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CURRICULUM INNOVATION IN SCIENCE TEACHING FOR TECHNOLOGICAL COMPETITIVENESS IN AN ERA OF INSECURITY AND ECONOMIC MELTDOWN

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Abstract

Science education plays a pivotal role in equipping learners with mindset, knowledge and skills needed to contribute and thrive in innovation-based economies and promoting technological competitiveness through science teaching and learning is important in a more coordinated and technological driven-world. Curriculum innovation in science teaching and learning becomes essential to ensure that students are literate in both scientific principles and its applications creatively and critically in technological and engineering contexts by employing project based learning, collaborative problem solving and the integration of digital tools which will help learners steer through modern science and technological competitiveness at the national and global levels depends heavily on how well students are prepared to tackle scientific and technological challenges. This paper therefore, explores the curriculum innovation in science teaching for technological competitiveness. The curriculum innovation employed should demonstrate improved students' engagement, conceptual understanding and readiness for future technological advancement and the curriculum itself should serve as a tool for educational institution to inculcate the knowledge of science and the skills to apply technological advancement in driving innovation and competitiveness in a global economy and also the curriculum should be dynamic, interdisciplinary and forward looking by fostering creativity, scientific curiosity and technological proficiency, which will help prepare a generation that can adapt to and lead to technological leadership tomorrow.

Keywords: Curriculum Innovation, Science Teaching and Learning, Science Teaching for Technological Competitiveness, Technological Competitiveness

Introduction

In a rapidly evolving, knowledge-driven world, science education remains a foundational pillar for fostering economic competitiveness, national development, and global relevance. Beyond equipping learners with factual scientific knowledge, science education is tasked with developing in individuals the capacity to think critically, engage in systematic inquiry, and apply scientific principles to real-world challenges. These competencies are crucial for nurturing innovation, promoting technological advancement, and preparing a workforce that can thrive in a digital economy. Curriculum innovation—the continuous improvement and reengineering of content, pedagogy, and delivery modes—is therefore indispensable in

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ensuring that science education remains relevant, impactful, and future-oriented (Ng, 2022; Halinen & Holappa, 2020).

Globally, countries that have successfully transitioned into innovation-based economies have made deliberate efforts to reform their science curricula. In Finland, for example, curriculum transformation has emphasized phenomenon-based, interdisciplinary learning where science is taught in connection with real-life situations. Students are encouraged to explore scientific ideas through experimentation and problem-solving, which cultivate critical thinking, collaboration, and digital literacy (Halinen & Holappa, 2020). Singapore and South Korea have similarly embedded inquiry-based learning and the use of advanced digital technologies such as simulations, coding, robotics, and virtual labs into their science education systems, preparing students for high-level participation in technology sectors (Ng, 2022; Lee & Choi, 2024).

Across the African continent, science education reform is increasingly being recognized as a strategic response to developmental challenges and as a means of harnessing Africa's demographic dividend. The African Union's Agenda 2063 articulates a vision of Africa where science, technology, and innovation are key drivers of transformation, and urges member states to integrate 21st-century skills into their education systems (Kamei & Katsuno, 2021). Rwanda and Ghana have made strides by implementing competency-based science curricula that promote hands-on experimentation, creativity, and entrepreneurial thinking. However, studies show that implementation is often hampered by challenges such as inadequate teacher preparation, insufficient laboratory facilities, and limited access to digital tools, particularly in rural and underserved areas (Mukasa & Ochieng, 2023; Babb & Stockero, 2020).

In Nigeria, the National Policy on Education prioritizes curriculum innovation to equip students with relevant skills, promote national development and address societal needs. This has remained largely aspirational rather than actualized. Despite multiple reviews of the national science curriculum and its alignment with global trends, teaching and learning in many schools remain dominated by teacher-centered methods, memorization of facts, and minimal practical engagement (Onuorah et al., 2022). Laboratory work is often simulated verbally or demonstrated by teachers without student involvement, due to largely inadequate facilities or lack of consumable materials. Moreover, digital technologies, which are central to modern science education globally, are rarely integrated into classroom instruction, primarily because of infrastructural deficits and teacher unfamiliarity with such tools (Aina & Adedoja, 2022).

These structural weaknesses are further compounded by systemic insecurity that significantly disrupts educational delivery. Insecurity in Nigeria has escalated in recent years, with insurgency in the Northeast, banditry in the Northwest, herder-farmer conflicts in the Middle Belt, and cultism and kidnapping in the South. These security challenges have had a debilitating effect on schools. Emordi and Egbuchulam (2023) report that school attacks have led to prolonged closures, displacement of teachers and students, and psychological trauma among learners. Insecurity not only limits access to schools but also erodes the enabling environment necessary for inquiry-based and practical science teaching, which often requires safety, stability, and access to equipment.

Alongside insecurity is Nigeria's prolonged economic downturn, characterized by inflation, rising unemployment, and underfunding of the education sector. Despite commitments to allocate 15–20% of national budgets to education (as recommended by UNESCO), Nigeria has consistently failed to meet this benchmark. The result is chronic underfunding of science education, leading to dilapidated laboratories, non-functional ICT infrastructure, and absence of resources for teacher retraining (Eneogu et al., 2024). Students from poor households are disproportionately affected, with many dropping out or failing to engage meaningfully in school due to hunger, inability to pay fees, or pressure to contribute to family income (Attahiru & Yabo, 2025).

Nonetheless, research has demonstrated that effective curriculum innovation, even when implemented within resource-constrained settings, can significantly enhance science learning outcomes. In Lagos State, Tokunbo et al. (2023) found that activity-based, peer-group instructional strategies led to significant improvement in students' achievement in integrated science. Similarly, Usman et al. (2023) reported that STEM problem-based learning improved students' performance in biology, even in classrooms lacking full laboratory infrastructure. These findings suggest that with creative curriculum design and appropriate teacher support, science education can be made more engaging, impactful, and contextually relevant—even in environments marked by insecurity and economic instability.

Globally, studies also affirm the efficacy of low-cost, scalable curriculum innovations. For example, Choi and Song (2021) found that virtual laboratories, accessed through smartphones or school computer labs, improved student motivation and conceptual understanding in science. Levinson (2021), in a meta-analysis, showed that project-based learning approaches consistently outperform traditional instruction in fostering collaboration, creativity, and knowledge retention. In Africa, the Practical Education Network (PEN) model

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has been widely praised for equipping science teachers in Ghana with techniques to deliver hands-on science lessons using everyday materials (Babb & Stockero, 2020). Such context-appropriate innovations offer valuable insights for reforming science education in Nigeria.

Taken together, these global, regional, and local experiences suggest that curriculum innovation in Nigerian science education must be strategic, responsive, and future-ready. It must go beyond superficial reforms and address foundational pedagogical and structural barriers. A truly innovative science curriculum should be dynamic, interdisciplinary, and adaptable to the realities of insecurity and economic challenges. It should foster curiosity, creativity, collaboration, and technological fluency—skills that are not only essential for academic success but also for national survival and economic resilience in the 21st century. Therefore, this opinion paper explores how curriculum innovation in science education can serve as a critical lever for promoting technological competitiveness in Nigeria, particularly in the face of rising insecurity and economic challenges. It aims to highlight the global best practices, regional innovations, and local possibilities for reimagining science teaching and learning to build a future-ready generation.

The Core Issue

In the face of global technological transformation, education systems are under increasing pressure to produce graduates with the scientific knowledge, digital literacy, and creative capacity needed to compete in innovation-driven economies. Science education, in particular, is pivotal to national development, as it fosters critical thinking, technological proficiency, and problem-solving abilities essential for industrial growth and economic competitiveness (Ng, 2022; Usman et al., 2023). However, the Nigerian science curriculum, despite undergoing several reforms, remains predominantly content-heavy, exam-oriented, and disconnected from real-world applications (Onuorah et al., 2022; Aina & Adedoja, 2022). This stagnation in pedagogical innovation has made it increasingly difficult for Nigerian graduates to match the demands of the 21st-century global workforce, thereby threatening the nation's position in the global knowledge economy.

A pressing concern is that most science classrooms in Nigeria still emphasize rote learning, with limited integration of inquiry-based or project-based approaches that stimulate curiosity, creativity, and problem-solving skills (Onuorah et al., 2022). In contrast, countries like Finland and Singapore have adopted experiential, interdisciplinary science curricula with a strong emphasis on digital tools, leading to measurable improvements in student outcomes and innovation readiness (Halinen & Holappa, 2020; Ng, 2022). Nigeria's lag in this regard has resulted in a widening skills gap between its students and their international counterparts, especially in the areas of STEM innovation and technological literacy (Levinson, 2021).

These disruptions directly affect the delivery of science education, as practical lessons, laboratory sessions, and group-based activities often require safe, stable learning environments. The resulting instability not only impedes cognitive development but also severely limits the effectiveness of any curriculum innovation that requires sustained engagement and experimentation.

Simultaneously, Nigeria's persistent economic crises further cripple the education sector. Chronic underfunding has led to dilapidated school infrastructure, outdated laboratory equipment, and minimal access to ICT resources, which are critical for modern science teaching (Eneogu et al., 2024). Teachers often lack access to continuous professional development in digital pedagogy and curriculum design, further widening the gap between curricular intentions and instructional practice (Aina & Adedoja, 2022; Attahiru & Yabo, 2025). This economic and technological disconnect contributes to poor student engagement, low science achievement, and under-preparedness for future careers in STEM fields.

Although empirical studies suggest that curriculum innovation—especially project-based, problem-solving, and technology-mediated strategies—can significantly improve student achievement and engagement in science (Tokunbo et al., 2023; Usman et al., 2023), such approaches remain underutilized in Nigeria. The continued reliance on traditional methods is not only pedagogically outdated but also strategically misaligned with the nation's aspirations for industrialization and global competitiveness.

Therefore, there is an urgent need to rethink and redesign science curricula in Nigeria to meet the demands of the 21st century. This entails integrating flexible, inquiry-driven, and technology-supported approaches that can survive insecurity, leverage limited resources, and foster students' scientific and technological resilience. Without such innovation, the vision of developing a globally competitive, innovation-driven Nigerian economy will remain elusive.

Curriculum Innovation: Concepts and Global Trends

Curriculum innovation refers to comprehensive changes in educational frameworks that enhance relevance, deepen engagement, and promote future-ready competencies (Simamora, 2024). In science education, this process emphasizes shifting from traditional lecture-based approaches to inquiry-led, learner-centered strategies. These revamped methods foster critical thinking, creativity, and problem-solving—skills essential not only for academic success but also for thriving in science, technology, engineering, and mathematics (STEM) careers (Baran et al., 2021). By redesigning content to be interdisciplinary and reflective of real-world phenomena, curriculum innovators aim to make science education more meaningful and impactful.

Globally, systems such as Finland, Singapore, and South Korea have led the way in integrating digital tools, virtual laboratories, robotics, and collaborative projects into core curricula (Halinen & Holappa, 2020; Ng, 2022; Choi & Song, 2021). In Finland, curriculum reform revolves around phenomenon-based learning, where students study topics such as climate change or energy through multiple subject lenses, reinforcing science as a relevant tool for understanding real-world issues (Halinen & Holappa, 2020). In contrast, Singapore emphasizes inquiry-based modules complemented by structured digital resources, ensuring students develop strong scientific reasoning skills alongside technological literacy (Ng, 2022). Studies show that these countries have achieved superior performance in science measures and have cultivated a culture of innovation (Halinen & Holappa, 2020).

Science Teaching as a Tool for Technological Competitiveness

Project-Based Learning (PBL) is widely recognized as an effective educational approach for equipping students with the skills needed for technological innovation. PBL involves students in long-term, open-ended projects that require investigation, planning, execution, and presentation—mirroring real scientific processes. In Nigeria, Babalola and Keku (2023) demonstrated that Ethno-STEM integrated PBL significantly improved creative thinking, ingenuity, and cultural context awareness among secondary learners. This form of learning bridges scientific inquiry with local relevance, fostering a deeper conceptual understanding and appreciation of science as a tool for societal development.

Further evidence of PBL's impact comes from Usman et al. (2023), who reported that Nigerian biology students engaging in STEM-PBL performed better not only in exams but also in applying scientific concepts to practical scenarios. Similarly, Okoye and Osuafor (2021) found that learners exposed to PBL exhibited greater mastery of key experimental skills—such as hypothesis formulation and data analysis. Globally, Levinson's (2021) meta-analysis confirms that PBL enhances creativity, teamwork, self-regulation, and technology fluency more effectively than teacher-centered instruction. PBL thus emerges not just as an instructional strategy but as a strategic pathway for fostering innovation skills aligned with global workforce demands.

Digital Tools and Inquiry-Based Approaches

Inquiry-based learning involves students in the authentic practices of science—asking questions, designing experiments, analyzing data, and drawing conclusions. This pedagogical model fosters deeper understanding, scientific literacy, and lifelong curiosity (Shivolo & Omari Mokiwa, 2024). When inquiry is supported by digital tools such as simulations, virtual labs, and interactive platforms, it becomes more accessible and effective—particularly in environments where physical laboratories are scarce. Students can safely explore complex concepts, repeat experiments, and visualize phenomena that would otherwise be difficult to demonstrate in resource-limited settings.

A comprehensive review by Choi and Song (2021) found that virtual labs significantly improve students' conceptual understanding and motivation toward science. Their meta-analysis, encompassing studies across multiple countries, revealed that students using virtual labs achieved measurable gains in comprehension and showed higher interest in STEM fields compared to peers in traditional settings. Importantly, these effects were most pronounced in under-resourced schools, highlighting the transformative potential of even basic digital technologies. Thus, integrating inquiry with digital tools offers a powerful strategy for enhancing scientific learning and preparing students for technologically advanced futures.

Challenges to Curriculum Innovation in Nigeria

Despite the clear benefits of innovative approaches, significant barriers hinder their widespread implementation in Nigeria. First among these is the lack of adequate infrastructure. Many schools lack functioning laboratories, reliable electricity, internet connectivity, and essential consumables—all of which are necessary for inquiry-based or project-focused learning (Eneogu et al., 2024). Without these fundamentals, even well-designed curricula remain theoretical exercises rather than lived educational experiences, limiting their potential impact on students.

Second, teacher capacity remains a critical constraint. Onuorah et al. (2022) report that the majority of Nigerian science teachers receive little to no training in PBL, digital pedagogy, or inquiry-driven instruction. This gap restricts their ability to adopt and sustain innovative methodologies in the classroom. Furthermore, recurring episodes of insecurity—marked by violence and school closures—disrupt academic continuity and reduce opportunities for implementing long-term projects or experiments (Emordi & Egbuchulam, 2023; Ogunbunmi & Olaoye, 2024). Such instability undermines both teacher confidence and student engagement, weakening the foundation needed for sustained curriculum innovation.

Additional equity concerns complicate the picture. While Tokunbo et al. (2023) found that peer-group PBL enhanced girls' participation and achievement in Lagos classrooms, broader structural inequalities—such as gender norms, regional disparities, and socioeconomic barriers—continue to restrict access to quality science education for many learners. These intersecting challenges call for carefully designed interventions that are inclusive, adaptive, and sensitive to context.

Continental Examples and Opportunities

African initiatives demonstrate that effective curriculum innovation can emerge from resource-limited settings. In Ghana, the Practical Education Network (PEN) has trained science teachers to deliver engaging, hands-on lessons using low-cost, improvised materials. Peer-reviewed evaluations confirm that PEN enhances student motivation, understanding, and experimental confidence even in schools lacking full laboratory infrastructure (Babb & Stockero, 2020). This model provides a scalable blueprint for delivering meaningful science education in similar contexts across Nigeria.

In Zimbabwe, Lab-Hackathons have empowered students and educators to design and build affordable scientific apparatus using local materials and open-source designs—a creative response to equipment shortages (Webb et al., 2019). Meanwhile, South Africa's STEMulator project offers interactive simulations and activities accessible on mobile devices, providing virtual labs even in schools without physical facilities (STEMulator, 2024). These creative, community-driven innovations combine cost-effective design with pedagogical rigor—offering valuable lessons in context-appropriate curriculum reform for Nigeria.

Core Characteristics of a Future-Ready Science Curriculum

Emerging from global and African examples, a future-ready science curriculum embodies four interlocking characteristics:

1. Interdisciplinary & Dynamic: It blends science with technology, engineering, and mathematics to reflect real-world problem-solving and cultivate digital literacy (Ng, 2022; Baran et al., 2021). This holistic approach encourages students to view scientific concepts as tools for innovation rather than abstract facts.

2. Context-Sensitive & Resilient: It supports learning modalities that are adaptable to disruptions—such as modular assignments, low-cost experiments, virtual labs, and community-centered learning—to ensure continuity during insecurity or economic shocks.

3. Teacher-Supportive: It includes sustained, accessible professional development in PBL, inquiry, and digital instruction. Models like Ghana's PEN and online communities demonstrate how teachers can be empowered without requiring high-cost systems (Babb & Stockero, 2020).
4. Equity-Oriented: It intentionally addresses barriers across gender, region, and socioeconomic status, using strategies like peer-group learning, culturally relevant content, and flexible engagement methods to ensure that no learner is left behind (Tokunbo et al., 2023).
Together, these attributes outline a science curriculum that can deliver meaningful innovation, resilience, and equity even amidst insecurity and resource constraints.

Synthesis of Core Ideas

The thematic exploration demonstrates that curriculum innovation—integrating project-based, inquiry-based, and digitally enhanced approaches—is essential for equipping science learners with competencies required in today's fast-paced innovation economy (Ng, 2022; Levinson, 2021). Global best practices from Finland, Singapore, and South Korea exemplify how integrating technology and real-world problem-solving into science curricula enhances scientific understanding and boosts student readiness for STEM careers (Halinen & Holappa, 2020; Choi & Song, 2021). At the same time, research from Nigeria shows that methods like Ethno-STEM and peer-based PBL can effectively adapt global innovations to local contexts and improve student outcomes (Babalola & Keku, 2023; Usman et al., 2023). However, persistent challenges—including infrastructural deficits, insecure learning environments, and inadequate teacher training limit these innovations' scalability (Eneogu et al., 2024; Emordi & Egbuchulam, 2023; Onuorah et al., 2022). Together, these findings underscore a central imperative: curriculum innovation must be strategic, adaptable, and contextually grounded to foster technological competitiveness in Nigeria.

Implications for Curriculum Designers and Educators Shift Toward Practical, Applied Science Teaching

Curriculum designers and educators must prioritize hands-on, applied learning experiences that connect science concepts to real-world challenges. Evidence from Nigeria indicates that project-based and inquiry-driven pedagogies significantly boost students' creative thinking, problem-solving skills, and scientific literacy (Okoye & Osuafor, 2021; Babalola & Keku, 2023). By embedding structured, culturally relevant projects—such as Ethno-STEM—they can foster deeper conceptual understanding and a stronger connection between science and daily life, ultimately preparing learners for technological innovation and competitiveness.

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Integrate Digital and Entrepreneurial Skills in Curriculum

As the digital economy expands globally and within Africa, science curricula must integrate digital literacy and entrepreneurial thinking alongside scientific principles. Virtual laboratories, coding modules, and simulations have been shown to enhance conceptual understanding and foster technological fluency, even in resource-limited settings (Choi & Song, 2021; Shivolo & Omari Mokiwa, 2024). Embedding entrepreneurship through activities such as science fairs and solution-based projects can cultivate innovation mindsets and prepare students to apply science knowledge creatively in business and technology contexts (Levinson, 2021).

Align Curriculum with Technological Development Agendas

Curriculum planners e.g. National Education Research and Development Council (NERDC) should collaborate with National Agency for Science and Engineering Infrastructure (NASENI) to map curriculum to industrial needs. This ensures alignment between instructional content and national technological development goals. Nigeria's education policies highlight the importance of STEM for national growth, but classroom practices often remain static (Aina & Adedoja, 2022). By coordinating curriculum design with industrial priorities and innovation agendas—through regular collaboration with government agencies and industry partners—science education can better supply future-ready graduates equipped with relevant skills, thereby enhancing the country's capacity for technological development (Babb & Stockero, 2020).

Recommendations

Institutionalize Curriculum Innovation Review Cycles

Government and curriculum authorities (e.g., NERDC) should formalize recurring curriculum review cycles that incorporate stakeholder input from educators, industry experts, and development agencies. These cyclical updates would embed innovation imperatives—such as digital integration and equity strategies—into core curriculum documents, preventing long delays and ensuring relevance in rapidly changing educational landscapes (Ng, 2022).

Train Teachers in Digital and Inquiry-Based Pedagogies

To bridge the gap between innovative designs and classroom practice, comprehensive teacher training programs are essential. Initiatives should include workshops, peer-learning communities, and microcredential courses that emphasize inquiry, digital integration, and project-based methods. Models like Ghana's Practical Education Network demonstrate the effectiveness of community-based support systems in fostering teaching innovation in low-resource settings (Babb & Stockero, 2020).

Strengthen Education-Industry Linkages

Partnerships between schools, universities, and industries can enrich the science curriculum. Examples from Africa include lab hackathons and co-curricular innovation events where students construct actual devices under expert guidance (Webb et al., 2019). Such collaborations provide learners with real-world context, technical mentorship, and hands-on opportunities—bridging theory and application to support national innovation ecosystems.

Build Curriculum Resilience Against National Crises

Given Nigeria's insecurity and economic volatility, curricula must be designed for flexibility and continuity. Suggestions include modular curriculum units, asynchronous digital modules, virtual labs, and community-based learning platforms—allowing instruction to continue safely outside formal school environments in times of crisis. Such resilience enhances both educational survival and long-term curriculum innovation (Emordi & Egbuchulam, 2023).

Conclusion

In summary, this chapter emphasizes that for Nigeria to harness science education as a driver of technological competitiveness amid insecurity and economic instability, curriculum innovation must be systemic, adaptive, and locally grounded. By adopting applied, digital, and inquiry-based approaches; aligning curriculum with national priorities; and ensuring teacher support and crisis resilience, science education can serve as a powerful engine for national development. Implementing these recommendations—through institutional policy, capacity building, and strategic partnerships—will empower young Nigerians to navigate challenges and assume leadership in the global innovation landscape.

References

Aina, J. K., & Adedoja, G. O. (2022). *Repositioning science education curriculum in Nigeria for technological development*. African Journal of Curriculum and Instructional Studies, 13(2), 101–114.

Attahiru, H., & Yabo, A. U. (2025). *Impact of insecurity and socioeconomic factors on out-of-school children in Sokoto State: Counselling implications*. African Journal of Humanities and Contemporary Education Research, 18(1), 61–71.

Babalola, E. O., & Keku, E. (2023). *Ethno-STEM integrated project-based learning to improve students' creative thinking skills*. International Journal of Ethnoscience and Technology in Education.

Babb, J., & Stockero, S. (2020). *Impact of Practical Education Network on students in selected Ghanaian Junior High School science classrooms.* African Journal of Research in Mathematics, Science and Technology Education, 24, 216–228.

https://doi.org/10.1080/18117295.2020.1814662

Baran, M., Baran, M., Maskan, A., & Karakoyun, F. (2021). *The influence of project-based STEM applications on the development of 21st century skills.* Journal of Turkish Science Education, 18(4).

Choi, H., & Song, Y. (2021). *Effects of virtual labs on students' scientific reasoning and motivation: A meta-analysis.* Journal of Science Education and Technology, 30(2), 172–185.

Emordi, P. J., & Egbuchulam, P. C. (2023). *Internal insecurity in Nigeria and the conundrum of Out-of-school children.* People Centred – Journal of Development Administration, 8(2), 49–62.

Eneogu, N. D., Chukwu, C. L., & Obiorah, N. J. (2024). *Perceived influence of economic crisis on students and lecturers in Nigerian tertiary institutions.* International Journal of Economics Education Research, 6(1), 1–13.

Halinen, I., & Holappa, A. S. (2020). The Finnish curriculum reform: Fostering 21st-century skills.Education Sciences, 10(1), 6.

Kamei, A., & Katsuno, Y. (2021). Curriculum innovation and policy shift in African education systems. *Comparative Education Review*, 65(3), 401–422.

Lee, J., & Choi, K. (2024). Inquiry-based STEM learning in Korea's digital classrooms. *Asia-Pacific Journal of Science Education*, 12(1), 23–41.

Levinson, R. (2021). Does project-based learning improve student creativity and collaboration? A meta-analysis. *International Review of Education*, 67(3), 315–338.

Mukasa, S., & Ochieng, F. (2023). Competency-based science curriculum in East Africa: Successes and challenges. *African Journal of Educational Research*, 15(4), 235–251.

Ng, P. T. (2022). Curriculum reform in Singapore: Towards a 21st-century education. *Asia Pacific Journal of Education*, 42(1), 3–17.

Ogunbunmi, S. T., & Olaoye, O. F. (2024). Impacts of insecurity on higher education in Nigeria. *Journal of Economics and Environmental Education*, 8(1), 210–219.

Okoye, M. N., & Osuafor, A. M. (2021). Effects of project-based learning on acquisition of science process skills in Awka. *AJSTME*, 6(2), 10–20.

Onuorah, A. I., Chukwuma, E. C., & Ofojebe, W. N. (2022). Innovative teaching strategies and curriculum delivery in Nigerian science classrooms. *Nigerian Journal of Curriculum Studies*, 29(1), 89–102.

Shivolo, T., & Omari Mokiwa, H. (2024). Inquiry-based science education: Namibian teachers' perspectives. *International Journal of Research in STEM Education*, 6(1), 97–112.

Simamora, E. (2024). Outcomes of project-based learning integrated with STEM: A systematic review. *International Journal of Educational Research Review*.

Tokunbo, D. B., Adejumo, O. O., & Frank, S. E. (2023). Effect of peer-group activity-based learning strategy on students' academic achievement in integrated science in Lagos State, Nigeria. *UNIZIK Journal of STM Education*, 6(1), 179–187.

Usman, G. B. T., Ali, M. N., & Ahmad, M. Z. (2023). Effectiveness of STEM problem-based learning on the achievement of biology among secondary school students in Nigeria. *Journal of Turkish Science Education*, 20(3), 453–467.

Webb, H., Nurse, J. R. C., Bezuidenhout, L., & Jirotka, M. (2019). *Lab hackathons to overcome lab equipment shortages in Africa.* LabHackathon Proceedings.