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SCIENCE PROCESS SKILLS APPROACH AND STUDENTS' ACADEMIC PERFORMANCE IN PRACTICAL PHYSICS IN SECONDARY SCHOOLS

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Abstract
This study investigated the effect of the Science Process Skills Approach (SPSA) on senior secondary school students' academic performance in practical physics in Gembu Education Zone, Taraba State, Nigeria. A quasi-experimental pretest-posttest non-equivalent control group design was adopted. The sample comprised 110 Senior Secondary School II students drawn from two intact classes. The experimental group (n=60) was taught using SPSA, while the control group (n=50) was taught using the Alternative to Practical method (ATP). The Mechanics Practical Performance Test (MPPT), a 27-item multiple-choice instrument (KR-20 = 0.72), was used for data collection. Mean, standard deviation, and Analysis of Covariance (ANCOVA) were used to answer three research questions and test three null hypotheses at α = 0.05. Results showed that students taught with SPSA had significantly higher posttest mean scores (45.47) than the control group (31.84), with a mean gain of 36.04 compared to 22.41. ANCOVA revealed a significant main effect of instructional approach on performance [$F(1,107)=242.424$, $p<0.05$, partial $\eta^2 = 0.694$]. No significant gender difference was found within the SPSA group [$F(1,57)=0.697$, $p>0.05$]. The study concludes that SPSA is an effective, gender-inclusive strategy for improving students' performance in practical physics. Recommendations include the adoption of SPSA by physics teachers and its integration into teacher education programmes.

Keywords: Science process skills approach, academic performance, practical physics, gender, alternative to practical, Nigerian secondary schools

Introduction

Physics is a fundamental science subject that drives technological innovation and national development. At the senior secondary school level, physics aims to equip students with critical thinking, problem-solving skills, and practical competencies for further studies and technological careers (Achor & Gbadamosi, 2020). However, despite its importance, students' performance in physics—especially in the practical component—has remained persistently poor. The West African Examinations Council (WAEC) Chief Examiners' reports from 2015 to 2024 consistently identify students' inability to observe, measure, manipulate apparatus, record data accurately, and interpret graphs as major weaknesses. In Taraba State, the average yearly failure rate in WAEC physics exceeds 66% (Taraba State Ministry of Education, Resource Center Jalingo, 2025). One of the primary causes of poor performance is the predominance of teacher-centred instructional methods, particularly the Alternative to Practical approach, where students memorize experimental procedures and results without actually performing hands-on experiments (Ngema, 2016; Ramnarain, 2016).

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This method fails to develop the science process skills (observing, measuring, inferring, experimenting, etc.) that are essential for meaningful learning in physics.

The Science Process Skills Approach (SPSA) is a learner-centred, inquiry-based instructional strategy that explicitly develops and applies these skills through guided hands-on experimentation (Abdullah, 2019). Studies from other parts of Nigeria have shown that SPSA improves students' conceptual understanding and achievement (Akinbobola & Afolabi, 2020; Jack & Ndong, 2022). However, limited empirical evidence exists on the effectiveness of SPSA specifically in Taraba State. Furthermore, gender issues remain inconclusive: some studies report male superiority in physics (Anderson, 2016), while others find no significant differences (Uzomah, et al. 2024; Okedeji & Hannah, 2018).

This study therefore addressed the following gaps: (1) poor academic performance in practical physics among secondary school students, and (2) the lack of empirical evidence on the effectiveness of SPSA in Taraba State. The study sought to determine whether SPSA produces better performance outcomes than the Alternative to Practical method and whether gender influences these outcomes.

Purpose of the Study

The purpose of this study was to investigate the effect of the Science Process Skills Approach on secondary school students' academic performance in practical physics. Specifically, the study sought to:

1. Determine the difference in the mean performance scores of students taught practical physics using SPSA and those taught using Alternative to Practical.
2. Determine the difference in the mean performance scores of male and female students taught practical physics using SPSA.

Research Questions

1. What is the difference in the mean performance scores of students taught practical physics using SPSA and those taught using Alternative to Practical?
2. What is the difference in the mean performance scores of male and female students taught practical physics using SPSA?

Null Hypotheses

H_{o1}: There is no significant difference in the mean performance scores of students taught practical physics using SPSA and those taught using Alternative to Practical.

H_{o2}: There is no significant difference in the mean performance scores of male and female students taught practical physics using SPSA.

Methodology

Research Design: A quasi-experimental pretest-posttest non-equivalent control group design was adopted. This design is appropriate when random assignment of intact classes is not feasible in school settings.

Group	Pretest	Treatment	Posttest
Experimental (E)	O_1	SPSA	O_2
Control (C)	O_1	Alternative to Practical	O_2

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The study was conducted in Gembu Education Zone, Sardauna Local Government Area, Taraba State, Nigeria, located on the Mambilla Plateau. The zone has 58 public secondary schools with functional physics laboratories.

The target population comprised all 2,467 Senior Secondary School II (SS II) students offering physics in the 58 public secondary schools in Gembu Education Zone during the 2024/2025 academic session (1,555 male, 912 female).

A sample of 110 students was drawn using multi-stage sampling. In the first stage, Gembu Education Zone was selected from the ten education zones in Taraba State using simple random sampling. In the second stage, Gembu town was selected through simple random sampling. In the third stage, two public secondary schools were purposively selected based on the availability of functional physics laboratories, qualified physics teachers, and laboratory assistants. The selected schools were Government Day Secondary School, Gembu, and Government Secondary School, Gembu. Government Day Secondary School, Gembu, was assigned to the experimental group, while Government Secondary School, Gembu, served as the control group through random sampling technique. This combination of probability and non-probability sampling ensured fairness in selection and suitability of the sample for the research objectives.

In summary, experimental group (Government Day Secondary School, Gembu): 60 students (32 male, 28 female). The control group (Government Secondary School, Gembu): 50 students (28 male, 22 female). Intact classes were used to avoid disruption of normal school activities.

Instrument for Data Collection

The Mechanics Practical Performance Test (MPPT) was developed by the researcher. Initially 50 multiple-choice items (four options A–D), after pilot testing and item analysis, 27 items were retained (facility index 0.30–0.70; discrimination index ≥0.20). The maximum obtainable score was 100. The instrument covered four mechanics topics: simple pendulum, Hooke's law, simple harmonic motion of a cantilever, and determination of unknown mass.

Reliability: Pilot tested on 30 SS II students at Government Day Secondary School, Nguroje (outside study area). Kuder-Richardson Formula 20 (KR-20) yielded a reliability coefficient of 0.72, which is acceptable for educational research (Fraenkel & Wallen, 2009).

Validity: Face and content validity were established by three experts (two in Science Education, one in Measurement and Evaluation) from Taraba State University, Jalingo.

Procedure

The study lasted eight weeks (pretest, four weeks of treatment, posttest). Two trained research assistants (regular physics teachers of the selected schools) delivered instruction using structured lesson plans.

- Experimental group (SPSA): Students actively performed experiments in small groups, following guided inquiry. Each lesson emphasised process skills: observing, measuring, recording, inferring, graphing, and communicating.
- Control group (Alternative to Practical): Teacher demonstrated experiments; students copied procedures, observations, and conclusions from the board. No hands-on student participation.

Controls: Same topics, same duration (40 minutes per lesson, twice a week); pretest scores used as covariate; regular teachers delivered instruction (minimising Hawthorne effect); groups from different schools to prevent cross-contamination.

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Data Analysis and Results

Data were analysed using SPSS version 25.

- Research questions: Mean and standard deviation.
- Hypotheses: One-way and two-way Analysis of Covariance (ANCOVA) at α = 0.05, with pretest scores as covariates.

Research Question 1: What is difference in the mean performance scores of students taught practical physics using Science Process Skills Approach and those taught using Alternative to Practical?

Table 1: Mean Performance Scores of SPSA and ATP Groups

Group	N	Pretest Mean (SD)	Posttest Mean (SD)	Mean Gain
SPSA	60	9.43 (2.18)	45.47 (3.60)	36.04
ATP	50	8.68 (1.92)	31.84 (5.35)	22.41
Mean difference				13.63

Table 1 shows that students taught with SPSA had a mean gain of 36.04 compared to 22.41 for the ATP group, with a difference of 13.63 in favour of SPSA.

1. Research Question 2: What is difference in the mean performance scores of male and female students taught practical physics using Science Process Skill Approach?

Table 2: Mean Performance Scores of Male and Female Students under SPSA

Gender	**N**	**Pretest Mean (SD)**	**Posttest Mean (SD)**	**Mean Gain**
Male	32	9.81 (2.45)	45.94 (3.95)	36.31
Female	28	9.00 (1.76)	44.93 (3.14)	35.93
Mean difference				0.38

The mean gain for males (36.31) and females (35.93) differed by only 0.38, favouring males marginally as seen in Table 2.

Hypothesis Testing

Hypothesis 1: There is no significant difference in the mean performance scores of students taught practical physics using Science Process Skills Approach and those taught using Alternative to Practical.

Table 3: ANCOVA for Performance of SPSA and ATP Strategies

Source	**Sum of Squares**	**df**	**Mean Square**	**F**	**p**	**Partial η²**
Corrected Model	5205.369	2	2602.684	137.020	0.000	0.719
Intercept	6057.860	1	6057.860	318.921	0.000	0.749
PrePerformance	141.204	1	141.204	7.434	0.007	0.065
Strategies	4604.819	1	4604.819	242.424	0.000	0.694
Error	2032.450	107	18.995			
Total	176896.000	110				
Corrected Total	**7237.818**	**109**				

R Squared = 0.719 (Adjusted R Squared = 0.714)

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Table 3 reveals that $F(1,107) = 242.424$, $p = 0.000 < 0.05$. Therefore, H_{01} is rejected. There is a significant difference in the mean performance scores of students taught using SPSA and those taught using ATP. The partial eta squared (0.694) indicates that 69.4% of the variance in performance scores is attributable to the instructional approach.

Hypothesis 2: There is no significant difference in the mean performance scores of male and female students taught practical physics using Science Process Skill Approach.

Table 4: ANCOVA for Performance by Gender (SPSA Group Only)

Source	Sum of Squares	df	Mean Square	F	p	Partial η^2
Corrected Model	35.213	2	17.606	1.372	0.262	0.046
Intercept	5353.833	1	5353.833	417.056	0.000	0.880
Preperformance	20.012	1	20.012	1.559	0.217	0.027
Gender	8.949	1	8.949	0.697	0.407	0.012
Error	731.721	57	12.837			
Total	124800.000	60				
Corrected Total	766.933	59				

R Squared = 0.046 (Adjusted R Squared = 0.012)

Table 4 shows that $F(1,57) = 0.697$, $p = 0.407 > 0.05$. Therefore, H_{02} is not rejected. There is no significant difference in the mean performance scores of male and female students taught using SPSA. Gender accounts for only 1.2% of the variance (partial $\eta^2 = 0.012$).

Discussion

This study has revealed that students taught practical physics using SPSA performed significantly better (mean gain 36.04) than those taught using ATP (mean gain 22.41). The instructional approach explained 69.4% of the variance in performance scores (large effect size). The finding that SPSA significantly improved students' performance in practical physics aligns with previous studies. Unamma (2024) reported that students taught with individual laboratory activities outperformed those taught with conventional methods. Essien et al. (2024) found similar results for physics students taught using individual laboratory activities. Adebayo et al. (2023) specifically investigated SPSA and found significant performance gains compared to conventional methods. Jack and Ndong (2022) also reported that students taught using the Science Process Approach performed better than those taught using the Alternative to Practical method. From the finding of Achor, et al. (2024), teachers' assessment, classroom activity/practices improved process skills acquisition and performance signficantly. Similarly, Dakang, et al. (2021) showed that use of interactive student's notebook with feedback in physics classroom enhanced academic performance signficantly when compared with the control gorup.

The superiority of SPSA can be explained by its learner-centred, inquiry-based nature. When students actively manipulate apparatus, record their own data, and draw their practices and own conclusions, they construct meaning rather than passively receive information. This aligns with Ausubel's meaningful learning theory, which posits that new knowledge is retained longer when it is linked to existing cognitive structures through active engagement. In contrast, the Alternative to Practical method encourages rote memorisation of procedures and results, which does not promote deep understanding.

There was no significant gender difference found in performance under SPSA, indicating that SPSA is gender-inclusive. The absence of a significant gender difference is an important contribution.

This finding contradicts earlier stereotypes of male superiority in physics (Anderson, 2016) but agrees with more recent studies. Okero et al. (2021) found that boys and girls exposed to the Science Process Skills Teaching Approach performed equally well in chemistry. Shawai et al. (2022) also reported no significant gender differences in performance when practical activities were used. This suggests that when instruction is activity-based and student-centred, gender disparities disappear. The SPSA requires no gender-specific abilities; both sexes participate equally in hands-on tasks.

Curricular Implications of the Findings

The curricular implications of the findings of this study are explained briefly in this section:

1. Redesigning Instructional Methods

The massive performance difference (mean gain of 36.04 vs. 22.41) and the huge 69.4% effect size show that how we teach matters more than almost anything else.By implication, curriculum planners should phase out Alternative to Practical (ATP) methods, where students merely read about or look at pictures of physics experiments. Also, the syllabus should explicitly mandate the teaching of science process skills. These include basic skills like observing, measuring, and classifying, as well as integrated skills like formulating hypotheses and controlling variables; lessons must be structured around student-led experimentation rather than teacher-centered passive lectures.

2. *Revision of Assessment Formats*

If the curriculum changes how students learn, it must also change how they are tested. This means that the national and school-level examinations need to move away from multiple-choice or written descriptions of experiments. Similarly, tests should evaluate a student's actual capacity to manipulate equipment, record accurate data, and draw scientific conclusions.

3. *Enhancing Teacher Training Programs*

Teachers cannot teach skills they have not mastered themselves. It is implied that colleges of education and universities must rewrite their teacher-preparation curricula to ensure new instructors are experts in SPSA. Secondly, school boards must design ongoing workshops to retrain current teachers who are used to traditional or ATP teaching styles.

4. *Promoting Gender Equity and Inclusivity*

Because the study found no significant difference in performance between genders under SPSA, it proves that hands-on science levels the playing field. Thus, curricular policies should champion SPSA as a primary strategy to encourage girls to succeed in physics and pursue future STEM fields. Also, textbooks and curriculum guides should be rewritten to emphasize collaborative, skill-based laboratory activities that engage all students equally.

5. *Resource and Infrastructure Allocation*

An experiential curriculum cannot exist without the proper tools. Policymakers must align budget allocations with the curriculum by funding physical science laboratories and providing kits for schools

Conclusion

This study concludes that the Science Process Skills Approach is significantly more effective than the Alternative to Practical method in enhancing students' academic performance in practical physics. Furthermore, SPSA is gender-inclusive, providing equal benefits to male and female students. The large effect size (69.4%) confirms the practical significance of adopting SPSA in physics classrooms.

Recommendations

1. Physics teachers should adopt the Science Process Skills Approach in all practical physics lessons, moving away from teacher-demonstration-only methods.
2. Curriculum planners at the Nigerian Educational Research and Development Council (NERDC) should explicitly integrate SPS objectives into the senior secondary physics curriculum.
3. Teacher training institutions should incorporate SPSA pedagogy into pre-service and in-service training programmes.
4. School administrators should ensure physics laboratories are adequately equipped to support hands-on SPSA activities.
5. Policymakers should mandate and fund inquiry-based science instruction as a national policy.
6. Examination bodies (WAEC, NECO) should design practical physics assessments that directly measure process skills rather than theoretical recall.

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