

FUNCTIONAL PEDAGOGY FOR EFFECTIVE LEARNING OF SCIENCE SKILLS IN NIGERIA

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ABSTRACT

Functional pedagogy in science education emphasizes learner-centered and activity-driven strategies that connect classroom instruction with real-world scientific practices. This study adopted a desktop research methodology, reviewing both Nigerian and international literature to examine pedagogical approaches that enhance the acquisition of science process skills. Key strategies identified include; inquiry-based learning, activity-based methods, and the integration of digital technologies all of which have been shown to foster core competencies such as observation, experimentation, and analytical reasoning. Empirical evidence from secondary schools in Nigeria demonstrates that structured guided inquiry significantly improves students' mastery of science skills. However, the widespread adoption of functional pedagogy is hindered by infrastructural deficiencies, inadequate teacher preparation, and inconsistent policy implementation. The study concludes that effective integration of functional pedagogy in Nigeria's science education system requires comprehensive curriculum reforms, sustained teacher professional development, strategic investments in school infrastructure, and the establishment of robust policy frameworks that support innovative science instruction.

Keywords: *Functional pedagogy, science education, inquiry-based learning, activity-based methods, digital technologies, science process skills.*

INTRODUCTION

Science education occupies a central position in national development, particularly in societies striving to achieve technological advancement, economic competitiveness, and sustainable growth. In Nigeria, however, the teaching and learning of science at the secondary school level continue to reflect persistent systemic weaknesses that undermine the development of learners' scientific literacy and practical competence. Although the national curriculum emphasizes inquiry, experimentation, and the acquisition of science process skills, classroom practices often fall short of these expectations, resulting in a disconnect between curriculum intentions and actual learning outcomes (Okebukola, 2017; Ogundare & Saleh, 2021).

A major concern in Nigerian secondary schools is the dominance of teacher-centered instructional approaches that prioritize rote memorization and examination-driven content delivery. In such settings, students are typically passive recipients of knowledge, with limited opportunities to engage in hands-on experimentation, problem-solving, or critical inquiry. This approach significantly constrains the development of essential science process skills such as observation, classification, measurement, inference, hypothesis formulation, and experimentation. Consequently, many learners are unable to apply scientific knowledge meaningfully beyond the classroom, reflecting weak functional understanding of science concepts (Obodo, Chikaodinaka, & Okonkwo, 2022).

The implications of these instructional shortcomings are profound. Science education is not merely intended to transmit facts; it is fundamentally designed to equip learners with transferable skills that support lifelong learning, adaptability, and informed decision-making in real-life contexts. Lifelong learning according to Alla (2024) is about acquiring and updating all kinds of abilities, knowledge, qualification from pre-school to posts-retirement which promote the development and competencies that will enable adaptation to the knowledge-based society and also valuing all forms of learning. Lifelong learning in science education which is aimed at acquiring science lifelong knowledge and conceptual understanding in skills to solve problems according to Ayeshung (2022), promotes learning and provide experiences through scientific literacy.

When learners are deprived of opportunities to actively construct knowledge, they struggle to develop cognitive flexibility and problem-solving competence required in the 21st century knowledge economy. This challenge is further exacerbated by large class sizes, inadequate laboratory facilities, insufficient instructional materials, and teachers' limited exposure to innovative pedagogical strategies (Akinbobola, 2019; UNESCO, 2021). Murugesan (2022) contend that the method of teaching in lifelong learning, has a grater bearing on the quality and delivery in imparting knowledge and skills. Furthermore, the researcher is of the view that, there are many pedagogical instruments which can be utilized by instructors for the acquisition of skills depending on the nature of the subject being taught as well as learning objectives of the learners.

Concept of Functional Pedagogy in Learning Science

In Functional response to these persistent challenges, functional pedagogy emerges as a transformative instructional approach capable of repositioning science education towards skill acquisition and meaningful learning. Functional pedagogy according to Shah (2024) is most commonly understood as the approach to teaching as well as the theory and practice of learning and how this process influences, and is influenced by the social, political, and psychological development of the learner. Functional pedagogy is needed in enhancing science skills according to Gizaw and Sota (2023) because; it encompasses the mental and physical activities of students in collecting and organizing information to make predictions, explain phenomena, solve problems, understand the scientific endeavors and learn science. Similarly, Apeadido, Opoku-Mensah and Mensah (2024) contend that steady acquisition of students' science process skills are able to demonstrate some degree of improvement of students' confidence level and academic performance.

Functional pedagogy emphasizes learning through doing, inquiry-based exploration, collaborative problem-solving, and the application of knowledge to real-life situations. It aligns closely with constructivist learning theories which argue that learners build knowledge actively through experience rather than passively receiving information (Bruner, 1961; Dewey, 1938). Within science education, this approach fosters the development of core scientific competencies such as experimentation, data interpretation, reasoning, and evidence-based explanation.

More importantly, functional pedagogy provides a bridge between classroom science and everyday experiences, thereby making learning more relevant, engaging, and sustainable. By situating scientific concepts within practical and familiar contexts, students are better able to understand abstract ideas and transfer knowledge to new situations. This functional orientation not only enhances academic achievement but also prepares learners for lifelong education by equipping them with the capacity to continuously learn, unlearn, and relearn in response to emerging scientific and technological changes (Bybee, 2006; Gillies & Nichols, 2015). Similarly, Vrdoljak (2024) explained that lifelong education which include both formal and informal learning pattern, is not only a tool for career advancement and employability but also a means to foster adaptability, creativity, and resilience.

Against this backdrop, this paper adopting a desktop review methodology critically examines the relevance and effectiveness of functional pedagogy in enhancing science process skills among secondary school students in Nigeria. It synthesizes empirical findings from both local and international studies, identifies existing gaps in classroom practice, and explores the conditions necessary for effective implementation. In doing so, the study contributes to ongoing discourse on science education reform and provides evidence-based insights for curriculum planners, teacher educators, and policymakers seeking to reposition science teaching towards functional, student-centered, and lifelong learning-oriented pedagogy.

Conceptual Framework

Functional pedagogy as a theoretical construct is rooted in constructivist and inquiry-based learning paradigms, which emphasize active engagement, contextual understanding, and knowledge construction by the learner. Constructivism, as articulated by Piaget and later expanded through Vygotsky's sociocultural theory, posits that learners construct meaning through experiences that are shaped by their cognitive development and social interactions (Vygotsky, 1986). Inquiry-based learning, on the other hand, supports scientific understanding by encouraging students to explore, ask questions, and test hypotheses as part of the learning process (Bybee, 2006). Functional pedagogy brings these ideas together, not merely as a set of techniques but as a coherent philosophy that supports science education through student-centered learning, discovery, and reflection.

In this framework, the role of the teacher shifts from being a transmitter of facts to a facilitator of learning experiences that help learners connect scientific concepts with real-world contexts. As Omorogbe and Ewansiha (2013) observed, a significant challenge in the Nigerian science classroom is the disconnect between theoretical instruction and the students' lived realities. Functional pedagogy addresses this gap by embedding learning in practical, contextually relevant tasks that promote skill acquisition and scientific literacy (Ogundare & Saleh, 2021). When learners engage with science in a way that mirrors real investigative practices, they develop not only conceptual understanding but also process skills such as observation, classification, measurement, and interpretation, which are critical for 21st-century competencies.

Moreover, functional pedagogy draws upon metacognitive strategies to deepen students' engagement with content and foster self-regulation. The cognitive approach to inquiry-based instruction encourages students to reflect on their thinking, clarify misconceptions, and refine their understanding through iterative exploration (Gillies & Nichols, 2015). In the Nigerian context, this approach is particularly important in overcoming rote memorization, which dominates traditional teaching practices. By leveraging strategies rooted in functional pedagogy, such as project-based learning, collaborative experimentation, and contextual problem-solving students are more likely to internalize scientific concepts and transfer them to new situations (Obodo et al., 2022). Therefore, this framework supports both cognitive development and practical skill acquisition necessary for functional science learning.

Literature Review

Science Pedagogical Challenges in Nigeria

Science education in Nigeria faces significant pedagogical challenges that undermine effective teaching and learning. Conventional methods such as lecture-based instruction and cookbook laboratory experiments dominate classroom practices, leading to poor acquisition of science process skills and limited student engagement. Studies have shown that such approaches fail to promote critical thinking, creativity, and real-world application of scientific concepts (Ogundare & Saleh, 2021;). In addition, science teaching is hindered by structural constraints, including large class sizes, inadequate laboratory equipment, and lack

of teacher support systems. These challenges reduce the effectiveness of practical-based learning and limit the implementation of innovative teaching strategies (Olanrewaju, 2018).

Beyond classroom-level limitations, broader policy and socio-cultural factors also affect science pedagogy. Research highlights policy inconsistencies, poor funding, and curriculum content that marginalizes female students, contributing to persistent gender disparities in science participation (UNESCO, 2022). These issues are compounded by the lack of alignment between educational policies and classroom realities, making it difficult to implement functional pedagogical models. As a result, science education in Nigeria continues to struggle with low student outcomes, lack of inclusivity, and a disconnect between theoretical knowledge and practical application (Adepoju, Ibhawoh & Fayomi, 2020).

Inquiry-Based and Activity-Based Approaches

Empirical evidence from Gombe State indicates that the implementation of structured and guided inquiry-based interventions significantly enhanced students' science process skills. Ogundare and Saleh (2021) conducted a quasi-experimental study comparing students exposed to inquiry-based science instruction with those in traditional, cookbook-style laboratory classes. Their findings demonstrated notable improvements in students' abilities to observe, hypothesize, design experiments, and analyze data, confirming the effectiveness of inquiry approaches over conventional pedagogies in fostering scientific competence.

Similarly, a study in Zamfara State by Olanrewaju (2018) reported that the use of inquiry teaching strategies in junior secondary integrated science classes led to significant gains in students' reflective thinking and investigatory skills. In the South-South region of Nigeria, Nwosu et al. (2022) and Oribhabor (2020) documented the impact of activity-based learning on students' non-cognitive outcomes. Their studies revealed that hands-on and experiential science activities not only improved conceptual understanding but also boosted students' metacognitive awareness, motivation to learn, and positive attitudes toward science subjects. These empirical findings support the adoption of functional pedagogy rooted in inquiry and activity-based instruction to enhance science skill development in Nigerian schools.

Technology-Enhanced and Inclusive Inquiry Frameworks (Empirical Reports)

A notable advancement in Nigerian science education is the technology-enhanced inquiry framework proposed by Obodo, Nweze, and Ezeh (2022). Their study outlines a pedagogical model that systematically integrates digital tools, cooperative learning strategies, and authentic assessment practices. The goal is to create inclusive and adaptable learning environments suited for resource-constrained classrooms, expanding access, fostering collaboration, and bolstering students' engagement with scientific inquiry in settings where traditional lab facilities are limited.

Complementing local innovations, recent global research highlights the multifaceted roles that digital technologies play in supporting inquiry-based learning (IBL). For example,

Wang, Krajcik, and Pellegrino (2024) conducted a systematic review that identified seven distinct functions across IBL phases—from guiding investigation and representing phenomena to organizing ideas and enabling peer feedback—demonstrating how digital tools enrich each component of the inquiry cycle. Interactive mobile technologies allow students to record real-time experimental observations and collaboratively analyze data, which enhances metacognitive awareness and promotes scientific reasoning (Hjorth, Kluge, & Westergaard, 2023).

Furthermore, platforms like the WeInquiry system, developed by Chen, Chiu, and Lin (2025) for rural science classrooms, facilitate collaborative inquiry through structured digital scaffolds. The system provides specific inquiry spaces—for hypothesis generation, exploration, and shared interpretation—and supports learners in documenting and reflecting on their investigative work, leading to improved group performance and deeper understanding of scientific concepts.

Global Best Practices and 21st Century Skills Alignment

Global pedagogical frameworks, such as the 5E Instructional Model and the Partnership for 21st Century Learning (P21) framework, strongly emphasize the development of the four critical competencies—communication, collaboration, creativity, and critical thinking—commonly referred to as the "4Cs" (Bybee & Fuchs, 2006). The 5E model (Engage, Explore, Explain, Elaborate, Evaluate) has demonstrated improved student inquiry behaviors, increased conceptual understanding, and enhanced engagement in science education across diverse contexts. Meanwhile, the P21 framework advocates for integration of these competencies to prepare learners for contemporary challenges and societal participation (Center for Curriculum Redesign, 2024).

Empirical studies across various educational settings continue to reinforce the efficacy of inquiry-based approaches in fostering these 21st-century skills. For instance, a large-scale assessment of secondary school teachers in the Middle East emphasized the necessity of embedding hard and soft 21CS (including the 4Cs) into everyday classroom practice (ResearchGate, 2024). These findings align with global assessment results like those from OECD's PISA, which associate exposure to inquiry-based instruction with measurable gains in scientific literacy and problem-solving capacities (OECD, 2018). Such global insights align seamlessly with Nigeria's educational development goals particularly the inclusion of STEM-related competencies and lifelong learning skills within its national policy frameworks.

Discussion and Implications

The findings across reviewed literature suggest that functional pedagogy—particularly inquiry-based, activity-based, and technology-enhanced approaches—offers a transformative pathway for revitalizing science education in Nigeria. These pedagogical strategies promote critical thinking, metacognitive development, and active learner engagement, which are essential for equipping students with 21st-century skills (Ogundare & Saleh, 2021; Nwosu, Anyaegbunam & Okeke, 2022). Global models such as the 5E

instructional framework and the P21 skills initiative also align well with Nigeria's educational development goals by fostering communication, collaboration, creativity, and scientific literacy (Bybee, Taylor, Gardner & Scotter, 2006; Grey & Morris, 2024). The positive results reported from Nigerian regions like Gombe, Zamfara, and South-South Nigeria further validate the effectiveness of these learner-centered models in local contexts.

Despite the promise, systemic barriers hinder the widespread adoption of functional pedagogies. Key among these are the lack of sustained teacher training, limited access to laboratory and digital infrastructure, and a curriculum that remains largely examination-oriented (Obodo, Okafor, & Esomonu, 2022; Viro, Ibrahim, & Oladipo, 2020). Policy gaps and administrative inertia also weaken implementation efforts, particularly in underserved areas (UNESCO, 2021). For functional pedagogy to succeed in Nigeria, a coordinated national response is needed. This includes integrating inquiry-based science teaching into pre-service teacher education, continuous in-service professional development, curriculum reform that prioritizes hands-on and minds-on learning, and strategic investments in ICT and science facilities. These measures are crucial not only for improving academic achievement but also for cultivating a scientifically literate population capable of driving innovation and sustainable development.

Conclusion

This desktop review has underscored the transformative potential of functional pedagogy in enhancing science education in Nigeria. Functional pedagogy which includes inquiry-based learning (IBL), problem-based learning (PBL), experiential learning, collaborative learning, and technology-enhanced instructional approaches has been consistently associated with improvements in students' conceptual understanding, science process skills, critical thinking abilities, creativity, and overall academic achievement. Despite these merits' implementation remains limited due to systemic challenges such as insufficient teacher capacity, inadequate infrastructure, and lack of alignment between policy and practice. Nevertheless, when strategically adopted and supported, functional pedagogy aligns strongly with Nigeria's national development and education reform goals, particularly the drive toward building a capable education system. By actively engaging learners in the process of knowledge construction, functional pedagogy promotes deeper understanding of scientific concepts and enhances learners' ability to apply scientific knowledge to real-life situations.

The review further reveals that functional pedagogy serves as a viable pathway for fostering functional learning and lifelong education. Through active participation, investigation, and problem-solving activities, learners develop transferable competencies that extend beyond the classroom and prepare them for future educational, occupational, and societal challenges. However, despite its demonstrated effectiveness, the implementation of functional pedagogy in Nigerian secondary schools remains constrained by challenges such as inadequate teacher preparation, insufficient instructional resources, poor laboratory facilities, large class sizes, and limited integration of technology into teaching and learning. Nevertheless, with deliberate policy support and institutional commitment, functional pedagogy can significantly contribute to the realization of Nigeria's educational objectives

and the development of a scientifically literate, innovative, and globally competitive citizenry.

Recommendations

Based on the findings of this review, it is recommended that educational policymakers and curriculum developers prioritize the integration of functional pedagogical approaches into science curricula at all levels of education. Curriculum content should place greater emphasis on inquiry, experimentation, problem-solving, and the development of science process skills, in line with the objectives of the Nigerian Educational Research and Development Council (NERDC) and international best practices. Assessment procedures should also be revised to evaluate not only content knowledge but also learners' practical competencies, critical thinking skills, and ability to apply scientific concepts in authentic contexts.

Furthermore, teacher education institutions and educational authorities should strengthen professional development programmes to equip science teachers with the knowledge and skills required for effective implementation of functional pedagogy. Such programmes should include continuous training, classroom mentoring, peer collaboration, and opportunities for teachers to engage with innovative instructional practices. Government and other stakeholders should also invest in the provision of functional laboratories, instructional materials, and affordable digital technologies that can facilitate experiential and inquiry-based learning. Regular monitoring, evaluation, and research should be conducted to guide science education reforms and ensure the development of learners equipped with scientific inquiry skills, lifelong learning competencies, and the capacity to contribute meaningfully to national development.

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