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PHYSICS EDUCATION AS THE FULCRUM OF STEM POLICY IMPLEMENTATION IN NIGERIA

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ABSTRACT
Nigeria's STEM policy treats physics as one subject among equals, yet physics arguably functions as the connective, foundational discipline underlying Science, Technology, Engineering, and Mathematics as a whole. This study examined the structural relationship between physics and the other STEM disciplines, the current state of physics education in Nigerian secondary schools, and the alignment between national STEM policy and physics pedagogy, and it developed evidence-based policy recommendations. The study adopted a narrative and critical literature review, drawing on peer-reviewed sources, government documents, and international reports published between 2022 and 2026, thematically organised around six research questions. Physics was found to supply the mathematical, conceptual, and reasoning foundations that other STEM fields depend on. Physics education in Nigeria, however, remains undermined by persistently low WASSCE credit-pass rates, widespread out-of-field and underqualified teaching, inadequate laboratory infrastructure, weak ICT integration, and enduring gender disparities. Nigeria's STEM frameworks were found to foreground physics insufficiently, leaving a gap between policy ambition and curricular practice. The study recommends that sustained improvement in physics teaching quality, teacher professionalisation, laboratory investment, and technology integration be pursued as a strategic lever for advancing Nigeria's STEM policy objectives, alongside a more explicit repositioning of physics within national STEM curriculum design, resource allocation, and evaluation frameworks.

Keywords: Interdisciplinary Education, Nigeria, physics education, secondary education, STEM policy, teacher quality

Introduction

The twenty-first-century global economy increasingly depends on scientific knowledge and technological skills. Countries that develop strong STEM education systems are better positioned for sustainable growth, industrial success, and social innovation (Dominguez et al., 2024; Nugraha et al., 2024). In sub-Saharan Africa, especially Nigeria, this need is urgent due to demographic pressures, youth unemployment, and the requirements of the digital and green economies. With a population of over 220 million, Nigeria is Africa's most populous country and has increasingly emphasized Science, Technology, Engineering and Mathematics (STEM) education through successive policy initiatives, programmes and investments aimed at developing human capital and supporting technological and economic development (Federal Ministry of Education, 2025). The Federal Ministry of Education, the National Universities Commission (NUC), and the National Educational Research and Development Council (NERDC) have created frameworks to integrate science and mathematics into all levels of the national curriculum (Chisom et al., 2023; Okon et al., 2024).

Despite this policy ambition, the implementation of STEM education in Nigeria remains bedevilled by well-documented structural inadequacies: poorly equipped laboratories, an acute shortage of qualified subject teachers, low student enrolment and poor performance of students in science subjects, gender disparities, and a persistent misalignment between curriculum content and industry demands (Chisom et al., 2023; Adeduyigbe et al., 2024). Among the STEM subjects, physics occupies a peculiar position. It is simultaneously the discipline most feared by students, the one most deficient in qualified teachers, and yet, paradoxically, the foundational discipline upon which all others structurally rest (Jegede & Adedayo, 2013; Kibona, 2025).

This paper takes as its central premise the claim, supported by theoretical analysis and the empirical literature, that physics is not merely one component of STEM but its connective tissue. Physics provides the mathematical formalism that underpins engineering; the atomic, electromagnetic, and thermodynamic principles that underlie chemistry and materials science; the biomechanical and biophysical foundations of biology and medicine; and the computational modelling logic that animates modern technology. The corollary is powerful: if physics is taught and understood properly, the essential conceptual infrastructure of STEM education is largely in place. Conversely, persistent failure in physics education implies systemic underachievement in STEM, regardless of how ambitiously STEM policy is written.

This research paper operationalises this premise through a systematic review of literature from 2022 to 2026. It identifies the objectives, research questions, and hypotheses that govern the inquiry; reviews the theoretical foundations; examines empirical evidence on physics education in Nigeria; and draws policy conclusions for the national STEM strategy.

Statement of the Problem

Despite Nigeria's national STEM education policy and numerous intervention programmes, physics education continues to face widespread student underperformance, with WASSCE credit-pass rates consistently below 50% (from 2019 to 2023), inadequate instructional resources, a shortage of qualified physics teachers, low student interest, and curricula that insufficiently reflect the discipline's applied and integrative nature (WAEC, 2023; Chisom et al., 2023; Ede & Anosike, 2023). These challenges are not merely departmental inconveniences; they represent structural barriers to STEM achievement because the conceptual framework and problem-solving methodologies that physics imparts are precisely those required for competence in the sciences, engineering, technology, and advanced mathematics.

The problem is further compounded by a policy architecture that treats the four STEM disciplines as separate but equal components of an integrated whole, without adequately recognising the epistemic hierarchy in which physics plays a generative role. As a result, interventions in science and technology education, engineering awareness, and mathematical literacy are often built on a foundation of poor understanding of physics, making them episodically effective at best and systemically insufficient at worst.

There is therefore an urgent need to establish, both theoretically and empirically, physics education as the primary lever for STEM policy implementation in Nigeria.

Research Objectives

This study is guided by the following objectives:

1. To examine the structural and conceptual relationship (integration) between physics and the other STEM disciplines (Science, Technology, Engineering and Mathematics).
2. To assess the current state of physics education in Nigerian secondary schools, with particular reference to teaching quality, laboratory infrastructure, student achievement, and teacher qualification.
3. To evaluate the degree of alignment between Nigeria's STEM education policy frameworks and the pedagogical delivery of physics in the national curriculum.
4. To investigate the extent to which improvements in physics education outcomes predict and enable broader STEM education achievement in the Nigerian context.
5. To develop and propose evidence-based policy and curriculum recommendations for leveraging physics education as the primary mechanism for STEM policy realisation in Nigeria.

Research Questions

The following research questions direct the study:

1. What is the structural relationship between physics and the other STEM disciplines?
2. In what ways does physics provide the conceptual and methodological foundation for Science, Technology, Engineering, and Mathematics (STEM) Education?
3. What is the current state of physics education in Nigerian secondary schools in terms of teacher quality, laboratory provision, student enrolment, and academic achievement?
4. To what extent does Nigeria's STEM education policy adequately reflect and operationalise the foundational role of physics within the STEM curriculum?
5. Is there a significant relationship between the quality of physics education delivery and overall STEM education outcomes in Nigeria?
6. What policy and curriculum interventions are most effective for using physics education as a strategic leverage point for the realisation of STEM policy objectives in Nigeria?

Literature Review

1 Conceptual Framework: Physics as the Nexus Discipline of STEM

The concept of STEM as an integrated educational framework has received extensive scholarly attention over the past two decades. STEM education encompasses interdisciplinary and transdisciplinary approaches that connect Science, Technology, Engineering, and Mathematics to promote integrated learning and real-world problem-solving across educational levels (Quigley et al., 2017). STEM is treated as integrated, but still lacks a balanced and well-developed theoretical understanding of what each discipline, especially physics, actually contributes to that integration.

Physics occupies a uniquely central position in this constellation. As Kibona (2025) observes, physics is a foundational component of STEM education because it underpins understanding across multiple scientific disciplines, making its emphasis essential for developing comprehensive scientific literacy. This observation resonates with classical positions in the philosophy of science: where physics provides the mathematical formalism (differential equations, vectors, statistical mechanics) that engineers deploy in structural analysis and circuit design, the atomic and subatomic models that chemists use to explain bonding and reactivity, the electromagnetic and biomechanical principles that biologists apply to neuronal signalling and locomotion and the computational modelling approaches that computer scientists use in algorithm design and simulation.

Dominguez et al. (2024) provide compelling evidence from an integrated physics-mathematics course for engineering students, demonstrating that the interdisciplinary benefits of modelling instruction in physics extended naturally to other STEM disciplines. Students who applied mathematical concepts such as derivatives and integrals to physical phenomena, for example, forces, motion and energy, subsequently demonstrated superior capacity for interdisciplinary problem-solving. This finding directly supports the argument that physics serves as the intellectual hinge between the abstract (mathematics) and the applied (technology and engineering).

From a Physics Education Research (PER) perspective, research on physics learning, reasoning, and instructional approaches provides a strong basis for developing active-engagement and inquiry-based laboratory strategies that promote students' scientific inquiry and reasoning skills (Docktor & Mestre, 2014). Crucially, since scientific reasoning is a more domain-general cognitive ability, success in physics can more readily inform research and education practices across other STEM fields (Bao & Koenig, 2019). This bi-directional relationship- physics as the recipient of mathematical rigour and physics as the donor of reasoning skills to other disciplines- makes it uniquely positioned as a connective hub.

Among the STEM disciplines, the unique conceptual and analytical roles of mathematics and physics give them unmatched influence in preparing learners for advanced STEM study (Kibona, 2025). High achievement in physics not only predicts long-term academic retention in STEM fields but also shapes students' confidence, interest, and career aspirations. Badmus and Jita (2023) further establish that Further Mathematics positively predicts students' performance in physics, reinforcing the bidirectional mathematical-physical nexus. Conversely, weak physics foundations create cascading underperformance across engineering, chemistry, and technology courses.

2 The STEM Integration Paradigm: International Perspectives

The global consensus on STEM education increasingly favours integrated, interdisciplinary approaches over separate subject teaching. Nugraha et al. (2024) articulate the foundational concepts of interdisciplinary STEM education, demonstrating that interdisciplinary thinking is essential to understanding and solving real-life problems and requires multiple disciplinary viewpoints. The Engineering Design Process (EDP), as documented in a quasi-experimental study by Safitri et al. (2024), seamlessly integrates physics education with practical and interdisciplinary problem-solving approaches, significantly improving students' problem-solving skills.

A Springer volume edited by Cai and Hwang (2024) on disciplinary and interdisciplinary education in STEM notes that the possible relationships and connections between individual disciplines, such as mathematics and physics, and broader STEM education remain underexplored. This gap is particularly acute in the African educational research context, where indigenous knowledge integration, resource constraints, and unique socio-cultural factors shape the conditions of possibility for STEM integration.

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3 STEM Education Policy in Nigeria: Historical and Contemporary Contexts

Nigeria's engagement with STEM education has evolved through several policy generations. The National Policy on Education (Federal Republic of Nigeria, 2013), the National Science and Technology Education Policy (Federal Ministry of Education, 2019), and more recent curriculum frameworks through the Nigerian Educational Research and Development Council (NERDC) have progressively embedded STEM as a priority. The 2023 National Digital Learning Policy further reflects Nigeria's intent to align education with the demands of the digital economy (Federal Ministry of Education, 2023; UNESCO-IICBA, 2024). Aina (2022) traces the development of STEM education in Nigeria, noting advances in curriculum design alongside persistent implementation challenges rooted in resource scarcity and systemic governance weaknesses.

Chisom et al. (2023), in a comprehensive review published in the International Journal of Applied Research in Social Sciences, found out that Nigerian STEM education has witnessed advancements in teaching methodologies and curriculum development, but these positive strides coexist with significant challenges such as persistent gender disparities, resource inadequacies, and deficiencies in teacher training. The study calls for strategic policy reforms targeting teacher development, curriculum updating, and technology integration, all of which intersect directly with the physics education challenge.

Okon et al.'s (2024) writing on STEM education recent developments, argue that no single discipline can impart the comprehensive skills required for twenty-first-century competence. They propose that a collaboration between STEM education and Technical and Vocational Education and Training (TVET) is the most productive pathway for Nigeria, particularly given the youth unemployment crisis. However, this collaboration is critically contingent on strong physics foundations, since virtually all technical and vocational education fields- electrical installation, mechatronics, civil construction, electronics, and renewable energy- draw directly on physics principles.

The practical implications of this dependency are illustrated by Adewale et al. (2025), who examine the integration of STEM and TVET in Nigerian technical colleges. Middle leaders in these institutions reported that students' inadequate physics backgrounds significantly constrained the effectiveness of TVET instruction. This finding reinforces the claim that physics education is not merely one component of the STEM ecosystem; it is the load-bearing wall.

4 The State of Physics Education in Nigerian Secondary Schools

Physics education in Nigeria faces a convergent set of structural challenges that have been extensively documented in recent literatures. At the most fundamental level, student performance in physics at the senior secondary level has remained persistently poor. WAEC Chief Examiners' Reports (2023) reveal that over the five years from 2019 to 2023, the percentage of students achieving credit passes (A1-C6) in physics rarely exceeded the 40% threshold, a pattern that Ede & Anosike (2023) describe as a cause for serious concern among educators and policymakers alike.

Research into the determinants of this underperformance points to multiple intersecting factors. Adeduyigbe et al. (2024) identify the influence of school type on students' learning difficulties and misconceptions about electricity (an aspect of physics) in Ondo State, finding that public school students faced systematically disadvantaged learning environments compared to their private school counterparts. Oyenwuchi & Owolabi (2022) demonstrate that the indigenous knowledge systems strategy, when integrated into physics teaching, improved student achievement scores in quasi-experimental studies in Lagos, suggesting that culturally responsive pedagogy can improve physics outcomes when properly implemented.

Teacher quality is a critical variable. Aliu et al. (2024) reveal a disturbing pattern: the government is recruiting graduates who did not study physics at university and have no teaching qualifications into physics teaching positions. One study participant, a self-identified non-physics graduate teaching physics, stated that they were "trying to cope" with the subject matter demands of the classroom. Studies by Aderonmu & Adolphus (2023) and Adebule et al. (2023) have also shown that physics education in Nigerian secondary schools is often delivered by non-specialist teachers, with evidence indicating that non-physics graduates are actively engaged in teaching the subject, reflecting broader systemic staffing and capacity challenges. This situation of unqualified instructors teaching foundational STEM subjects represents a structural collapse of the STEM pipeline at its most critical joint.

The role of laboratory infrastructure is equally significant. According to Ahmed et al. (2025), examining the availability and utilisation of science laboratory apparatus in Kwara State secondary schools shows that well-equipped laboratories significantly enhance science comprehension and students' ability to apply theoretical knowledge through hands-on experiments. However, many Nigerian schools operate with obsolete, poorly maintained, or absent laboratory facilities (Oyelowo, 2023). Akinbobola's earlier contention, cited in Ahmed et al. (2025), that teaching science without adequate laboratory resources undermines the value of these subjects and deters students from pursuing related courses in higher education, is consistently supported by recent empirical findings (Shambare and Jita, 2025; Mohammed et al., 2022; Kumari et al., 2024; and Nicol et al., 2022).

Information and Communication Technology (ICT) integration in physics teaching is another dimension of the challenge. A study on Nigerian secondary physics teachers' perceptions of ICT integration by Srinivasan (2024) found that a significant number of states in Nigeria have not fully embraced the adoption of ICT tools for teaching physics, resulting in limited influence of the initiatives aimed at technology integration in the secondary school curriculum. The pupil-to-qualified-teacher ratio in some public senior secondary schools reaches as high as 45, making even conventional pedagogy difficult, let alone technologically mediated instruction.

5 Physics Achievement, Mathematics, Engineering design, computational thinking and STEM Connectivity

A growing body of evidence establishes the predictive relationships between physics achievement and STEM performance more broadly. In the work of Badmus & Jita (2023), further mathematics was investigated as a predictor of students' performance in physics through a correlational analysis of three years of secondary education, confirming the bidirectional mathematical-physical competence nexus.

Bong et al. (2024) presented a comprehensive review of factors influencing STEM achievement; they synthesise a broad literature on achievement predictors and highlight the particularly potent role of physics and mathematics in shaping STEM pipeline retention. Their Bronfenbrenner-informed ecological systems analysis reveals that the individual cognitive factors (physics and mathematics proficiency), the school-level mesosystem factors (teacher quality, laboratory access), and the macrosystem factors (national policy, funding) all interact to produce the STEM achievement outcomes observed in any given educational context.

Awofala et al. (2022), examining Nigerian secondary school students' mathematics productive disposition as a correlate of achievement, find that attitudinal variables toward mathematics are significantly associated with performance, with implications for physics a subject that is essentially applied mathematics in many of its core domains. The mutual dependency between mathematical confidence and physics understanding creates a virtuous (or vicious) cycle that STEM policy must consciously seek to harness.

It is worth noting that the literature reviewed here does not speak with one voice on this question. Some scholars accord mathematics, rather than physics, the more general foundational role within STEM, since mathematical literacy underlies all four STEM disciplines more or less equally (Awofala et al., 2022). Others would caution that the physics-centred argument advanced in this paper rests mainly on theoretical reasoning and correlational evidence rather than on direct experimental tests within the Nigerian secondary school context, so the claim that physics is uniquely foundational is best treated as a strong working hypothesis rather than a fact.

Further strands of the literature advance mathematics, engineering design, or computational thinking, rather than physics, as the true fulcrum of STEM. Professional mathematics bodies argue that mathematics is the one discipline on which every other STEM field equally depends and should therefore sit at the structural centre of any STEM program (National Council of Teachers of Mathematics, 2018); Ben-Jacob (2019) makes this claim more directly, contending that mathematics is the foundation on which the other STEM disciplines are built and that early mathematical success predicts broader STEM achievement. A second strand holds that no single subject is foundational and that the Engineering Design Process (EDP) instead binds STEM together as the pedagogical structure through which scientific and mathematical content is applied and integrated in practice (Ayop, 2020). A third, more contemporary strand argues that computational thinking, not physics, is now the competency that most directly underlies performance across STEM, since algorithmic reasoning, abstraction, and problem decomposition transfer across all four disciplines in the digital economy (Wing, 2006; Alifah & Widodo, 2024). Taken together, these perspectives suggest that the "fulcrum" role attributed to physics in this paper is contested rather than settled, and that alternative disciplinary or pedagogical centres remain credible in the wider literature.

6 Theoretical Framework

This study draws on two complementary theoretical frameworks: Constructivism and the Nexus Model of STEM integration.

Constructivism, as developed by Piaget (1972) and extended by Vygotsky's social constructivism, holds that learners actively construct knowledge by integrating new information with existing cognitive structures. As applied to physics education, this framework argues that deep conceptual understanding in physics, not rote memorisation, is the foundation upon which students build more complex scientific and technological knowledge (Dominguez et al., 2024). The implications for pedagogy are clear: inquiry-based, laboratory-centred, and problem-solving-oriented physics instruction is not merely a best practice; it is a structural necessity for STEM integration.

The Nexus Model of STEM integration, proposed in this paper as an analytical framework, positions physics at the centre of a relational diagram in which the other STEM disciplines radiate outward, connected to physics through specific conceptual and methodological bridges. Mathematics provides the formal language that physics uses and enriches; engineering applies physical principles to material design; chemistry shares the atomic and energy frameworks of physics; biology borrows biophysical, optical, and biomechanical models; and technology translates physical principles into devices and systems. Under this model, the depth of physics understanding acts as the radius of the STEM competence circle: the deeper the physics, the wider the STEM reach.

Methodology

1 Research Design

This study employs a critical literature review methodology, supplemented by critical policy analysis. The critical review approach was selected because the central claims of the paper about the foundational role of physics in STEM and the state of physics education in Nigeria require synthesis across a broad empirical literature rather than original data collection. The policy analysis component examines key Nigerian STEM education policy documents (National Policy on Science and Technology Education (2019)) in relation to the literature findings.

2 Search Strategy and Inclusion Criteria

Literature was identified through searches of Google Scholar, Scopus, the Directory of Open Access Journals (DOAJ), Semantic Scholar, and ResearchGate. Search terms included: "physics education Nigeria," "STEM education Nigeria," "physics STEM integration," "STEM policy Nigeria," "physics teacher quality Nigeria," "science laboratory Nigeria secondary school," and combinations thereof. The temporal scope of the primary literature review was restricted to publications from 2022 to 2026 to ensure currency and relevance to the contemporary policy environment, though seminal theoretical works from earlier periods are cited where directly relevant. Only peer-reviewed articles, book chapters, government policy documents, and reports from recognised international organisations like UNESCO, African Union and United Nations were included. Grey literature and non-peer-reviewed blog posts were excluded.

3 Analysis

Thematic analysis was used to organise the literature findings around the six research questions. Sources were coded according to themes: (1) physics-STEM structural relationship; (2) physics teaching quality and outcomes in Nigeria; (3) policy-curriculum alignment; (4) physics achievement as STEM predictor; and (5) policy and curriculum interventions. Policy documents were subjected to content analysis, examining the degree to which physics was explicitly or implicitly foregrounded as a foundational discipline within STEM frameworks.

Findings and Discussion

1 Physics as the Structural Foundation of STEM: What the Literature Confirms

The literature unambiguously supports the foundational hypothesis of this paper. Physics provides the conceptual and methodological skeleton of STEM education. Dominguez et al. (2024) demonstrate that the integration of physics and mathematics through modelling produces students who can apply interdisciplinary knowledge across engineering design problems. The STEM-based Engineering Design Process literature (Safitri et al., 2024) shows that designing renewable energy systems, structures, or electronic circuits requires an understanding of physics principles as the primary epistemic entry point. Kibona, I. (2025) establishes that physics forms a foundational component of STEM because it underpins understanding across multiple scientific disciplines.

The qualitative evidence from pre-service physics teachers studied by Kozhabekova et al. (2025) shows that interdisciplinary approaches centred on physics, where students see how physics connects to engineering, medicine, and environmental science, develop stronger intrinsic motivation to explore STEM subjects further. The STEM Ways of Thinking (SWoT) framework, developed by Subramaniam et al. (2025), integrates design, science, mathematics, metacognitive reflection, and computational thinking within a physics laboratory context, demonstrating that the laboratory is a natural site for integrating all STEM competencies.

These findings are consistent with the expectation raised in H_{01}: the structural evidence strongly suggests that the quality of physics teaching has significant causal and correlational relationships with STEM outcomes. The theoretical and empirical question of the specific magnitude and directionality of this relationship in the Nigerian context remains an important agenda for future quantitative research.

2 Physics Education in Nigeria: A Diagnostic

The current state of physics education in Nigeria can be characterised as a system under structural stress. Five major diagnostic findings emerge from the following literature:

Firstly, academic performance is consistently poor. WAEC data (2023) show that fewer than 50% of candidates achieve credit passes in physics over multiple years, a pattern corroborated by Ede and Anosike (2023) and Adeduyigbe et al. (2024). The Nasarawa North Senatorial Zone study by Ismaila and Yahaya (2025) found consistent but only modest improvement in physics performance from 2020 to 2024, and the analysis confirmed that boarding school students performed significantly better than day school students, implicating the school environment and teaching continuity as key variables.

Secondly, teacher quality is critically compromised. Recent empirical studies found that the teaching of physics in Nigerian secondary schools is frequently undertaken by non-specialist teachers, that is, individuals who do not possess formal training or academic degrees in physics or physics education. This situation arises within a broader context of systemic teacher shortages and qualification gaps in the science education workforce. For instance, Aderonmu and Adolphus (2023) provide direct evidence that non-physics majors are actively engaged in delivering physics curriculum content, highlighting the prevalence of out-of-field teaching. Complementing this, Adebule et al. (2023) report incomplete implementation of the physics curriculum, a condition partly attributed to limitations in teacher capacity, including inadequate subject mastery and pedagogical preparedness. This qualitative finding is structurally consistent with Srinivasan (2024) observations on ICT integration challenges, in which teacher capacity limitations severely restrict pedagogical innovation. The shortages and lack of qualifications make it impossible to achieve the physics curriculum, hence affecting the achievement of the overall STEM education Policy.

Thirdly, laboratory infrastructure is inadequate. Ahmed et al. (2025) document the differential impact of laboratory availability on science achievement in Kwara State, while Oyelowo (2023) establishes the positive impact of functional laboratories on student attitude and achievement in physics. The ubiquity of laboratory shortages in the literature points to an underfunding of the practical dimension of physics education that directly undermines both physics achievement and the broader applied dimension of STEM.

Fourthly, ICT integration is lagging. Srinivasan (2024) identify widespread challenges to technology integration in physics classrooms in southwestern Nigeria, rooted in a combination of poor infrastructure, weak policy implementation, and insufficient teacher capacity. Given that technology is the T in STEM, the failure to use technology in physics teaching represents a double failure: it weakens physics learning and simultaneously prevents students from experiencing the very technology integration that STEM policy envisions.

Finally, gender disparities persist. Chisom et al. (2023) and Adeduyigbe et al. (2025) both document significant gender gaps in physics learning difficulties, with female students disproportionately affected by instructional deficits and attitudinal barriers. Given that the closing of STEM gender gaps is a stated objective of Nigerian educational policy, the physics classroom is a critical battleground for gender equity in STEM.

3 STEM Policy and Physics Curriculum: The Alignment Gap

From the policy analysis, while Nigerian STEM education policy articulates broad interdisciplinary aspirations, it does not sufficiently foreground physics as the structural centre of the STEM framework. The National Policy on Education (Federal Republic of Nigeria, 2013) and the implementation guidelines of the National Policy on Science and Technology Education (Federal Ministry of Education, 2019) treat physics as one science subject among several, without explicitly recognising or operationalising its foundational cross-disciplinary role. This represents a significant theoretical oversight with major practical consequences.

Chisom et al. (2023) call for strategic policy reforms and recommend research collaboration across STEM fields for an integrated curriculum and an amendment of the Policy to accommodate free STEM education at secondary and tertiary levels. This structural policy recommendation is consistent with the focus of this paper: if physics (and by extension STEM) education is foundational to national development, it warrants the status and resource protection accorded to fundamental national interests.

The STEM-TVET integration literature (Okon et al., 2024; Adewale, 2025) further reveals that the policy frameworks at the TVET interface acknowledge the importance of science foundations without specifically prescribing the depth of physics understanding required for technical competence. This gap between policy aspiration and curriculum specificity is a key point of leverage for reform.

4 Physics Achievement as a STEM Predictor: Evidence Assessment

While the direct empirical investigation of physics achievement as a systemic STEM predictor in the Nigerian context is limited in the 2022–2026 literature, partly reflecting the research gap this paper identifies, there is substantial indirect evidence. Badmus and Jita (2023) establish the predictive relationship between mathematics performance and physics achievement. Bong et al. (2024) synthesise the global literature on STEM achievement factors and consistently found that physics and mathematics competence are among the strongest predictors of advanced STEM study engagement and career entry. Dominguez et al. (2024) demonstrate in an experimental setting that integrated physics-mathematics instruction produces superior STEM outcomes for engineering students.

Taken together, these findings provide a reasonable basis for inferring that in the Nigerian context, systematic improvement in physics teaching and learning would produce measurable gains in broader STEM outcomes. This inference is consistent with the theoretical framework advanced in this paper and provides the evidential basis for the policy recommendations that follow.

Summary and Recommendations

1 Repositioning Physics at the Centre of STEM Policy

Nigeria's STEM education policy documents should be revised to explicitly recognise physics as the foundational, connective discipline of the STEM framework. This recognition should be reflected in: (a) curriculum design priorities that ensure deep, inquiry-based physics learning precedes and informs other STEM subjects; (b) resource allocation formulae that weight physics laboratory provision and teacher development more heavily; and (c) evaluation frameworks that assess physics learning outcomes as a proxy indicator for broader STEM policy attainment. This recommendation is consistent with Chisom et al. (2023) and Okon et al. (2024). This reform could be funded from existing Federal Ministry of Education and NERDC budgets; the biggest hurdle is the bureaucratic resistance to overhauling long-established curriculum and policy documents.

2 Professionalising the Physics Teaching Workforce

The evidence of widespread non-specialists teaching physics in Nigerian secondary schools (Aderonmu & Adolphus, 2023) demands an urgent policy response. Recommendations include: (a) mandatory subject-matter credentialing for physics teachers, enforced through state and federal teacher registration systems; (b) differential pay incentives for physics specialists, particularly in rural and peri-urban postings; (c) pre-service teacher education reforms that deepen disciplinary physics training alongside pedagogical content knowledge; and (d) structured in-service professional development programmes drawing on constructivist and inquiry-based pedagogical models (Dominguez et al., 2024; Kozhabekova et al., 2025). This is a medium- to long-term reform financeable through TETFund and state teacher-development budgets, with the limited current supply of qualified physics graduates willing to enter teaching as its most significant obstacle.

3 Laboratory Infrastructure Investment

A national physics laboratory upgrading programme should be established, with ring-fenced funding from both federal and state education budgets. Drawing on Ahmed et al. (2025) and Oyelowo (2023), the programme should prioritise: minimum equipment standards for senior secondary physics laboratories; supply-chain mechanisms for regular maintenance and replacement of apparatus; virtual laboratory platforms as supplements in under-resourced settings; and school-university partnerships that allow secondary students access to university laboratory facilities. The inclusion of laboratory quality indicators in school inspection and accreditation frameworks is also essential. This can best be financed through ring-fenced federal and state capital budgets or development-partner grants, with Nigeria's constrained education financing the most likely obstacle to sustained implementation.

4 ICT Integration in Physics Teaching

Consistent with Srinivasan (2024), physics-specific ICT integration strategies should be developed and deployed through the Federal Ministry of Education. This includes physics simulation software (such as Physics Education Technology (PhET) Interactive Simulations by the University of Colorado), digital oscilloscopes and data-logging tools, and online professional communities of practice for physics teachers. The Teacher Professional Development investment recommended above should include ICT competency as a core strand. This is an initiative financeable through the Federal Ministry of Education's digital learning budget and public-private technology partnerships, with unreliable electricity and internet access in many schools the most probable obstacle.

5.5 Research Investment and Knowledge Generation

A specific research agenda on physics-STEM integration in Nigerian schools and universities should be funded through the Tertiary Education Trust Fund (TETFund) and the National Research Fund. Priority research questions include: the empirical quantification of the physics-STEM achievement relationship in Nigeria; the effectiveness of contextualised and ethnoscience-informed physics pedagogy; the impact of differential laboratory provision on physics and STEM outcomes; and the role of gender-responsive physics pedagogy in closing female STEM participation gaps. This agenda directly addresses the research gap identified by Bong et al. (2024) and Cai and Hwang (2024). This is a long-term investment fundable through TETFund and the National Research Fund, with competition from other funding priorities within Nigeria's limited research budget as its most likely obstacle.

Conclusion

This paper has traced the connective role physics plays across the STEM disciplines and diagnosed the structural weaknesses that currently undermine physics education in Nigeria. The recurring pattern across the literature reviewed is that persistent underperformance in physics is closely bound up with the wider difficulties Nigeria faces in realising its STEM policy objectives. Nigeria's STEM education ambitions, as codified in successive policy frameworks, will not be realised through generic STEM advocacy or wholesale curriculum restructuring alone. They require targeted, evidence-grounded investment in the specific disciplinary foundations of STEM: above all, physics. The five objectives, six research questions, and four null hypotheses articulated in this paper provide an organising framework for subsequent empirical research that can test these claims quantitatively and qualitatively in Nigerian educational contexts. The recommendations offered for policy repositioning of physics, teacher professionalisation, laboratory investment, ICT integration, and research funding are not merely technical prescriptions. They reflect a deeper theoretical commitment: the recognition that the architecture of knowledge matters, that disciplines are not equal in their structural contributions to scientific understanding, and that Nigeria's STEM future depends, more than any other single factor, on the quality of physics education in its schools and universities. Sustained improvement in physics education would substantially advance, though not by itself fully guarantee, Nigeria's STEM policy goals.

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