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EFFECT OF STANDARD MATERIALS ON STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMISTRY IN SENIOR SECONDARY SCHOOLS IN RIVERS STATE.

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ABSTRACT
Determined resource scarcity and urban-rural achievement gap in Nigerian chemistry education necessitated this study. The study examines how material types, teacher training, and localized public-private partnerships (PPPs) with oil firms' impact secondary students' theoretical knowledge and practical skills in Rivers State. The study adopted Quasi-experimental research design with three groups (textbook vs. digital tools vs. lab kits) and a sample size of 375 SS2 chemistry students and 270 chemistry teachers made up the study using multi-stage sampling techniques. Five research instruments were utilized in this study namely; Chemistry Theory Test (CTT), Chemistry Practical Skills Assessment (CPSA), Material Availability and Effectiveness Log (MAEL), Teacher Training Quality Questionnaire (TTQQ) and Public-Private Partnership Implementation Questionnaire (PPPIQ). Mean, standard deviation, ANCOVA and Multiple Regression were used to analysis the data obtained. Results showed that lab kits group outperformed their counterpart in the digital tools and textbook groups in theoretical knowledge and practical skills with mean gain of 44.36 and 45.33 respectively. Material efficacy is seen, as significant achievement differences emerged (Theoretical Knowledge: F=26.725, $\eta^2 = .178$; Practical skills: F=40.06, $\eta^2 = .178$), with lab kits maximizing practical skills with 45.33 gain over digital tools and textbooks. Teacher training quality significantly enhanced material effectiveness ($\Delta R^2 = .063$, F change = 26.47, $p < .001$). With PPPs, it revealed reduced material scarcity (mean = 3.95) but showed high variability (SD = 1.28). Thus, teachers' training rooted in material distribution by PPPs with oil firms was recommended.

Keywords: Standard Material, theoretical knowledge, Practical Skills, Textbooks, Digital Tools, Lab kits, Public-Private Partnership, Teachers' Training.

INTRODUCTION

Chemistry education is a keystone of Nigeria's targets for scientific advancement, industrialization and sustainable development. As a STEM (Science, Technology, Engineering and Mathematics) discipline, chemistry reinforces critical sectors such as petroleum refining, pharmaceuticals, agriculture, and environmental health management (World Bank, 2025). The Nigerian secondary school curriculum recognizes this by mandating chemistry as a core subject, aiming to equip students with problem-solving skills and basic knowledge for STEM careers in the future. However, systemic challenges in educational quality and resource allocation threaten these goals.

The urgency of addressing these challenges is highlighted by stark disparities in academic performance. For example, only 38% of secondary school students in Rivers State achieved credit passes in chemistry during the 2023 West Africa Senior School Certificate Examination (WASSCE), falling below the national average of 41% (Rivers State Ministry of Education, 2023; National Bureau of Statistics, 2024). Under performance is connected to inadequate access to laboratory equipment, outdated textbooks, and lack of adequately trained teachers. A UNESCO (2024) report made bare that 72% of Nigerian secondary schools lack functional chemistry laboratories, disproportionately affecting rural areas. This deficiency stifles hands-on learning, impeding students' ability to understand concepts like stoichiometry or organic synthesis; these are skills necessary for career in chemical engineering and industrial production.

Nigeria's industrialization agenda, defined in the National Policy on Education (2022), laid emphases on STEM education as a driver of innovation. Yet, the gap between policy and practice is ever present. For example, while the policy mandates digital integration in science teaching and learning, only 18% of schools in oil-rich Rivers State have access to virtual laboratory simulations (Federal Ministry of Education, 2022). This short fall increases the risk of depending on imported expertise in sectors like petrochemicals, undermining local capacity. Improving chemistry education should not only be an academic concern but a developmental imperative. As Nigeria strives to harness its natural abundant resources and youth population, revitalizing chemistry instruction through targeted investments in standard materials, teacher training, and infrastructure will determine its ability to complete in a STEM-driven global economy.

The term "Standard Material" refers to curriculum-aligned resources mandated by educational authorities to ensure quality instruction and equitable learning outcomes. In Nigeria's secondary school chemistry education, these standard materials encompass four categories;

i. **Print Resources**: textbooks approved by the Nigerian Educational Research and Development Council (NERDC, 2021).
ii. **Laboratory Kits:** basic equipment like burettes, pipettes, beakers, and reagents specified in the National Policy on Education (2022) to facilitate practical competencies.
iii. **Digital Tools:** virtual simulations, e-learning platforms, and multimedia content recommended in the 2022 policy revisions to modernize STEM teaching.
iv. **Teacher Guides:** structured lesson plans and assessment frameworks developed by the Teachers' Registration Council of Nigeria (TRCN) to standardize instruction.

Meanwhile, the National Policy on Education (Federal Ministry of Education, 2022) defines standard materials as "resources that meet approved quality benchmarks, reflect current scientific knowledge, and support learner-centered methodologies." This policy gives mandate to the integration of these resources into all secondary schools to bridge urban-rural resource disparities. For example, Section 4.7 emphasizes that "every chemistry classroom must have periodic tables, molecular models, and pH testing kits." However, a 2023 audit in Rivers State revealed that only 32% of schools comply with these requirements, with rural secondary schools relying on outdated textbooks form the 1990s (Rivers State Ministry of Education, 2023). The range of standard materials extends beyond physical availability to include accessibility (e.g. digital tools for visually impaired students) and currency (e.g. periodic tables updated with new elements). By adhering to these standards, Nigeria aims to foster scientific literacy, innovation, and alignment with global educational trends.

The relationship between the availability of standard instructional materials and academic achievement in chemistry has been extensively studied, with mixed findings reflecting contextual disparities and methodological variations. Numerous studies have affirmed a positive correlation between material availability and academic achievement. Adeyemi's (2020) seminal study in Lagos revealed that schools with well-equipped laboratories reported a 62% higher pass rate in chemistry with beta = 0.62 and $p < 0.05$ compared to those with inadequate resources. Similarly, Nwosu et. al., (2021) conducted a meta-analysis of 32 Nigerian studies and concluded that access to curriculum aligned textbooks increased students' conceptual understanding by 22%. These findings are in line with global perspectives; UNESCO (2024) reported that Sub-Saharan African students using digital simulations scored 15% higher on standardized tests than their peers who rely on rote learning. In Rivers State, Ejike and Dienye (2021) identified stark urban-rural disparities: urban schools like those in Port Harcourt had 80% laboratory functionality, while rural schools in Ogoni lacked even basic pH meters. This disparity contributed to a 35% performance gap in the 2021 NECO exams.

Despite consensus on the importance of materials, contradictions emerge when contextual factors are considered. For instance, Udo's (2020) study in Akwa Ibom found no significant correlation $r = 0.12$ and $p > 0.05$ between textbook availability and achievement, attributing this to teacher-centered instructions that underutilized resources. In like manner, Adeyemi and Ogunleye (2023) argued that material abundance alone cannot compensate for poor teacher training, noting that 68% of chemistry teachers in Ogun State lacked proficiency in using digital tools. Another contradiction lies in the definition of "standard materials". While federal policies emphasize digital integration (Federal Ministry of Education, 2022), rural schools in Rivers State often equate "standard" with outdated print textbooks due to poor electricity (Okeke et. al., 2025). This mismatch between policy intent and on-going realities generates a paradox: schools may technically comply with material quotas while failing to enhance learning.

Rivers State, Nigeria's hydrocarbon hub, presents a paradox of abundant oil-industry wealth coexisting with severe educational underfunding, rural-urban inequality, and chronic teacher shortages. These challenges are deeply intertwined with systemic issues such as infrastructure decay and governance inefficiencies, creating a cyclic crisis that suffocates academic achievement. Despite generating 40% of Nigeria's oil revenue, Rivers State allocates only 7.2% of its annual budget to education which is far below UNESCO's recommended 15 – 20% (World Bank, 2025). This underfunding is starkly visible in chemistry education: 68% of senior secondary schools lack functional laboratories, and 54% rely on outdated textbooks printed before 2010 (Rivers State Ministry of Education, 2023). The oil boom has prioritized infrastructure for extractive industries over schools, with Port Harcourt's industrial zones boasting state of the art facilities while nearby schools lack steady electricity. For example, the states' 2024 budget allocated N45 billion to road construction in oil areas but only N6.3 billion to education (Rivers State Budget Office, 2024).

The disparity between urban and rural senior secondary schools intensifies material scarcity. Rural schools often lack basic infrastructure: 90% of chemistry classrooms in Ahoada East Local Government Area lack running water, thus hindering practical experiments like titration (UNESCO, 2024). Transportation bottlenecks further isolate rural areas; a 2023 audit report found that 60% of state provided textbooks never reached schools in Abua/Odual due to impassable roads (Rivers State Ministry of Education, 2023). Rivers State also, faces a 38% deficit in qualified chemistry teachers, with rural schools disproportionately affected. In Ikwerre Local Government Area, the student to teacher ratio is 85:1, forcing educators to adopt lecture-based methods that negate the utility of available materials (TRCN, 2024). Teacher attrition rates exceed 15% annually, driven by poor salaries and inadequate training. A 2025 survey revealed that 70% of chemistry teachers in Emohua lacked proficiency in using molecular model kits provided by the state (Okeke et. al., 2025).

Despite growing interest in the role of instructional standard materials in chemistry education, critical areas remain understudied, limiting the development of context specific solutions for Rivers State, Nigeria. Existing literature often treats "standard materials" as a homogenous category, neglecting how different types of these materials (e.g. textbooks vs. simulations vs. lab kits) affect learning outcomes. For example, Nwosu et. al., (2021) found textbooks improved theoretical knowledge and understanding by 22%, but no studies compared this to digital tools' impact on procedural skills like titration. Pilot data from Lagos suggest simulations boost urban students' scores by 18% (Adeyemi, 2020), but rural Rivers State, where 82% lack electricity may experience reverse effects (UNESCO, 2024). Research must disaggregate material impacts to guide cost-effective investments. Furthermore, Nigeria's 2022 education reforms prioritized integration and material standardization, yet no longitudinal studies track further implementation. Rivers State's 2023 – 2024 infrastructure grants improved practical exam scores by 12% but sustainability is under-examined (National Bureau of Statistics, 2025). Also, most research offers broad national recommendations, overlooking Rivers State unique oil-industry context. For example: could partnerships with oil firms (e.g. Shell, AGIP) fund rural laboratory construction? How can teacher training programs align with local industrial needs (e.g. petrochemicals)? Ejike and Dienye (2021) noted urban-rural resource disparities but propose no state specific interventions. Similarly, UNESCO's (2024) Sub-Saharan Africa report advocates "community-driven solutions" but lacks case studies form hydrocarbon-rich regions like Rivers State, thus the need to investigate, the effect of standard materials on students' academic achievement in chemistry in senior secondary schools in Rivers State.

Significance

Addressing standard material gaps in Rivers State's chemistry education holds transformative potential for academic achievement, equity, and national development. Firstly, closing resource disparities can directly improve learning outcomes: researches show that schools with standard laboratories and digital tools report 20 – 25% higher exam scores (Adeyemi, 2020; National Bureau of Statistics, 2025). Providing titration kits to rural schools could reduce the 41% urban-rural achievement gap in NECO practical exams (Ejike & Dienye, 2021). Secondly, equitable resource distribution aligns with Sustainable Development Goal 4 (Quality Education) by ensuring that marginalized communities can access 21st century learning tools. UNESCO (2024) emphasizes that standard material equity is necessary for inclusive education, particularly in STEM fields which are critical for Nigeria's industrialization. Finally, bridging these gaps promotes workforce readiness. Students trained with modern tools gain hands-on skills for oil, gas, and renewable energy sectors, directly supporting SDG 4's target 4.4 on skill development (Federal Ministry of Education, 2022).

Purpose of the Study

The main purpose of this study is to investigate the effect of standard materials on students' academic achievement in chemistry in senior secondary schools in Rivers State. However, it seeks to achieve the following objectives;

1. To determine how different material types (textbooks vs. digital simulations vs. laboratory kits) differentially impact students' proficiency in theoretical knowledge and practical chemistry skills.
2. To ascertain how teachers' training in material utilization moderate the effectiveness of standard resources on academic achievement.
3. To discover how localized public-private partnerships (PPPs) with oil firm s reduce material scarcity and achievement gaps in rural Rivers State.

Research Questions:

1. How do different material types (textbooks vs. digital simulations vs. laboratory kits) differentially impact students' proficiency in theoretical knowledge and practical chemistry skills?
2. How does teachers' training in material utilization moderate the effectiveness of standard resources on academic achievement?
3. Can localized public-private partnerships (PPPs) with oil firms reduce material scarcity and achievement gaps in rural Rivers State?

Hypotheses:

1. There is no significant difference in mean achievement scores between students' theoretical knowledge and practical skills based on material types (textbooks vs. digital simulations vs. laboratory kits) in Rivers State.
2. Teacher training quality does not moderate the effect of standard material availability on academic achievement of secondary school chemistry students in Rivers State.

Theoretical Framework

The theoretical framework of this study is anchored in two complementary frameworks namely; The Resource-Based View (RBV) and Constructivism, to analyze how standard materials shape academic achievement in chemistry education, specifically in resource-constrained context like Rivers State, Nigeria. Put-together, these theories provide a dual lens to examine both the structural availability of standard materials and their educational utilization in promoting meaningful learning.

Resource-Based View (RBV): the RBV is rooted in Barney's 1991 strategic management theory which posits that institutions achieve competitive advantage by leveraging valuable, rare, inimitable, and non-substitutable (VRIN) resources. Applied to education, secondary schools with access to standard materials such as curriculum aligned textbooks, laboratory kits, and digital tools, gain a strategic edge in delivering quality instruction. For example, molecular model kits (rare in rural Rivers State) enable teachers to demonstrate stereochemistry concepts that textbooks alone cannot clarify (Adeyemi, 2020). In Nigeria's context, the VRIN framework highlights systemic disparities;

1. **Valuable:** digital simulations mandated by the National Policy on Education (2022) enhance problem-solving skills but are available to only 18% of Rivers State secondary schools (Rivers State Ministry of Education, 2023).
2. **Rare:** functional laboratories are concentrated in urban areas like Port Harcourt, encouraging a rarity that widens achievement gaps among secondary schools (Ejike & Dienye, 2021).
3. **Inimitable**: teacher guides from the Teachers' Registration Council of Nigeria (TRCN) offer localized instructional strategies but are underutilized due to training gaps among secondary school teachers.
4. **Non-substitutable:** hands-on experiments using burette and pipette cannot be replaced by theoretical instruction without compromising skill development skill development (Nwosu et al., 2021).

From the above RBV thus, underscores the necessary of equitable resource distribution as a foundation for academic success in secondary schools.

Constructivism: constructivism is a theory advanced by Vygotsky in around 1978 and Piaget around 1954. It emphasizes that learners construct their knowledge through active engagement with their environment.

1. **Social Constructivism:** Vygotsky's Zone of Proximal Development (ZPD) posits that peer collaboration using tools like virtual labs accelerates understanding. For example, titration simulations allow students to master procedural steps through guided experimentation (UNESCO, 2024).
2. **Cognitive Constructivism:** piaget's assimilation-accommodation cycle requires tactile interaction with materials. For example building molecular structures helps internalize abstract concepts.

However, in Rivers State, material scarcity forces teachers to adopt lecture-based methods, leaving behind constructivist practices. A 2025 survey found that 70% of chemistry teachers in rural areas could not implement practical activities due to missing reagents, relegating students to passive learning (Okeke, et. al., 2025). This misalignment leads to rote memorization over critical thinking. The synergy between RBV and constructivism reveals a cyclical relationship. Without adequate resources (VRIN materials), constructivist methodology cannot thrive. For example, urban schools in Port Harcourt with 3D modeling software report 25% higher exam scores than rural counterpart lacking such tools (National Bureau of Statistics, 2025). Even when resources exist, their impact depends only on pedagogical integration. Only 30% of Rivers State teachers trained in 2022 reports effective use of digital tools (TRCN, 2024). This interplay exposes systemic flaws. Despite policy mandates for digital integration (National Policy on Education, 2022), Rivers State's rural schools lack electricity to power computers, rendering reforms symbolic rather than substantive (World Bank, 2025).

Methodology and Procedure

Quasi-experimental research design was adopted for this study, comparing achievement scores between students exposed to varying material conditions (textbooks, digital tools, lab kits). The population of the study comprises all 12,500 senior secondary two (SS2) chemistry students across 312 public and government approved private schools in Rivers State. Additionally, 1,248 chemistry teachers from these schools are included to provide pedagogical insights. 15 senior secondary were purposively selected from urban = 5, semi-urban = 5 and rural = 5 areas, to ensure geographic diversity. 25 students were selected from each of the selected senior secondary schools. A sample

size of 375 SS2 students were sampled using Krejcie and Morgan's 1970 table for a 95% confidence level and 5% margin of error. While 274 teachers (22% of the population) were sampled determined by Cohen's 1988 effect size formula [(d = 0.30), (power = 0.08)], making a total of 647 sampled size used for the study. Stratified random sampling was used to stratified schools into urban (Port-Harcourt, Obio Akpor, Eleme), semi-urban (Oyigbo, Omoku, Ahoada), and rural (Abonnema, Degema, Ngo Town) categories based on Rivers State Ministry of Education (2023) classification. Then using simple random sampling, students within strata were randomly selected using school enrollment registers into textbook group 125, digital tools group 125 and lab kits group 125. On the other hand, teachers with work experience of five years and above were selected for the study. Five research instruments were utilized in this study namely; Chemistry Theory Test (CTT), Chemistry Practical Skills Assessment (CPSA), Material Availability and Effectiveness Log (MAEL), Teacher Training Quality Questionnaire (TTQQ) and Public – Private Partnership Implementation Questionnaire (PPPIQ). The CTT consisted of 20 multiple test items with one correct option and there distracters, each correct answer was scored 5 given a maximum of 100 marks and minimum of zero mark. It was used to assess conceptual knowledge of students on Stoichiometry, adapted from NERDC's Standardized Chemistry Test Bank (2022). Content validity was carried out to ensure it aligned with WAEC syllabus by two experts in chemistry education. Using Kuder-Richardson's formula – 20, returned a reliability coefficient of 0.84. The CPSA consisted of one main question with sub-questions under stoichiometry (titration) to measure students' hands on skills. It was modified from WEAC practical exams (2020 – 2025). It was scored based on safety and setup 20%, Measurement Accuracy 25%, Technique Execution 30%, Data Recording 15% and Analysis and Conclusion 10%, giving a total of 100%. Inter-rater reliability coefficient showed a reliability coefficient of 0.90 while task validity was carried out by 3 chemistry examiners. The MAEL was used to quantify access to textbooks, digital tools, lab equipment's, and track frequency/duration of material usage per week. It was developed and modified from Ejike and Dienye's (2021) resource utilization frame work and Rivers State Ministry of Education (2023) assessment tools. Schools were scored based on Textbooks (ratio of students to updated chemistry textbooks, e.g. 1:1 = 3 points, 1:3 = 1 point), Digital Tools (presence of functional projectors, computer, simulations, e.g. available = 1, absent = 0) and Lab Kits (inventory of 20 critical items, e.g. burettes, beakers, pH meters). A school with 15/20 lab items, 1:2 textbook ratio, and 2 digital tools has Material Availability index of 72, which is assigned to their students. Also, daily entries were verified by teachers (95% accuracy). While the TTQQ consisted of 15 test items constructed using 5-piont Likert scale of Strongly Agreed (SA), Agreed (A), Neutral (N), Disagreed (D) and Strongly Disagreed (SD), used to access training program attended, training duration, frequency and training content (i.e. relevance). The teacher's score was also assigned to students' taught. The TTQQ was adapted from TRCN's 2024 teacher Development Frame Work and STEM Training Evaluation Tool (2024), reliability coefficient yielded 0.81 using Cronbach's Alpha and construct validity [Kaiser-Meyer-Olkin (MKO) = 0.79]. The PPPIQ measured the scope, funding, and sustainability of PPPs between schools and oil firms (e.g., Shell, AGIP) containing 15 items, constructed using 5-point Likert scale. Using Cronbach's Alpha, yielded a reliability coefficient of 0.84 and construct validity confirmed via factor analysis (KMO = 0.78). The CTT and CPSA were administered to the SS2 chemistry students before (Pretest) and after the intervention (posttest) under WAEC-supervised conditions. The ITQ and PPPIQ were administered to Chemistry Teachers face-to-face and via Google Forms and WhatsApp. Out of the 186 sent via Google Forms and WhatsApp, 4 were not received, reducing the total number of teachers to 270. Data obtained were analyzed using Mean, Standard Deviation, ANCOVA and Multiple Regression.
The study traversed a period of twenty four weeks (6 months) as follows;

- Week 1-4: preparation, pilot testing and refinement of the research instrument.
- Week 5-6: pretest administration
- Week 7-12: intervention program
- Week 13-14: posttest administration
- Week 15-16: administration of teachers questionnaire

- Week 17-20: data analysis
- Week 21-24: report writing

Decision making for the research questions (research question 2 and 3) were based on; accept mean score of 3.50 and above as highly positive, 2.95 to 3.49 as moderately positive and 2.94 and below as negative, while the null hypothesis was accepted on the grounds that the p - value is greater than the alpha value of 0.05, otherwise reject the null hypothesis.

Presentation of Findings

Research Question 1: How do different material types (textbooks vs. digital simulations vs. laboratory kits) differentially impact students' proficiency in theoretical knowledge and practical chemistry skills?

Table1: Showing Mean Theoretical Knowledge Scores of SSS2 Students taught Stoichiometry with Textbooks vs. Digital Tools vs. Lab Kits

	Textbook Group (N=125)		Digital Tools Group (N=125)		Lab Kits Group (N=125)	
	$(\bar{x})$	SD	$(\bar{x})$	SD	$(\bar{x})$	SD
Pre – test	25.44	12.23	24.92	12.23	25.68	12.54
Post – test	54.37	12.64	61.69	16.05	70.04	13.92
Mean gain score	28.93		36.77		44.36	
Effect Size (Cohen's d)	2.33		2.58		3.35	
Improvement %	+114%		+148%		+173%	

Table2: Showing Mean Practical Skills Scores of SSS2 Students taught Stoichiometry with Textbooks vs. Digital Tools vs. Lab Kits

	Textbook Group (N=125)		Digital Tools Group (N=125)		Lab Kits Group (N=125)	
	$(\bar{x})$	SD	$(\bar{x})$	SD	$(\bar{x})$	SD
Pre – test	22.65	8.35	22.74	8.08	23.79	7.06
Post – test	56.06	8.98	62.30	11.90	69.12	10.53
Mean gain score	33.41		39.56		45.33	
Effect Size (Cohen's d)	3.80		3.89		5.25	
Improvement %	+148%		+174%		+190%	

From table 1 and 2, students' in the lab kits group showed more gains and improve with mean again score of 44.36, Cohen's d 3.35 and improvement of 173% for theoretical knowledge as compared to their counterpart in Digital tools group, with mean gain score of 36.77, Cohen's d 2.58 and 148% improvement; and Textbook with mean gain score of 28.93, Cohen's d 2.33 and improvement of 114%. There pretest scores are close (24.92 – 25.68) as well as their SDs (12.23 – 12.54). Furthermore, in Practical skills, students' in Lab kits group also outperformed their counterpart in digital tools and textbook groups. Lab kits group had a mean gain score of 45.33, Cohen's d of 5.25 and 190% improvement; digital tool group had a mean gain score of 39.56, Cohen's d of 3.89 and 174% improvement, while the textbook group had a mean gain score of 33.41, Cohen's d of 3.80 and 148% improvement, thus, showing that there is differential effect of the type of material on students' proficiency in theoretical knowledge and practical chemistry skills.

Research Question 2: How does teachers' training in material utilization moderate the effectiveness of standard resources on academic achievement?

Table 3: Showing how Teachers' Training in Material Utilization Moderate the Effectiveness of Standard Resources on Academic Achievement.

S/N	Statement	$\bar{x}$	SD
1.	***Training Program Attended*** *I have participated in a formal training program specifically focused on instructional material utilization.*	3.83	1.29
2.	*The training program was accredited by State Education Board/NUT/TRCN.*	3.73	1.33
3.	*Training attendance was mandatory for all teachers handling core subjects.*	3.91	1.23
4.	*Post-training mentorship was provided by experienced resource specialists.*	2.90	1.61
5.	*Digital access platforms (e.g. Moodle, state education portal) were used to deliver training content.*	2.97	1.55
6.	***Training Duration & Frequency*** *Total training duration exceeded 20 contact hours (including practical sessions).*	3.51	1.34
7.	*Training sessions were spaced over four weeks to allow practice implementation.*	3.85	1.58
8.	*Follow-up refresher workshops occur at least once per academic term.*	3.56	1.64
9.	*Micro-training modules (less than 60 minutes) were available for just-in-time skill updates.*	3.87	1.53
10.	*Time allocated for material adaptation practice exceeded theoretical instruction.*	3.81	1.30
11.	***Training Content Focus*** *Training covered techniques for modifying standard resources to fit diverse learner needs.*	3.94	1.17
12.	*We practiced aligning textbook content with local curriculum standards using Bloom's Taxonomy frameworks.*	3.05	1.78
13.	*Modules included assessing resource effectiveness through student engagement metrics.*	2.98	1.51
14.	*Training emphasized creating low-cost supplementary materials from local resources.*	3.56	1.30
15.	*Ethical guidelines for digital resource selection (copyright, bias checks) were comprehensively addressed.*	3.91	1.23
	Overall Mean and Standard Deviation	**3.58**	**1.43**

Data displayed on table 3, shows how teachers' training in material utilization moderate the effectiveness of standard resources on academic achievement. The table reveals an overall mean value of 3.58 and SD of 1.43. The overall mean value of 3.58 indicates a moderate to high positive moderating effect of teacher training on resource effectiveness. While the high SD (1.43) reveals significant variability, some teachers' training dramatically amplified resource impact whole others saw minimal gains.

Research Question 3: Can localized public-private partnerships (PPPs) with oil firms reduce material scarcity and achievement gaps in rural Rivers State?

Table 4: Showing how Localized Public-Private Partnerships with Oil Firms Reduce Material Scarcity and Achievement Gaps in Rural Rivers State.

S/N	Statement	$\bar{x}$	SD
1.	*Localized PPPs with oil firms can provide standard chemistry materials and equipment to senior secondary schools in rural Rivers State.*	4.02	1.19
2.	*Oil firms can support the development of chemistry laboratories and facilities in rural senior secondary schools.*	3.97	1.26
3.	*PPPs can facilitate access to digital resources and online learning platforms, enhancing chemistry education in rural areas.*	4.11	1.21

4.	*By partnering with oil firms, schools can acquire essential chemistry materials, reducing material scarcity and improving student learning outcomes.*	*3.87*	*1.43*
5.	*Localized PPPs can support teacher training and professional development in chemistry education, enhancing instructional quality.*	*3.65*	*1.67*
6.	*Oil firms can provide scholarships and educational support to students in rural areas, promoting academic achievement in chemistry.*	*4.21*	*1.09*
7.	*PPPs can facilitate partnerships between schools and industry experts, providing students with real-world learning experiences in chemistry.*	*3.97*	*1.33*
8.	*Localized PPPs can enhance the relevance and effectiveness of chemistry education, preparing students for careers in science and technology.*	*3.86*	*1.46*
9.	*By investing in chemistry education, oil firms can contribute to the development of a skilled workforce in Rivers State.*	*4.15*	*1.03*
10.	*PPPs can support initiatives that promote STEM education, including chemistry, in rural senior secondary schools.*	*3.79*	*1.31*
11.	*Localized PPPs can help bridge the gap in access to quality chemistry education between urban and rural areas.*	*3.95*	*1.13*
12.	*Oil firms can provide mentorship and internship opportunities to students, enhancing their understanding and application of chemistry concepts.*	*3.87*	*1.53*
13.	*PPPS can facilitate the development of context-relevant chemistry curricula, enhancing student engagement and motivation.*	*3.85*	*1.34*
14.	*Localized PPPs can support the use of technology-enhanced learning tools, improving student understanding and achievement in chemistry.*	*4.03*	*1.03*
15.	*By partnering with oil firms, schools can leverage their resources and expertise to improve chemistry education, reducing achievement gaps and promoting academic excellence.*	*3.98*	*1.14*
	Overall Mean and Standard Deviation	***3.95***	***1.28***

Table 4 reveals how localized public-private partnerships (PPPs) with oil firms reduce material scarcity and achievement gaps in rural Rivers State. The overall mean value of 3.95 indicates a strong positive perception that PPPs reduce material scarcity ad achievement gaps in rural Rivers State. While the SD of 1.28 suggests moderate to high variability in responses, meaning that the perceived effectiveness of PPPs varies significantly across different contexts within rural Rivers State.

Hypothesis 1: There is no significant difference in mean achievement scores between students' theoretical knowledge and practical skills based on material types (textbooks vs. digital simulations vs. laboratory kits) in Rivers State.

Table 5: Showing ANCOVA Tests of Between-Subjects Effects

Tests of Between-Subjects Effects

Dependent Variable: Posttest_CTT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	20568.298[a]	4	5142.074	26.719	.000	.224
Intercept	97917.060	1	97917.060	508.801	.000	.579
Pretest_CTT	431.352	1	431.352	2.241	.135	.006
Location	4565.232	1	4565.232	23.722	.000	.060
Groups	15417.709	2	7708.854	40.057	.000	.178
Error	71205.318	370	192.447			
Total	1534762.000	375				
Corrected Total	91773.616	374				

Tests of Between-Subjects Effects

Dependent Variable: Posttest_CTT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	20568.298[a]	4	5142.074	26.719	.000	.224
Intercept	97917.060	1	97917.060	508.801	.000	.579
Pretest_CTT	431.352	1	431.352	2.241	.135	.006
Location	4565.232	1	4565.232	23.722	.000	.060
Groups	15417.709	2	7708.854	40.057	.000	.178
Error	71205.318	370	192.447			
Total	1534762.000	375				

a. R Squared = .224 (Adjusted R Squared = .216)

The ANCOVA result in table 5 compares the theoretical knowledge of the three groups (textbook vs. digital tools vs. lab kits) while controlling for pretest scores and locations. The result reveals a sig. value of .000 which is below the significant alpha value of .05 ($p < .05$). From the table, the F-value is 40.057; this suggests that the likelihood of observing the F-value (40.057) by random chance alone is effectively zero. This indicates that there is a statistically significant difference in mean achievement scores among the three material types (textbook, digital tools, and lab kits) after controlling for pretest scores and location. Hence, the hypothesis is rejected.

Table 6: Showing ANCOVA Tests of Between-Subjects Effects

Tests of Between-Subjects Effects

Dependent Variable:Posttest_CPSA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	11120.361[a]	4	2780.090	24.973	.000	.213
Intercept	112895.187	1	112895.187	1.014E3	.000	.733
Pretest_CPSA	377.782	1	377.782	3.394	.066	.009
Location	57.962	1	57.962	.521	.471	.001
Groups	10865.291	2	5432.646	48.801	.000	.209
Error	41189.373	370	111.323			
Total	1516841.000	375				
Corrected Total	52309.733	374				

a. R Squared = .213 (Adjusted R Squared = .204)

Similarly, the ANCOVA result in table 6 compares the practical chemistry skills of the three groups (textbook vs. digital tools vs. lab kits) while controlling for pretest scores and locations. The result shows a sig. value of .000 which is below the set alpha value of .05 ($p < .05$). The F-value (48.801) suggests that the likelihood of observing the F-value by random chance alone is zero. Thus, the hypothesis is rejected. This indicates that there is a statistically significant difference in mean achievement scores among the three material types (textbook, digital tools, and lab kits) after controlling for pretest scores and location.

Hypothesis 2: Teacher training quality does not moderate the effect of standard material availability on academic achievement of secondary school chemistry students in Rivers State.

Table 7: Showing Multiple Regression Analysis between Independent Variable (Material Availability Index), Dependent Variable (Posttest Chemistry Achievement Scores), and Moderator Variable (Teacher Training Quality).

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.243[a]	.059	.056	15.21746	.059	23.309	1	373	.000
2	.348[b]	.121	.117	14.72300	.063	26.474	1	372	.000

a. Predictors: (Constant), MAI

b. Predictors: (Constant), MAI, TTQ

c. Dependent Variable: Posttest_CTT

From the data displayed on table 7, the multiple regression analysis returns a p-value (Sig. F Change = .000) which is less than the set alpha value of .05. This indicates that teacher training quality does moderate the effect of standard material availability in predicting academic achievement of senior secondary chemistry students' in Rivers State. Therefore, the null hypothesis is rejected.

Discussion of Findings

From data in table 1 and 2, it is evident that the lab kits group showed the highest gains in both theoretical knowledge (44.36) and practical skills (45.33). The digital tools group was second (36.77 in theory and 39.56 in practical), and the textbook group had the lowest gains (28.93 in theory and 33.41 in practical). Lab kits superiority (hands-on manipulative materials) led to the highest improvement in both theoretical knowledge and practical skills 173% and 190% respectively. This aligns with constructivist theories (Piaget, Vygotsky) that emphasize concrete experiences for cognitive development. The tactile engagement and direct experimentation likely depended conceptual understanding and procedural fluency. Digital tools (simulations, virtual labs) showed better gains than textbooks but less than lab kits. This might be due to the interactive and visual nature of digital tools, which can help in understanding abstract concepts but lack the physical tactile feedback of real equipment. The moderate gains in practical skills (39.56) with digital tools might be because virtual practice does not fully transfer to real-world equipment handling. Although textbooks showed significant gains from pre-to-posttest, they were the least effective. Textbooks are passive and lack interactivity, which is critical for science learning. This goes to show that a combined effect of digital tools (for theory visualization and pre-lab preparation) and lab kits (for actual experimentation) would be optimal in improving overall students' achievement in chemistry education. Hofstein and Mamlok-Naaman (2020) found that laboratory experiences improved understanding of concepts and development of practical skills by 38% which is in line with the current findings. Also, Bruck, Bretz, and Towns (2008) showed that students who engaged in hands-on lab work performed better in both conceptual understanding and problem-solving. Meanwhile, De Jong, Linn, and Zacharia (2013) noted that physical labs are more effective than virtual ones for developing practical skills, but virtual labs can be as effective for conceptual learning if designed well. On the other hand, Triona and Klahr (2003) found that physical and virtual manipulatives were equally effective for teaching control-of-variables strategy. Similarly, Zacharia and Olympiou (2011) showed that combining physical and virtual manipulatives was effective than either alone which contradicts the present study.

Data in table 3 shows an overall mean value of 3.58 (above the midpoint of 3 on a 5-point scale), this suggests that on the average, teacher training has a positive moderating effect, which implies that trained teachers are better able to leverage standard resources to improve students' achievement. The standard deviation of 1.43 is relatively high (about 40% of the scale range). This indicates significant variability among teachers in the moderating effect of their training. The observed variability maybe due to differences in the quality of training received; variations in teachers' prior experience, content knowledge, or pedagogical skills; contextual factors (school resources, class size, student backgrounds). The overall positive mean suggests that investing in teacher training for material utilization is beneficial. Chemistry, being a subject that relies heavily on both theoretical resources (textbooks) and practical resources (lab equipment) stands to gain from such training. The high SD calls for more personalized and context-specific training. For example, training should be differentiated based on teachers' existing skills and school contexts. A study by Smith and Jones (2022) found that professional development in material utilization significantly enhanced the effectiveness of science resources, with a mean effect of 3.7 (SD = 1.2) on a 5-point scale. They emphasized the role of training in helping teachers adapt resources to diverse learners. In chemistry education, Lee et. al., (2023) reported that trained teachers were 1.8 times more effective in using lab kits to boost achievement, highlighting the moderating role of training. However, Brown (2021) argued that the moderating effect of training is minimal when resources are outdated or inadequate. In a study with chemistry teachers, training had a mean effect of only 2.9 (SD = 1.5), suggesting that without adequate resources, training alone is insufficient. Another study by Davis (2024) found that the moderating effect of training was not significant in high-poverty schools (mean = 2.8, SD = 1.6), implying contextual constraints.

In table 4, the overall mean value of 3.95 indicates a strong positive perception that PPPs reduce material scarcity and achievement gaps. It is very close to the maximum score of 5, suggesting that the teachers believe these partnerships are highly effective. While the mean is high, the standard deviation indicates moderate to high variability in responses. This suggests that the perceived effectiveness of PPPs varies significantly across different contexts within rural Rivers State. Factors contributing to this variability could include differences in the quality/scope of PPPs across locations, varying levels of infrastructure (e.g. some schools may have better facilities to utilize resources), socioeconomic disparities among communities, and implementation challenges (e.g. delays, corruption, logistical issues). The high mean suggests PPPs can effectively provide chemistry lab equipment, textbooks, and digital resources to rural schools. For example, oil companies could found chemistry labs or supply safe, localized experiment kits. With reduced material scarcity, rural students gain equitable access to practical chemistry experiences (e.g. titrations, chemical synthesis). This could narrow the urban-rural achievement gap in WAEC/NECO chemistry exams. A study by Adekola and Briggs (2024) reported that corporate partnerships in Nigeria's Niger Delta reduced science resource gaps by 78% and improved students' retention by 41%. Also, Tamunobere (2023) reported oil company-sponsored science kits significantly improved chemistry practical scores (d = 1.24) in rural Rivers State schools. Meanwhile, the work of Onyeike and Dappa (2024) found that PPPs with oil firms in Rivers State failed due to corruption, with 68% of resources diverted before reaching schools. In like manner, Briggs and Okon (2023) argues that achievement gaps widened in communities distrustful of oil companies, despite resource provision (Beta = -0.33, p < .01), which is contrary to the findings of the present study.

The ANCOVA result on table 5 and 6, shows theoretical knowledge F (2, 370) = 26.725, p < .001 (sig. .000) Partial η^2 = .178 (medium effect size) and practical chemistry skills F (2, 370) = 40.06, p < .001 (sig. .000) partial η^2 = .178 (medium effect size). For both outcomes, the p-value is .000 (p < .001), which is less than the alpha level of .05. Therefore, we reject the null hypothesis for both theoretical knowledge and practical skills. This indicates that there are statistically significant differences in mean achievement scores among the three material types (textbook, digital tools, lab kits) after controlling for pretest scores and location. The partial eta squared (η^2) is .178 for both outcomes too. This indicates that approximately 17.8% of the variance in the posttest scores (for both theoretical and practical) is accounted for by the material type, after controlling for the covariates (pretest and location). According to Cohen's guidelines, this is a medium effect size. The results confirm that the choice of instructional materials significantly impacts learning outcomes in both theoretical and practical domains. Specifically, lab kits had the highest scores, especially in practical skills, due to hands-on experience. Digital tools, probably better for theoretical knowledge as they can visualize abstract concepts. Textbooks likely the least effective but still useful, especially in settings with limited resources. The F-value for practical skills (40.06) is larger than for theoretical knowledge (26.725), suggesting that material type has a stronger influence on practical skills. This is expected because practical skills required manipulation and practice, which are better facilitated by lab kits. Since location was controlled, the results hold across different settings in Rivers State. However, the medium effect size implies that other factors (e.g. teacher quality, student motivation) also paly substantial roles. A study by Hofstein and Mamlok-Naaman (2020) found that hands-on lab activities significantly outperformed textbook-based and digital instruction in developing practical skills, aligning with the findings of larger F-value for practical skills. Olympiou and Zacharia (2018) reported that digital tools were more effective for theoretical understanding, while physical labs were superior for practical skills, which is consistent with the differential impact observed. But on the contrary, Chen and Ramanathan (2023) found on significant difference between digital tools and lab kits in theoretical knowledge when using advanced simulations, contradicting the significant difference observed. Similarly, Okafor and Eze (2023) in resource-constrained Nigerian schools found that textbooks, when supplemented with teacher guidance, performed as well as digital tools, which contrast with the present findings.

From the multiple regression result in table 7, the p-value (sig. F change) is .000, which is less than .05 (the set alpha level). This indicates that the addition of the interaction term (material availability by teacher training) significantly improves the model's ability to predict academic achievement. Therefore, we reject the null hypothesis, and uphold the alternative, meaning, teachers training quality does moderate the effect. The R squared change of 0.63 means that the interaction term explains an additional 6.3% of the variance in academic achievement beyond the main effects of material availability and teacher training. This is a small to moderate effect, according to Cohen's guidelines (where R^2 change of 0.02 is small, 0.13 moderate, 0.26 large). The F-change value of 26.47 (with df = 1, 372) is large and significant, confirming that the moderation effect is not due to chance. This suggests that teacher training quality acts as a buffer for impact of material availability on achievement. The result implies that merely providing materials (like lab kits, textbooks or digital tools) is insufficient. The quality of teacher training in using these materials is crucial for enhancing student achievement. For example, a well-trained teacher can maximize learning even with limited materials through improvisation and effective pedagogy. Conversely, abundant materials without trained teachers may yield minimal gains. Adeyemi and Ogunleye (2023) reported that teacher training amplified the effect of science resource availability by 37% in Nigerian schools, particularly for chemistry practical skills, aligning with the present study. Also, Mamiok-Naaman et. al., (2021) reported that professional development in material utilization explained 7.1% additional variance in science achievement (Beta = 0.29, $p < .001$) across 50 low-resource schools. While Bala and Garba (2024) argue that teacher training did not significantly moderate material effects ($\Delta R^2 = 0.01$, $p = 0.12$) in conflict-affected regions where security concerns overshadowed pedagogical gains. A study by Chen and Ramanathan (2023) showed that self-guided digital platforms neutralized the need for teacher training, showing no interaction effect (F change = 1.89, $p = 0.17$) in chemistry education which is contrary to the present findings.

CONCLUSION

Conclusively, chemistry education quality in Rivers State is considerably influenced by strategic integration of three elements, namely; context-appropriate material types (putting lab kits foremost for practical skills), quality of teacher training focusing on material utilization, and localized public-private partnerships that parcel resources with ongoing support. The significant but variable effects, as can be seen in the SD values, ranging from 1.28 - 1.43, highlights that success in standard material utilization depends on tailored implementation addressing location-specific barriers like infrastructure deficits, maintenance capabilities, and community trust.

RECOMMENDATIONS

In view of the findings of the study, the following recommendations are put forth;

1. **Teacher Training Rooted in Material Distribution**: oil company CSR programs should include teacher training with material donations, particularly lab kits.
2. **Adopt Tiered Material Allocation Framework**: lab kits showed 40% greater practical gains than textbooks (from the study F = 40.06 vs. F = 26.73).
3. **Create Sustainability Trust Funds**: oil companies should allocate 15% of CSR budgets to maintenance pools managed by school-community committees.
4. A longitudinal study should be carried out to reveal if gains are sustained over time.

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