborate, Evaluate) has become a cornerstone of science education, fostering critical thinking and conceptual understanding (Bybee, 2020). The 6E model further incorporated e-search, emphasising technology integration to enhance engagement and learning outcomes (Keen et al., 2021).

The 7E Learning instructional strategy has been recognised as particularly effective in physics practical, introducing stages such as Elicit and Extend to deepen critical thinking and application skills. This approach enables learners to relate theoretical ideas to practical experiments, thereby promoting advanced reasoning abilities and effective analytical competence. For example, a recent study by Joshi and Gupta (2022) demonstrated that students exposed to the 7E-instructional strategy during physics experiments showed significant improvement in academic performance and conceptual clarity compared to those taught using teacher-led demonstration methods.

Purpose of the Study

The primary aim of this research is to examine the effect of the 7E-learning instructional strategy on gender-related differences in physics practical achievement, among senior secondary school students in Lagos State.

The specific objectives of the research are to:

1. examine the main influence of gender on students' achievement in physics practical activities
2. determine the interaction effect of treatment and students' mathematical ability on achievement in physics practical activities.
3. examine how the combination of the instructional treatment and gender jointly influence their achievement in physics practical activities.
4. assess the combined influence of students' mathematical ability and gender on their achievement in physics practical activities

Research Questions

The following research questions were raised to guide the study:

1. What is the effect of students' gender on their achievement in physics practical?
2. What are the effects of instructional treatment and students' mathematical ability on their achievement in physics practical activities?
3. What influence do treatments and students' gender have on achievement in physics practical activities?
4. What effects do students' mathematical ability and gender have on their achievement in physics practical activities?

Research Hypotheses

The following hypotheses were developed for testing at a 0.05 level of significance.

1. There is no statistically significant effect of students' gender on their achievement in physics practical activities.
2. There is no statistically significant interaction effect between treatment and students' mathematical ability on their achievement in physics practical activities.
3. There is no statistically significant interaction effect between treatment and students' gender on their achievement in physics practical

4. There is no significant interaction effect of students' mathematical ability skill and gender on their achievement in physics practical

The significance of this study

The 7E-learning instructional strategy is multifaceted, offering valuable insights into several critical areas of education. First, the research directly addresses the persistent challenges in physics education, particularly the improvement of practical skills which have long been identified as an area of weakness in student performance. By exploring a learner-centred approach like the 7E-learning instructional strategy, this study has the potential to transform traditional, teacher-led demonstration teaching methods into more engaging, interactive, and collaborative learning experiences. This shift could enhance students' practical skills, fostering deeper understanding and better academic outcomes in physics practical.

For curriculum developers and educational policymakers, the findings from this research could provide essential data for designing more effective physics curricula that integrate practical work more seamlessly with theoretical content. Moreover, this study's exploration of gender and mathematical ability as moderating factors in physics achievement tackles important equity issues in science education. The insights gained could inform the development of targeted interventions, ensuring that all students, regardless of gender or prior experiences, have the support they need to excel in physics practical.

Literature Review

The growing concern over students' poor achievement in physics, particularly in the practical aspect of physics, has continued to attract scholarly attention in Nigeria, with emphasis shifting from teacher-led demonstration methods that limit students' hands-on engagement and experimental skills to innovative learner-centred strategies such as the 7E-learning instructional strategy. The 7E-learning instructional strategy, which includes the phases of engage, explore, explain, elaborate, evaluate, extend, and elicit phases, has been widely acknowledged for promoting active learning, conceptual understanding, and problem-solving skills. Empirical studies in Nigeria have consistently shown that activity-based and inquiry-driven approaches significantly enhance students' achievement in physics theory compared to conventional methods. For instance, Ovuworie, Ajaja, and Kpangban (2024) found that the 7E learning instructional strategy improved students' academic achievement and retention in physics more than the lecture method, emphasising its effectiveness in fostering deeper understanding. Similarly, Udofia, Akpan, Babayemi, and Ekpo (2025) reported that enhanced and activity-driven teaching methods significantly improved students' skills in conducting experiments, measurements, and data interpretation in practical physics. These findings align with Ogunleye (2021) and Akinbobola (2022), who emphasised that effective physics teaching in Nigeria must prioritise laboratory-based experiences that promote inquiry, manipulation of materials, and scientific reasoning, all of which are embedded within the 7E-learning instructional framework. Within the Nigerian context, studies such as Udofia et al. (2025) further affirm that enhanced teaching methods significantly influence students' achievement in practical physics, reinforcing the need for structured instructional strategies such as the 7E to address persistent learning difficulties.

Another critical dimension in physics education research is gender disparity in achievement, which has produced mixed findings in the literature. Although earlier views often pointed to male superiority in physics, more recent studies in Nigeria indicate that the use of innovative teaching methods can reduce or even eliminate gender-related performance gaps. For example, Ajibade and Ogunmola (2023) reported no significant difference between male and female students' performances in physics practical when exposed to activity-based instructional strategies, suggesting that such methods are gender-friendly. Gender differences in physics practical achievement have also received considerable attention, particularly regarding participation in laboratory activities and manipulation of equipment. Earlier studies often reported male students outperforming females in practical physics due to greater exposure to technical tasks and societal stereotypes; however, recent Nigerian studies suggest that such differences are diminishing with the adoption of interactive instructional strategies. Ajibade and Ogunmola (2023) found that when students were engaged in structured practical activities using learner-centred approaches, there was no significant difference between male and female students in terms of experimental skills, accuracy of measurements, and data interpretation. Furthermore, Simeon (2025) noted that gender disparities in physics practical are more related to instructional conditions than innate ability, arguing that equitable participation in laboratory tasks fosters confidence and competence among female students. Nonetheless, some studies (Adeoye, 2020) still report slight variations in performance, suggesting that while gender gaps are narrowing, they may persist in contexts where instructional practices are not fully activity-oriented or inclusive, thereby narrowing the gender gap. However, some studies still report slight variations in favour of one gender depending on contextual variables such as teaching style and assessment methods (Adeoye, 2020), indicating that gender differences may not be eliminated but are significantly moderated by instructional strategies.

In addition to gender, mathematical ability plays a crucial role in determining students' success in physics practical, particularly in areas involving measurement, graph plotting, error analysis, and interpretation of experimental data. physics practical is inherently quantitative, requiring students to apply mathematical concepts such as ratios, gradients, and algebraic relationships in analysing results. Nigerian studies have shown that students with higher mathematical ability tend to perform better in practical physics due to their proficiency in calculations and data handling (Akinmola, 2021; Salami & Adeyemi, 2023). However, recent literature suggests that structured instructional strategies like the 7E-learning instructional strategy can mitigate disparities arising from differences in mathematical ability by providing scaffolding through guided inquiry, collaborative learning, and step-by-step experimentation processes. For instance, Akinbobola (2022) observed that students with low mathematical ability improved significantly in practical tasks when exposed to activity-based instruction that emphasised peer interaction and teacher guidance during data analysis. This implies that the 7E-learning instructional strategy not only enhances hands-on skills but also supports the development of mathematical reasoning within the context of practical physics. Despite these insights, there remains a paucity of studies in Nigeria that concurrently examine the interaction of instructional strategy, gender, and mathematical ability on physics practical achievement.

Study Design and Methods

The study was conducted in Lagos State, with one school randomly selected from each of the six educational districts. A quasi-experimental design was employed, utilising a pre-test and post-test approach. In-tact classes from both experimental and control groups participated in the study. Three schools were assigned to the experimental group, while three other schools were designated as the control group. The sample included mixed schools.

Sample and Sampling Technique

A total of 372 SSII physics students drawn from six senior secondary schools took part in the study, selected through a multi-stage sampling procedure. In the initial stage, one zone was randomly picked from each educational district in Lagos State. Thereafter, one school was randomly selected from each of the chosen zones in the second stage. In the third stage, simple random sampling was used to assign three schools from districts with odd numbers to the experimental condition (175 students). The remaining schools from districts with even numbers were allocated to the control condition (197 students) through a ballot system.

Variables in the study

The current research investigates three primary variables categorised as Independent Variables, Dependent Variables, and Moderating Variables, aiming to provide distinct and coherent insights.

Independent Variables

The study's independent variables include two methods of instruction: the treatment, which involves the 7E-learning instructional strategy, and the conventional teacher-led demonstration method.

Dependent Variables

The study measured a single outcome variable, which was students' achievement in physics practical activities.

Moderating Variables

The study identified two moderating variables: gender and mathematics ability

Research Instrument

Three instruments were used to gather data for this study:

I. 7E-learning Instructional Physics Practical Package (7E-LIPPP): This is an instructional package developed by integrating the 7E-learning strategy in physics practical content delivery in Optics, Heat, and Electricity

II. Physics Practical Achievement Test (PPAT): This utilised practical questions sourced from WAEC past exams, specifically those highlighted in the WAEC Chief Examiner's Report 2020 (page 118). The test was given before and after the intervention in order to assess students' achievement in practical activities.

III. The test was administered as both a pre-test and a post-test to measure students' achievement in physics practical. Intervening variables such as teacher effects and group interactions were controlled through the presence of the researcher, raters, and physics teachers during the study. The PPAT consisted of two sections: personal data and students tasks

- **III. Mathematical Ability Skill Test (MAST)**

The Mathematical Ability Skill Test (MAST) evaluated students' proficiency in mathematical skills using WASSCE past questions from 2019 to 2024. The test included theoretical questions designed to assess students' mathematical skills relevant to physics practical, as mathematics is essential to understanding physics. Twenty randomly selected questions covered key topics such as measurement, reciprocals, square and cube roots, quadratic equations, trigonometry, graph plotting, and algebra. The open-ended questions aimed to evaluate students' application of mathematical concepts in physics.

Reliability of the Research Instruments

To establish the consistency of the instruments, the Kuder–Richardson Formula 20 (KR-20) was applied to determine reliability. The Physics Practical Achievement Test (PPAT) recorded a reliability index of 0.72, while the Mathematical Ability Skills Test (MAST) produced a coefficient of 0.82. These results suggest that both PPAT and MAST yield stable outcomes when administered repeatedly, indicating their adequacy as tools for assessing physics practical achievement.

Presentation and Interpretation of Results

Introduction

This chapter presents the findings derived from the analysis of the collected data. The results are organised according to the four research questions and the corresponding hypotheses stated earlier in the study.

Data Analysis and Interpretation of Findings

Table 1: ***Distribution of Respondents Across Groups***

Group	Frequency(F)	Percentage (%)
Experimental	175	47.1
Control	197	52.9
Total	372	100.0

Table 1: shows the distribution of respondents across two groups: Experimental and Control. Out of a total of 372 participants, 175 respondents (47.1%) belong to the Experimental Group, while 197 respondents (52.9%) are in the Control Group. This distribution indicates a slightly higher representation in the Control Group, but the overall sample is fairly balanced, allowing for effective comparative analysis between the two groups.

Table 2: ***Distribution of Respondents by Gender***

Gender	Frequency	Percentage (%)
Male	199	53.5
Female	173	46.5
Total	372	100.0

Table 2 presents distribution of respondents by gender. Out of the 372 participants,199 are male, representing 53.5% of the sample, while 173 are female, accounting for 46.5%. This gender distribution is relatively balanced, with a slightly higher proportion of male respondents, which helps ensure diverse perspectives in the study findings.

Presentation of Results

1. **Research Question 1:** What is the effect of students' gender on their achievement in physics practical?

Table 5a: Descriptive Analysis of Students' Achievement Gains Based on Gender

		Pre – Test		Post – Test		
Gender	N	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference
Male	199	6.73	1.93	15.78	6.19	9.05
Female	173	7.14	1.63	17.52	7.14	10.38

Table 5a shows the gain in physics practical achievement according to gender. Male students recorded an increase from a pre-test mean score of 6.73 (SD = 1.93) to a post-test mean score of 15.78 (SD = 6.19), giving a mean gain of 9.05. In contrast, female students improved from a pre-test mean score of 7.14 (SD = 1.63) to a post-test mean score of 17.52 (SD = 7.14), with a higher mean gain of 10.38. These findings indicate that both male and female students benefited from the instructional intervention, although female students demonstrated a marginally greater improvement in physics practical achievement.

2. **Research Question 2:** What are the effects of instructional treatment and students' mathematical ability on their achievement in physics practical activities?

Table 6a: Descriptive Analysis of Achievement Gain Based on the Interaction of Treatment and Mathematical Ability

			Pre – Test		Post – Test		
Treatment		N	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference
Experimental	Low	59	6.20	2.07	12.01	1.47	5.43
	High	116	6.85	1.87	12.23	1.72	5.44
Control	Low	92	6.31	1.84	20.42	6.40	14.11
	High	105	7.54	1.52	22.00	6.39	14.46

Table 6a presents the descriptive statistics of achievement gains as influenced by the interaction between treatment and students' mathematical ability. The results show that learners in the Control Group with low mathematical ability recorded a pre-test mean score of 6.31 (SD = 1.84) and a higher post-test mean score of 20.42 (SD = 6.40), yielding a mean gain of 14.11. Conversely, low-ability students in the experimental group obtained a pre-test mean score of 6.20 (SD = 2.07) and a post-test mean score of 12.01 (SD = 1.47), with a smaller mean gain of 5.43.

For students with high mathematical ability, improvement was also observed in both groups. However, the Control Group recorded a higher post-test mean score of 22.00 (SD = 6.39) compared to 12.23 (SD = 1.72) for the Experimental Group, indicating better performance in the control condition across ability levels.

3**. Research Question 3:** What influence do treatments and students' gender have on achievement in physics practical activities?

TABLE 7a: Descriptive Analysis of Achievement Gain Based on the Interaction of Treatment and Gender

			Pre – Test		Post – Test		
TREATMENT		N	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference
Control	Male	104	6.58	2.15	12.02	1.39	5.44
Group	Female	93	6.81	1.64	12.24	1.44	5.43
Experimental	Male	95	7.41	1.62	22.60	6.54	15.19
	Female	80	7.41	1.67	23.00	6.61	15.59

Table 7a presents the descriptive statistics of achievement gains arising from the interaction between treatment and gender. In the Control Group, male students recorded a pre-test mean score of 6.58 (SD = 2.15) and a post-test mean score of 12.02 (SD = 1.39), yielding a mean gain of 5.44. Female students in the same group obtained a pre-test mean score of 6.81 (SD = 1.64) and a post-test mean score of 12.24 (SD = 1.44), with a mean gain of 5.43.

These results suggest that both male and female students in the control condition showed comparable improvements in achievement following the intervention.

4. Research Question 4: What effects do students' mathematical ability and gender have on their achievement in physics practical activities?

Table 8a: Descriptive Analysis of Achievement Gain Based on the Interaction of Mathematical Ability and Gender

			Pre – Test		Post – Test		
TREATMENT		N	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference
Control	Male	104	6.47	2.33	13.06	4.33	6.59
Group	Female	93	6.61	1.59	14.61	15.52	8.00
Experimental	Male	95	7.66	1.75	16.73	6.62	9.03
	Female	80	7.28	1.68	18.11	7.38	10.83

Table 8a presents the descriptive statistics of students' achievement gains in physics practical activities, categorised by treatment condition and gender. In the Control Group, male students obtained a pre-test mean score of 6.47 (SD = 2.33) and a post-test mean score of 13.06 (SD = 4.33), yielding a mean gain of 6.59. Female students in the same group recorded a pre-test mean score of 6.61 (SD = 1.59) and a higher post-test mean score of 14.61 (SD = 15.52), with a mean gain of 8.00.

In the Experimental Group, male students improved from a pre-test mean score of 7.66 (SD = 1.75) to a post-test mean score of 16.73 (SD = 6.62), resulting in a mean gain of 9.03. Female students in the same group showed the highest performance, increasing from a pre-test mean score of 7.28 (SD = 1.68) to a post-test mean score of 18.11 (SD = 7.38), with a mean gain of 10.83.

Overall, the findings suggest that the instructional treatment had a positive effect on students' achievement, with female students generally demonstrating higher gains than their male counterparts across both groups.

Research Hypotheses

The following hypotheses were developed for testing at the 0.05 level of significance.

1. **Ho1:** There is no statistically significant effect of students' gender on their achievement in physics practical activities.

Table 4: Analysis of Covariance Summary of Students' Physics Practical Scores Based on Treatment, Mathematical Ability, and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Et*a Squared
Corrected Model	4018.457[a]	8	503.432	25.036	.000	.556
Intercept	2950.285	1	2950.285	147.012	.000	.479
Covariate	.008	1	.009	.000	.983	.000
Treatment	2494.575	1	2495.595	127.719	.001*	.437
Mathematical Ability	1.756	1	1.756	.087	.768	.001
Gender	127.719	1	127.719	6.420	.011	.039
Treatment * Ability	.484	1	.486	.024	.877	.000
Treatment * Gender	96.752	1	96.752	4.821	.030	.029
Ability * Gender	64.969	1	64.969	3.237	.074	.020
Treatment * Ability * Gender	32.359	1	32.359	1.612	.206	.010
Error	3210.925	370	20.068			
Total	52207.000	373				
Corrected Total	7230.379	372				

a. R Squared = 0.556 (Adjusted R Squared = 0.534)

b.* = p is significant at .05

The results presented in the table indicate that the 7E-Learning Instructional Strategy produced a statistically significant main effect on students' achievement in physics practical after adjusting for pre-test scores, F(1, 370) = 127.719; p = 0.001. Given that the p-value is less than 0.05, the main effect of the instructional treatment on students' physics practical achievement is considered statistically significant.

Table 5: Pairwise Comparison Results of Students' Achievement in Physics Practical

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
CONTROL	EXPERIMENTAL	-9.122*	.873	.000	-10.218	-7.601
EXPERIMENTAL	CONTROL	9.122*	.873	.000	7.601	10.218

*. The mean difference is significant at the .05 level.

The table presents the outcomes of a post hoc analysis of students' achievement scores across the treatment groups. The results indicate significant differences among the mean post-test scores, with the Experimental Group recording the highest mean, followed by the Team-Assisted Individualisation Group, while the Control Group had the lowest mean. The observed mean difference was 9.122 (SD = 0.873), and this difference was statistically significant at $p < 0.05$. These findings suggest that the experimental instructional approaches were more effective than the conventional teacher-led demonstration method.

Ho2: There is no statistically significant interaction effect between treatment and students' mathematical ability on their achievement in physics practical activities.

Table 4 shows that the effect of students' mathematical ability on achievement in physics practical was not statistically significant, $F(1, 160) = 0.087$; $p = 0.768$. Since the p-value exceeds the 0.05 significance level, the null hypothesis (H02) is not rejected.

In terms of effect size, the partial eta squared indicates that mathematical ability accounts for approximately 0.1% of the observed variation in students' physics practical achievement, suggesting a negligible influence.

1. **Ho3:** There is no statistically significant interaction effect between treatment and students' gender on students' achievement in physics practical

Table 4 shows that the effect of students' gender on achievement in physics practical was $F(1, 160) = 6.420$; $p = 0.11$. Since the p-value is greater than the 0.05 significance level, the result is not statistically significant; therefore, the null hypothesis is not rejected. This implies that gender does not have a significant influence on students' achievement in physics practical.

Regarding effect size, the partial eta squared indicates that gender accounts for about 3.9% of the variation in students' physics practical achievement, reflecting a small effect.

1. **Ho4:** There is no significant interaction effect of students' mathematical ability skill and gender on students' achievement in physics practical

The table shows that the interaction effect between treatment and students' mathematical ability on physics practical achievement was $F(1, 160) = 0.24$; $p = 0.877$. Since the p-value is greater than 0.05, the result is not statistically significant; therefore, the null hypothesis is not rejected. This indicates that there is no meaningful interaction effect between treatment and mathematical ability on students' performance in physics practical.

In terms of effect size, the partial eta squared shows that the combined effect of treatment and mathematical ability accounts for 0% of the variation in students' physics practical achievement, indicating a negligible influence.

Summary of Findings

1. The instructional treatment positively influenced students' achievement in physics practical activities in Lagos State.
2. Results on gender differences in physics practical achievement revealed that female students performed better than their male counterparts in both pre-test and post-test scores and recorded a higher overall gain after the treatment.
3. Students with high mathematical ability achieved greater mean gains than those with low mathematical ability within the treatment groups.
4. Learners were able to communicate effectively with one another, share their ideas, listen attentively, and contribute meaningfully during practical group activities.

Discussion of Findings

Recent educational research continues to illuminate the transformative potential of innovative instructional approaches in physics, building upon and extending previous findings with more nuanced and contemporary insights. The evolving landscape of physics instruction reflects a growing recognition of the need to move beyond traditional teaching methods in order to address the increasingly advanced expectations of modern education. This approach has demonstrated significant improvements in students' ability to formulate sophisticated hypotheses, design intricate experimental protocols and engage in more nuanced data analysis. Importantly, these studies have shown that such integrated approaches not only enhance physics achievement but also cultivate advanced scientific reasoning skills that extend beyond traditional disciplinary boundaries.

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