A TRANSFORMATIVE APPROACH TO STEAM EDUCATION IN NIGERIAN SECONDARY SCHOOLS: AN INTERDISCIPLINARY DESIGN PERSPECTIVE

BY

DR OMOLE ALFRED SUNDAY
Federal College of Education (Technical), Gusau.
Zamfara State. Nigeria
Email: alfredsundayomole@gmail.com

Abstract

This paper presents a comprehensive framework for the integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) education into Nigerian secondary schools through an interdisciplinary design lens. It argues that traditional educational models in Nigeria, which emphasize rote memorization and subject isolation, are inadequate for preparing students for 21st-century challenges. Instead, a transformative approach to STEAM education—rooted in interdisciplinary collaboration, design thinking, and cultural relevance—can foster innovation, critical thinking, and sustainable development. Drawing on recent scholarly literature, this study synthesizes global best practices and adapts them to the Nigerian context using models such as the Culturo-Techno-Contextual (CTC) framework and Bajah's interdisciplinary model. The paper outlines key components of an effective STEAM implementation strategy, including curriculum redesign, teacher training, student-centered learning environments, community engagement, and inclusive assessment. It also identifies systemic barriers such as policy gaps, resource limitations, and resistance to change, offering practical recommendations for overcoming them. The proposed model emphasizes locally relevant, project-based learning that empowers students to solve real-world problems. This article contributes to the discourse on educational reform in sub-Saharan Africa by providing a feasible, evidence-based roadmap for transforming secondary education through STEAM.

Keywords: STEAM education, interdisciplinary design, transformative pedagogy

Introduction

The global educational landscape is undergoing a profound transformation. As societies become increasingly driven by technology, innovation, and complex socio-environmental challenges, there is a growing demand for education systems that produce not just knowledgeable students, but creative problem-solvers, critical thinkers, and lifelong learners. In response, many countries have adopted STEAM education—an integrative approach that combines Science, Technology, Engineering, Arts, and Mathematics into a cohesive learning paradigm. STEAM education moves beyond the traditional siloed structure of school subjects. It encourages students to apply knowledge across disciplines in meaningful, real-world contexts. Unlike conventional teaching methods that prioritize memorization and standardized testing, STEAM emphasizes inquiry, collaboration, creativity, and hands-on learning. This shift is particularly important in developing nations like Nigeria, where the education system faces persistent challenges such as outdated curricula, inadequate infrastructure, and misalignment with labor market needs.

Nigeria, with a population of over 200 million and a youth bulge, stands at a critical crossroads. Its secondary education system serves millions of students, yet many graduate without the skills needed for higher education, employment, or civic engagement. According to UNESCO (2022), only about 30% of Nigerian secondary school graduates demonstrate functional literacy and numeracy. Moreover, science and mathematics performance remain low, and student disengagement is widespread. To address these issues, this paper proposes a transformative approach to STEAM education grounded in interdisciplinary design. Rather than importing Western models wholesale, the framework is tailored to the Nigerian context, emphasizing cultural relevance, accessibility, and sustainability. It builds on existing local educational philosophies—such as Bajah's interdisciplinary model—and integrates contemporary global insights from scholars advocating transdisciplinary and socially responsive pedagogy. The central argument of this paper is that interdisciplinary design is the core mechanism through which STEAM can become truly transformative in Nigerian secondary schools. When students engage in designing solutions to real problems—such as clean water access, waste management, or energy efficiency, they integrate knowledge from multiple subjects in authentic ways. This process not only deepens understanding but also fosters agency, innovation, and social responsibility.

The paper is structured as follows: Section 2 defines transformative STEAM education; Section 3 explores the role of interdisciplinary design; Section 4 analyzes the Nigerian educational context; Section 5 presents a proposed implementation framework; Section 6 discusses global case studies; Section 7 identifies barriers and solutions; Section 8 highlights the importance of cultural integration; and Section 9 offers a forward-looking vision. The conclusion calls for immediate, coordinated action to scale STEAM education across Nigeria.

Defining Transformative STEAM Education

Transformative STEAM education goes beyond simply adding the "A" (Arts) to STEM. It represents a fundamental rethinking of the purpose and process of education. As Taylor and Taylor (2019) explain, transformative education seeks to empower learners to question, reflect, and act upon their social and environmental realities. In the context of STEAM, this means shifting from passive knowledge reception to active knowledge creation.

Transformative STEAM is characterized by several key features:

Problem-based learning: Students engage with real-world issues such as climate change, public health, or urban planning.

Trans disciplinarity: Knowledge is not confined to subject boundaries but is integrated around themes and challenges.
Student agency: Learners take ownership of their projects, making decisions about design, research, and presentation.
Social relevance: Projects are connected to local communities and aim to produce tangible benefits.
Sustainability focus: Learning is aligned with long-term environmental, economic, and social well-being.
This approach aligns closely with the United Nations Sustainable Development Goal 4 (SDG-4), which calls for inclusive and equitable quality education (Adesina et al., 2023). In Nigeria, where educational inequality remains high, transformative STEAM offers a pathway to more equitable outcomes by valuing diverse forms of intelligence—including artistic, practical, and indigenous knowledge. Sargiotis (2025) further emphasizes that transformation in education requires systemic change. It is not enough to introduce a few STEAM activities; the entire ecosystem—curriculum, teaching methods, assessment, infrastructure, and policy—must evolve. This includes redefining the teacher's role from knowledge transmitter to facilitator and mentor. The inclusion of the Arts in STEAM is not decorative but essential. Liao (2016) argues that arts integration fosters creativity, emotional intelligence, and aesthetic reasoning—skills that are crucial for innovation. For example, when designing a sustainable housing model, students use engineering principles but also consider cultural aesthetics, user experience, and visual communication. This holistic approach ensures that technological solutions are not only functional but also human-centered.
Thus, transformative STEAM is not a subject or an extracurricular activity. It is a philosophy of education that prepares students to navigate complexity, embrace uncertainty, and contribute meaningfully to society.

The Role of Interdisciplinary Design in STEAM

At the heart of transformative STEAM lies interdisciplinary design—a pedagogical strategy that uses design thinking and project-based learning to integrate knowledge across disciplines. Design, in this context, is not limited to visual or industrial design. It refers to a systematic process of solving problems through empathy, ideation, prototyping, and iteration. Keane and Keane (2016) describe this as "STEAM by design," where students learn by doing, making, and improving. This method contrasts sharply with traditional instruction, where knowledge is often abstract and disconnected from application.
The design process typically includes the following stages:
Empathize: Understand the needs and experiences of users or communities.
Define: Clearly articulate the problem to be solved.
Ideate: Generate multiple creative solutions.
Prototype: Build a simple, testable version of the solution.

Test and Iterate: Evaluate the prototype and make improvements.

This approach has been successfully applied in various educational settings. For instance, Queiruga-Dios et al. (2021) describe a STEAM project in Spain where secondary students designed solutions to reduce plastic pollution in their local environment. They collected data, built filtration models, and created public awareness campaigns—integrating science, technology, engineering, and art.

In Nigeria, such projects could focus on issues like access to clean water, renewable energy, or food security. For example, students might design a low-cost water purification system using locally available materials. In doing so, they would apply chemistry (to understand contaminants), physics (to study filtration), mathematics (to calculate flow rates), engineering (to build the device), and art (to communicate its use through posters or videos). Eleni and Fotini (2017) highlight that interdisciplinary design promotes deep learning because it requires students to connect concepts across subjects. When learners see how mathematical ratios apply to musical scales or how geometry informs traditional weaving patterns, they develop a more coherent and meaningful understanding of knowledge. Moreover, design-based learning fosters resilience and adaptability. Since prototypes rarely work perfectly on the first try, students learn to view failure as part of the learning process. This mindset is essential in a world where rapid change and uncertainty are the norm.

To be effective, interdisciplinary design must be supported by appropriate curricular structures. Li (2024) identifies several strategies for successful integration:

Thematic units that connect multiple subjects around a central issue

Collaborative planning among teachers from different disciplines

Use of rubrics that assess both content mastery and design skills

Time and space for extended project work

When properly implemented, interdisciplinary design transforms classrooms into dynamic spaces of inquiry and innovation.

The Nigerian Educational Context: Challenges and Opportunities

Any discussion of STEAM education in Nigeria must begin with an honest assessment of the current educational landscape.

Nigeria operates one of the largest education systems in Africa, with over 15 million students enrolled in secondary schools (UBEC, 2023). However, the system faces numerous structural challenges:

Overcrowded classrooms: Average class sizes exceed 50 students, limiting individual attention.

Inadequate infrastructure: Many schools lack laboratories, libraries, electricity, and internet access.

Teacher shortages and training gaps: A significant proportion of teachers are unqualified or undertrained in modern pedagogies.

Outdated curriculum: The current curriculum remains largely content-heavy and exam-focused, with limited emphasis on critical thinking or application.
Assessment bias: National examinations (WAEC, NECO) prioritize recall over creativity or problem-solving.
Despite these challenges, Nigeria also possesses significant strengths that can support STEAM innovation:
A young, tech-savvy population: Over 70% of Nigerians are under 30, and mobile phone penetration is high.
Rich cultural diversity: Indigenous knowledge systems, crafts, music, and oral traditions offer fertile ground for culturally responsive STEAM.
Growing interest in innovation: Youth-led initiatives in coding, robotics, and entrepreneurship are emerging in urban centers.
Opara (2014) revisits Bajah's Interdisciplinary Model, developed in the 1970s as a response to the fragmented nature of science education in Nigeria. The model advocated for integrating science concepts around real-life phenomena, such as farming or health. Although it was not fully implemented, its core idea—linking education to lived experience—remains highly relevant.
Building on this legacy, Adesina et al. (2023) propose the Culturo-Techno-Contextual (CTC) framework, which emphasizes three pillars:
Cultural relevance: STEAM content should reflect local values, traditions, and knowledge systems.
Technological accessibility: Tools and resources should be affordable and usable in low-resource settings.
Contextual grounding: Learning should address real problems in students' communities.
For example, a STEAM project on sustainable agriculture might involve:
Studying soil composition (science)
Designing drip irrigation systems (engineering)
Using mobile apps to track crop growth (technology)
Calculating yield and profit margins (mathematics)
Creating murals or dramas to educate farmers (arts)
This approach ensures that STEAM is not perceived as a foreign or elitist concept but as a practical tool for local development.
The Nigerian context also demands flexibility. A one-size-fits-all model will not work. Urban schools with internet access may incorporate digital tools, while rural schools can focus on low-tech, hands-on projects. The key is adaptability and inclusivity.

A Proposed Framework for STEAM Implementation

To guide the integration of transformative STEAM education in Nigerian secondary schools, this paper proposes the Nigerian Interdisciplinary STEAM Design (NISD) Framework. It consists of five interdependent components:

Curriculum Redesign

The current curriculum should be restructured around thematic, project-based units rather than isolated subjects. Each term could focus on a broad theme such as:

Environmental Sustainability

Health and Well-being

Smart Communities

Creative Technologies

Within each theme, students engage in interdisciplinary projects that require research, design, and presentation. As Pan (2024) demonstrates in the Chinese context, restructuring science education around STEAM principles leads to deeper engagement and improved conceptual understanding.

Teacher Professional Development

Teachers are central to successful STEAM implementation. They require training in:

Interdisciplinary pedagogy

Project-based learning

Design thinking

Use of low-cost digital tools

Workshops, peer learning networks, and online courses can support capacity building. Spyropoulou and Kameas (2023) stress the need for a competence framework for STEAM educators, outlining the knowledge, skills, and attitudes required.

Student-Centered Learning Environments

Classrooms should be redesigned to support collaboration and creativity. Even with limited resources, schools can create:

Maker corners using recycled materials

Science gardens for environmental studies

Digital hubs with shared tablets or smartphones

Kim (2021) notes that the physical learning environment influences student behavior and motivation. Flexible seating, display boards for project progress, and access to tools encourage active participation.

Community and Industry Partnerships

Schools should form partnerships with local organizations, artisans, engineers, and NGOs. These collaborations provide mentorship, resources, and real-world context for student projects. As Unterfrauner et al. (2024) argue, socially innovative practices in STEAM strengthen civic engagement and community impact.

Inclusive and Authentic Assessment

Assessment should move beyond written exams to include:

Project portfolios

Peer and self-evaluation

Oral presentations

Community feedback
This approach aligns with Taylor and Taylor's (2019) vision of education for sustainable development, where learning outcomes are measured by impact and reflection, not just scores.
The NISD framework is not prescriptive but adaptable, allowing schools to implement it according to their resources and local needs.
1. The NISD Framework: Nigerian Interdisciplinary STEAM Design Model
To guide the implementation of transformative STEAM education in Nigerian secondary schools, this study proposes the Nigerian Interdisciplinary STEAM Design (NISD) Framework. The model integrates global best practices with local educational realities, emphasizing interdisciplinary design, cultural relevance, and systemic transformation.
The NISD Framework is built on five interconnected components, all centered on the learner and driven by real-world problem-solving. It reflects a shift from teacher-centered instruction to student-centered, project-based learning.

Global Case Studies and Lessons Learned
Several countries have successfully implemented STEAM education, offering valuable lessons for Nigeria.
In Spain, Queiruga-Dios et al. (2021) documented a STEAM project where students addressed plastic pollution through scientific investigation, engineering design, and artistic expression. The project improved student engagement and fostered environmental awareness.
In Brazil, Alves de Sousa (2024) describes how interdisciplinary projects were integrated into the curriculum using design-based learning. Students built solar ovens, studied energy efficiency, and presented their work in school fairs. Teacher collaboration and administrative support were critical to success.
Even in low-resource settings, innovation thrives. In India, schools have developed "science parks" using scrap materials. In Kenya, students have used basic electronics to build irrigation systems.
These examples show that success depends more on pedagogy than on resources. As Nguyen (2025) observes, the quality of teaching and the depth of student engagement matter more than the availability of high-tech equipment.
For Nigeria, the lesson is clear: start small, focus on process, and scale gradually.
Barriers to Implementation and Recommendations
Despite its potential, STEAM education faces significant barriers in Nigeria:
Lack of policy support: There is no national STEAM policy or dedicated funding.
Resource constraints: Many schools lack basic infrastructure.
Resistance to change: Some educators and parents view STEAM as non-essential or distracting from exam preparation.

Assessment misalignment: High-stakes exams do not reward creativity or project work.
Equity concerns: Girls and rural students may be excluded without targeted support.
To overcome these challenges, the following recommendations are proposed:
Develop a national STEAM policy with clear goals, timelines, and funding mechanisms.
Launch pilot programs in diverse schools to test and refine models.
Integrate STEAM into teacher education curricula at colleges of education.
Revise national exams to include practical and project-based components.
Promote gender equity through targeted scholarships and mentorship for girls in STEAM.
Leverage public-private partnerships for funding and technical support.
Change will not happen overnight, but as Sargiotis (2025) reminds us, transformation begins with intentional, incremental steps.

The Role of Culture in STEAM Education

One of the greatest risks in educational reform is cultural disconnect. If STEAM is seen as a Western import, it will fail to gain local ownership.
To ensure sustainability, STEAM must be culturally grounded. Nigeria's rich heritage in music, textiles, architecture, and storytelling offers abundant opportunities for integration.
For example:
Adinkra and Nsibidi symbols can be used to teach symmetry, coding, and communication.
Traditional drumming involves rhythm, mathematics, and acoustics.
Pottery and weaving demonstrate engineering principles and material science.
By valuing indigenous knowledge, STEAM becomes more inclusive and meaningful. As Zakaria and Md Osman (2024) argue, curriculum alignment with local culture enhances student motivation and identity.
Moreover, involving elders and community members in STEAM projects fosters intergenerational learning and strengthens social bonds.

Conclusion

This paper has argued that a transformative approach to STEAM education, rooted in interdisciplinary design, is both necessary and achievable in Nigerian secondary schools. By shifting from rote learning to problem-solving, from isolation to integration, and from abstraction to application, STEAM can prepare students for the complexities of the 21st century.
The proposed NISD framework offers a practical pathway for implementation, emphasizing cultural relevance, teacher support, and community engagement. While challenges exist, they are not insurmountable. With political will, strategic investment, and collaborative effort, Nigeria can lead the way in reimagining secondary education in Africa.

Future research should focus on evaluating pilot STEAM programs, assessing long-term impacts on student outcomes, and exploring scalable models for rural and underserved areas. Additionally, longitudinal studies on teacher development and policy implementation will be crucial.

Ultimately, the goal is not just to improve test scores, but to empower a generation of innovators, thinkers, and changemakers. STEAM education, when done right, is not just about learning science and art—it is about building a better future for all.

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