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HARNESSING ADVANCED SOFTWARE TECHNOLOGIES TO ENHANCE SCIENTIFIC LITERACY AND EXPOSURE IN THE POST-PRIMARY EDUCATION OF CROSS RIVER STATE, NIGERIA

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Abstract
This study investigates the transformative potential of advanced software technologies in bolstering scientific literacy and exposure among post-primary students in Cross River State, Nigeria. Amid global strides in educational technology, Nigerian schools face persistent challenges, including limited access to digital tools and inadequate teacher training. Employing a descriptive survey design, data were gathered through questionnaires from 400 participants (300 students and 100 teachers) across 10 public secondary schools in Calabar. Results indicate that 70% of students lack access to computers, while 75% of teachers report insufficient training in software integration. However, 85% of respondents believe tools like virtual labs and e-learning platforms could enhance scientific understanding. Key barriers include erratic power supply (92%) and poor internet connectivity (68%). The study proposes mobile-based learning and teacher capacity-building as viable solutions. Recommendations include government-led infrastructure upgrades, curriculum reforms to embed technology, and partnerships with tech firms to provide affordable tools. This research illuminates a path toward leveraging software technologies to foster scientific literacy, equipping students for a technology-driven future.

Keywords: Scientific Literacy, Advanced Software Technologies, Post-Primary Education, Digital Divide, Educational Technology.

Introduction

In an age where science and technology shape global progress, scientific literacy; the ability to engage with scientific concepts critically and apply them to real-world challenges is a cornerstone of education (Osborne & Dillon, 2008). In Nigeria's Cross River State, post-primary education struggles to cultivate this vital skill due to systemic barriers like outdated curricula, limited resources, and low digital literacy (Aderonmu & Adolphus, 2021). Advanced software technologies, including virtual laboratories, simulation tools, and e-learning platforms, offer a dynamic solution to these challenges, fostering interactive and inquiry-based learning that transcends traditional classroom constraints (Wieman et al., 2008).

The global education landscape has embraced technology-enhanced learning (TEL) to revolutionize science education. Tools like PhET Interactive Simulations and Labster enable students to explore complex concepts such as chemical reactions or physics principles through virtual experiments, making learning accessible in resource-scarce settings (Kurubacak & Altinpulluk, 2017). Platforms like Moodle and Google Classroom further promote collaborative learning, enhancing student engagement and

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critical thinking (Blau & Shamir-Inbal, 2017). In developed nations, TEL has boosted science performance by up to 20% (Duval et al., 2017), underscoring its potential.

In contrast, Cross River State faces a stark digital divide. The Cross River State Ministry of Education (2023) reports that only 25% of public secondary schools have functional computer labs, with rural areas particularly underserved. Internet access is limited to 15% of schools, and teacher digital literacy remains low, with 65% lacking training in software use (Bello & Ajao, 2024). These gaps align with broader Nigerian challenges, where infrastructural deficits and policy implementation lags hinder ICT integration (Ajadi et al., 2008; Federal Ministry of Education, 2019).

Despite these hurdles, opportunities abound. Mobile learning, leveraging Nigeria's high smartphone penetration (60% among youths), offers a cost-effective way to deliver educational content (Etim et al., 2016). Open-source tools like PhET are adaptable to low-resource contexts, while initiatives like Nigeria's Digital Literacy Programme show promise in bridging skill gaps (Orshi, 2018). This study explores how advanced software technologies can enhance scientific literacy in Cross River State's post-primary schools, addressing access, perceptions, and barriers to inform policy and practice.

Literature Review

Scientific literacy empowers students to navigate a world shaped by science, fostering critical thinking and problem-solving (Osborne & Dillon, 2008). In Nigeria, achieving this is complicated by overcrowded classrooms, outdated teaching methods, and limited technology access (Aderonmu & Adolphus, 2021). Advanced software technologies offer a pathway to transform science education by enabling interactive, student-centered learning (Wieman et al., 2008).

Global Advances in Technology-Enhanced Learning

Globally, software technologies have redefined science education. Virtual labs, such as PhET and Labster, provide immersive environments for students to experiment without physical equipment, enhancing conceptual understanding (Wieman et al., 2008). A study by Kurubacak and Altinpulluk (2017) found that virtual simulations improved student engagement by 30% in science subjects. E-learning platforms like Google Classroom facilitate collaborative learning, enabling students to access resources and engage in peer discussions, which fosters scientific inquiry (Blau & Shamir-Inbal, 2017). These tools have proven effective in low-resource settings, offering scalable solutions for developing nations (Hobbs, 2011).

Challenges in Nigeria's Education System

In Nigeria, the adoption of educational technologies is stymied by infrastructural and human capital challenges. Bello and Ajao (2024) report that 70% of secondary school students lack basic digital skills, while 60% of teachers are untrained in ICT integration (Orshi, 2018). In Cross River State, only 20% of schools have reliable internet, and power outages disrupt technology use in 85% of institutions (Cross River State Ministry of Education, 2023). These align with Ajadi et al.'s (2008) findings on Nigeria's digital divide, which disproportionately affects rural areas.

Opportunities for Software Integration

Despite these challenges, Nigeria's high mobile penetration offers a unique opportunity. Etim et al. (2016) found that cloud-based tools like Google Docs improved teacher effectiveness in Cross River's

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tertiary institutions, suggesting potential for secondary schools. Open-source software like PhET is cost-effective and offline-capable, ideal for resource-constrained settings (Wieman et al., 2008). Recent initiatives, such as Anambra State's Digital Literacy Programme, demonstrate that targeted interventions can enhance digital skills and student outcomes (Orshi, 2018). By leveraging these opportunities, Cross River State can advance scientific literacy.

Methodology

Research Design

This study utilized a descriptive survey design to assess the role of advanced software technologies in enhancing scientific literacy. This approach allowed for comprehensive data collection on access, perceptions, and barriers to technology use.

Population and Sample

The population included all students and science teachers in public secondary schools in Calabar, Cross River State. Using a multi-stage sampling technique, 10 schools were randomly selected from the 48 public secondary schools. From each school, 30 students (Senior Secondary 1–3) and 10 science teachers were purposively sampled, yielding 300 students and 100 teachers. The demographic profile is shown in Table 1.

Table 1

Demographic Profile of Participants

Variable	Category	Frequency	Percentage (%)
Students			
Gender	Male	165	55.0
	Female	135	45.0
Age	12–15 years	190	63.3
	16–18 years	110	36.7
School Location	Urban	210	70.0
	Rural	90	30.0
Teachers			
Gender	Male	58	58.0
	Female	42	42.0
Years of Experience	1–5 years	45	45.0
	6–10 years	30	30.0
	>10 years	25	25.0

Data Collection

Primary data were collected using the "Scientific Literacy and Technology Integration Questionnaire" (SLTIQ), developed based on Van Deursen et al.'s (2014) digital literacy framework and Aderonmu and Adolphus's (2021) scientific literacy model. The SLTIQ included sections on technology access, perceptions of software impact, and barriers to integration, using a 4-point Likert scale (1 = Strongly

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Disagree, 4 = Strongly Agree). Cronbach's Alpha yielded a reliability coefficient of 0.85. Data collection occurred in March 2025, with ethical approval from the Cross River State Ministry of Education.

Data Analysis

Quantitative data were analyzed using descriptive statistics (frequencies, percentages, means) and t-tests to compare urban and rural responses. Qualitative data from open-ended questions were thematically analyzed. SPSS version 25 facilitated data processing.

Results

Access to Software Technologies

Only 30% of students had regular access to computers, with 25% using smartphones for learning. Rural schools reported significantly lower access (10%) than urban schools (45%) ($t = 4.87$, $p < 0.01$). Among teachers, 25% used basic software like PowerPoint, but only 8% utilized specialized tools like virtual labs.

Table 2

Access to Software Technologies

Access Type	Students (%)	Teachers (%)
Computers/Tablets	30	35
Smartphones	25	20
Internet Access	20	25
Specialized Software	8	8

Perceptions of Software Impact

Eighty-five percent of students and 90% of teachers agreed that software technologies enhance scientific literacy ($M = 3.52$, $SD = 0.58$). Virtual labs were highly favored, with 75% of students noting they make science "engaging and practical."

Barriers to Technology Integration

Major barriers included erratic power supply (92%), lack of teacher training (75%), and poor internet connectivity (68%). Rural schools faced greater challenges, with 98% citing infrastructure deficits compared to 75% in urban schools ($t = 5.43$, $p < 0.01$).

Table 3

Barriers to Technology Integration

Barrier	Students (%)	Teachers (%)
Erratic Power Supply	92	90
Lack of Teacher Training	70	75
Poor Internet Access	68	65
Inadequate Infrastructure	85	80

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Qualitative Findings

Thematic analysis identified three themes: (1) excitement for interactive tools, (2) frustration with infrastructure, and (3) need for teacher training. Students described virtual labs as "fun and easier to understand," while teachers emphasized, "Training is essential to use these tools confidently."

Discussion

The findings highlight the potential of advanced software technologies to revolutionize scientific literacy in Cross River State. The enthusiasm for virtual labs aligns with Wieman et al.'s (2008) findings on their efficacy in fostering inquiry-based learning. However, limited access (30% for students) and infrastructural barriers mirror Nigeria's broader digital divide (Ajadi et al., 2008). The urban-rural disparity ($t = 4.87$, $p < 0.01$) underscores the need for equitable resource distribution.

Teacher training deficits, reported by 75% of educators, echo Orshi's (2018) findings, emphasizing professional development as critical for technology integration. Mobile learning, leveraging smartphones, offers a practical solution given Nigeria's mobile penetration (Etim et al., 2016). These findings suggest that while barriers are significant, strategic interventions can unlock the potential of software technologies.

Conclusion

Advanced software technologies hold immense promise for enhancing scientific literacy in Cross River State's post-primary schools. Despite high enthusiasm, barriers like erratic power, poor internet, and limited training hinder progress. By addressing these challenges through mobile learning, teacher training, and infrastructure investment, Cross River State can empower students with the scientific skills needed for a globalized world.

Recommendations

- Infrastructure Development: Invest in reliable power and internet, prioritizing rural schools.
- Teacher Professional Development: Implement ongoing ICT training for teachers, focusing on virtual labs and e-learning platforms.
- Mobile Learning Initiatives: Utilize smartphone-based platforms to deliver offline-capable educational content.
- Curriculum Integration: Revise the science curriculum to incorporate technology-driven pedagogies.
- Partnerships: Collaborate with tech companies to provide affordable devices and software.

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