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Science Education for Sustainable Development in Nigeria: Reorienting Curriculum, Teachers, and Youths for the SDGs

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Abstract

This paper argues that Nigeria must transform its science education system from a narrow vocational pipeline into a broad-based engine for sustainable development. Drawing on historical context, contemporary sustainability frameworks, and pedagogical theory, the paper identifies critical such as underfunding, infrastructure deficits, outdated pedagogy, weak policy implementation, and limited integration of Indigenous Knowledge Systems that constrain science education's ability to contribute to the sustainable development goals (SDGs). It proposes a practical agenda: ESD-infused curriculum modules mapped to prioritize SDGs, cascade teacher professional development with certification and incentives, experiential community-based projects, low-cost laboratory resources, targeted pilot programs across ecological zones, and a cross-sector governance mechanism to coordinate scale-up. The paper calls for action-research to evaluate learning gains, behavioral change, and cost-effectiveness, and it positions Nigeria's large youth cohort as the pivotal resource for achieving a just and resilient transition to sustainable development.

Keywords: education for sustainable development, science education, sustainable development goals, scientific literacy, indigenous knowledge systems, experiential learning, teacher professional development

Introduction

Education is a concept that has defied a universally accepted definition due to its complex nature (Okoronka et al., 2018). Science, and by extension Science Education (Mathematics inclusive), constitutes the pivot around which all scientific and technological development across the globe revolves. Today's world economy is knowledge-driven. In this regard, the knowledge of science is ever in demand as it has become a necessary requirement for meaningful living in society (Okoronka, 2007).

Being knowledgeable (scientific knowledge inclusive) is the focus of education, which itself is one of the key indices among the dimensions of measures of development, namely: Life expectancy, Education, and Gross National Income (GNI) for measuring the Human Development Index (HDI) (Nwadiani, 2011). HDI is a metric developed by the United Nations (UN) to take emphasis off economic growth measured by Gross Domestic Product (GDP) to include human, physical, and educational wellbeing as critical measures.

Okoronka et al. (2018) emphatically state that the trend in today's global economy is to invest massively in human capital development, which provides professional skill sets that empower citizens and graduates in science education to become agents of development. However, such efforts must now consider other contending development frameworks, especially the UN's AGENDA 2030, which has at its core 17 Sustainable Development Goals (SDGs). The SDGs are an offshoot of the Millennium Development Goals (MDGs) aimed at securing a sustainable, peaceful, prosperous, and equitable life on Earth for everyone now and in the future. A major task before the Nigerian science educator, therefore, is to ensure that the goals of science education are linked to the central tenets of Sustainable Development (SD).

Adewumi and Ade (2012) viewed human capital as the collective wealth of knowledge, training, skills, judgment, and accumulated experience of a population or nation. In order to protect human capital, experts advise that it is better to stay current and flow with trends. It is also necessary to acquire new skills concomitant with new technologies. It is against the backdrop of these emerging global trends and perspectives on development that this paper seeks to interrogate the topic of Science Education for Sustainable Development in Nigeria: Issues, Challenges and Prospects.

Conceptual Clarifications

In a discourse such as this, there is a need to take a close look at the key concepts and terms to clearly align their meanings to the context of their use and application. The following concepts are therefore examined with regards to their meaning in this paper: education, science, science education, sustainable development, issues, challenges, and prospects.

Education: Education is one of the most misunderstood concepts in the history of man. This is so because even the uneducated have their own idea of what education is or should be. Besides, societies differ in their stand and emphasis on what education should provide for their people and how to achieve it. Education is said to have both a narrow and wider meaning. There are also arguments arising from how best to provide it.

This paper does not intend to engage in the various arguments or dimensions of the meaning of education. Rather, the paper toes the path of education philosophers such as Paul Hirst and R.S. Peters, who conceived of education as a process of transmitting those things in society, that are

of worth. This includes, among others, knowledge and understanding (the cognitive perspective), skills, norms, competencies, information, etc., and the procedures and methods to be applied in so doing. The method used in educating must be morally and pedagogically acceptable and must not dehumanize the educatee. This concept of education is normative, as it lays down certain criteria and standards which should be satisfied before the process(es) qualify as educational. This conception of education may be equated to the notion of liberal education, which has its grounding in disciplines (subjects) in which knowledge is valued as an end in itself.

However, such a view of education tends to negate the schooling or socialization conception, which emphasizes ―vocation and stresses the extrinsic purpose of education, as well as the usefulness of knowledge and skills in preparing the educatee (child/learner) for life in general.

Our National Policy on Education has captured a good blend of these two approaches. For example, the primary school level (Lower Basic and Middle Basic) emphasizes vocational and socializing aspects, which also continues at the secondary level (Upper Basic and Senior Secondary) but with the injection of a reasonable slice of liberal education. However, at the tertiary level, liberal education finds its fullest expression in all vocational/career preparation of the youth. Education today anywhere on planet earth must be geared towards sustainable development and the vocational career preparation of the youth.

What is Science?

Science may be defined here, in agreement with the STAN Position Paper 2 (1992), as a rationally structured knowledge about nature, which embraces systematic methods and positive attitudes for its acquisition, teaching, learning, and application. Science has a nature which distinguishes it from other non-science subjects. The nature of science refers to how science works, the epistemological and ontological foundations, how scientists operate as a social group, and how society itself influences and reacts to scientific endeavors (Clough, 2011). This has been a missing component of our science teaching and learning. Additionally, science is critical to tackle complex challenges for humanity such as climate change, biodiversity loss, pollution, and poverty reduction, as it lays the foundation for new approaches and solutions.

Science Education: This is the field concerned with the sharing of science content and the teaching and learning of science at all levels of education, in order to build an understanding of the scientific community and its practices.

The goals of science education in Nigeria, according to the National Policy on Education (FRN, 2004), are:

- To cultivate an inquiring, knowing, and rational mind for the conduct of a good life and democracy;
- To produce scientists for national development;
- To service studies in technology and the cause of technological development, etc.

Science education in the 21st century requires that learners are adequately prepared to meet the challenges of the scientific Information, Communication, and Technology (ICT) environment. Okoronka et al. (2018) submit that this task is not as easy as teaching science for career and occupational choice, which has been the practice in the recent past. Science education today has the additional job of producing a scientifically literate society that understands and appreciates scientific culture.

This implies that the emphasis in teaching and learning science is no longer just to produce

would-be future scientists, but also to teach and inform the larger population of nonscientists. This is essential even if it is just to fulfill the objective of scientific literacy a necessary requirement to survive and contribute positively to resolving issues in our world today.

Sustainable Development: The definition and conceptions of sustainable development (SD) have generally depended on the background and/or interest of the person defining it, as well as the disciplines involved. However, experts adopt a multi-disciplinary approach in elucidating its meaning (Oyeshola, 2008). According to Lele (1999), sustainable development is a way of life and an approach to social and economic activities for all societies, rich and poor, which is compatible with the preservation of the environment. Pearce and Walford (1993) defined sustainable development as a process in which the natural resource base is not allowed to deteriorate. These definitions emphasize the irreplaceable and underappreciated role of environmental quality and inputs in the process of raising real income and quality of life.

Furthermore, the World Commission on Environment and Development (WCED, 1987) defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This definition emphasizes development strategies that would ensure continued economic growth and ecological stability without the wasteful and destructive exploitation of natural resources. In other words, economic development must take into account the impact of development activities on the environment. Captured more succinctly, sustainable development should combine concerns about the environment with economic issues. The current trend is to view sustainable development as a concept that sees our lives, activities, and society as nested within the environment.

The Stockholm Conference (1972), which emphasized social and human-centred development rather than the limited view of conservation, supports the idea that humanity's security, existence, economy, and well-being—both now and in the future—depend on the environment (Hopewood et al., 2005). Besides, environmental issues and problems are seen as global rather than local. Also implied is the principle of social justice, which ensures that emphasis is placed on human development, the eradication of poverty and other forms of inequalities, and ensuring that all people get a fair share of resources is equally implied.

Issues, Challenges, and Prospects

Issues: refer to questions that require decision-making rather than definitive solutions. They are often contentious, debatable, and controversial, representing points of dispute. In general, issues are unresolved problems or unsolved puzzles that underlie ongoing debates about certain phenomena. They constitute important subjects of argument or discussion. In the context of science, issues may be moralized and can generate social, cultural, economic, environmental, or even religious disputations.

Challenges- within the context of this discourse, refer to difficulties or tasks that stimulate interest and effort toward accomplishment or resolution. A challenge can be viewed as a problem, a matter that is difficult to settle or solve and a source of perplexity. Generally, problems can be addressed through specific techniques or strategies. Research, for instance, is often described as the scientific problem-solving approach. It is important to note that while not all issues are problems, some issues can indeed be framed as solvable problems.

A **prospect** is an expectation or vision of what might or will happen in the future. Prospects may indicate potential success or failure. Thus, examining the prospects of science education for sustainable development (SD) involves evaluating the likelihood of achieving its stated goals.

Science and science education in Nigeria are critical for addressing complex challenges and issues facing society such as climate change, biodiversity loss, pollution, and poverty reduction as they provide the foundation for innovative approaches and solutions. Furthermore, the issues and challenges hindering science education system, as a tool for the sustainable development of the nation require a clear identification of its hindrances. A collaborative way forward must be through collective efforts such as those provided by this paper.

Background of Science Education in Nigeria

The earliest introduction of Western education in Nigeria was facilitated by missionaries. The Church Missionary Society (CMS) established the first primary school in Badagry, Lagos, in 1848. The primary objective of missionary education was to train evangelists and catechists to assist in achieving their evangelistic goals (Okoronka and Adeoye, 2006), rather than to foster self-reliance among the recipients. This agenda also underpinned the post-primary schools they established later in the second half of the 19th century.

These schools followed three major patterns, summarized as follows:

- **Grammar or Classical Schools:** Emphasized a liberal education.
- **Teacher Training and Pastor Training Schools:** Focused on Christian religion and philosophy.
- **Vocational and Agricultural Schools:** Prioritized practical skills such as carpentry, horticulture, painting, and plumbing to provide lower-level manpower for maintaining the missionaries' infrastructural facilities and churches.

Consequently, science teaching and learning during this period were, at best, speculative and rudimentary. No formal or systematic attempt was made to teach science and mathematics. Several reasons accounted for this state of affairs, which included, among others: the high cost of science education (requiring laboratories, equipment, and materials), the lack of a uniform curriculum, and a shortage of qualified science teachers.

However, a shift began following the establishment of King's College, Lagos, in 1909 by the colonial government. This was largely in response to mounting pressure from early nationalists and freedom fighters. The establishment of this institution provided a significant boost to education in general, and to science and mathematics education in particular, across the country. It featured the first dedicated Physics, Chemistry, and Biology laboratories, designed to prepare candidates for the Cambridge Senior Local Examinations.

Despite this development, the British colonial government, much like the missionaries before them, was not genuinely interested in fostering science and technology for Nigerian self-reliance. For instance, it is noted that the first Governor-General of Nigeria, Lord Lugard, believed that ―Africans lacked what it takes‖ to study science and mathematics. Consequently, the introduction of science and mathematics in Nigerian schools was marked by insincerity, half-heartedness, and reluctance.

The colonial focus remained on inculcating the basic skills of Reading, Writing, and Arithmetic (known as the 3Rs) in the grammar schools. This approach served to produce a low-level workforce—such as secretaries, interpreters, and domestic helpers—to serve the colonial administration. There was little to no orientation toward producing self-reliant or entrepreneurial graduates.

This historical antecedent has set a persistent stage for science education in Nigeria, the effects of which are still felt today. This legacy needs to be critically interrogated as science educators make concerted efforts toward achieving sustainable development (SD). A crucial question remains: How have these historical factors impacted science teaching and learning in our schools?

Science Education, Sustainability, and Sustainable Development

Mrs. Kunisato, the Japanese Ambassador Extraordinary and Plenipotentiary and Japan's Permanent Delegate to UNESCO, states that sustainability science, in combination with education, has a key role to play in achieving sustainable development (SD). Sustainability science (as defined by the PNAS website) is an emerging field of research dealing with the interactions between natural and social systems and how those interactions affect the challenge of sustainability—meeting the needs of present and future generations while substantially reducing poverty. Scholars in this field consider how science can best accelerate the attainment of the Sustainable Development Goals (SDGs).

The Independent Group of Scientists appointed by the UN Secretary-General in 2019, led by

Brandtland and Groharlem, noted that the adoption of the SDGs ―was a key moment in building a consensus for urgent, inclusive action.‖ The group further asserts that as the world faces the imperative of tackling climate change and responding to radical, fast-paced shifts in global technology, consumption, and population patterns, a growing consensus recognizes sustainable development as the only viable path to avert environmental and social disaster.

The report further submits that the challenge of sustainable development is to secure human well-being in ways that are not only safe—meaning they do not threaten the Earth's systems with irreversible change—but also just. Ultimately, they add that sustainable development should be pursued by finding pathways that ―enable a good life for all, leaving no one behind, while safeguarding the environment for future generations and ensuring planetary justice.‖ These authors identified six essential points of interconnection across the SDGs and targets necessary for accelerating transformation, which include:

(i) Strengthening human well-being and capabilities

(ii) Shifting towards sustainable and just economies

(iii) Building sustainable food systems and healthy nutrition patterns

(iv) Achieving energy decarbonization with universal access to energy

(v) Promoting sustainable urban and peri-urban development

(vi) Securing the global environmental commons

The challenge facing science and mathematics educators is, therefore, to fashion ways and means to purposefully engage our teeming youth and learners through direct experiences and focused reflection. The goal is to increase their knowledge, develop their skills, clarify their values, and build their capacity to contribute to solving the social, environmental, economic, cultural, scientific, and technological issues of development by applying knowledge derived from science education.

This endeavor raises critical questions:

- What type of curriculum should we advocate?

- What should be the content of such a curriculum to constitute the intended learning experiences?
- What approaches and strategies should we adopt for teaching and learning?
- What assessment techniques are adequate for evaluating such a curriculum?

In making choices and decisions regarding these questions, it is important to recall the three predominant approaches to implementing sustainable development found in the literature (Hopwood et al., 2005).

The first approach assumes that business is the primary driver of sustainability. Advocates of this model posit that the solution lies in changing the role of government to reduce taxation, cut social welfare spending, promote privatization, and deregulate industries. They believe that improved management techniques, increased information flow, shifts in values, and new technology—all operating through the market mechanism—are the best means to achieve sustainable development. Proponents of this approach essentially advocate for maintaining the status quo with minor adjustments, a model reminiscent of the policies in Nigeria's post independence and post-civil-war eras. The second approach advocates for sustainable development (SD) through reforms. This perspective asserts that profound shifts in policy and lifestyles are indispensable. Consequently, it emphasizes persuading governments and international organizations to implement necessary reforms. Proponents, who often include academics, NGO experts, and some public agency officials, base their arguments on technological innovation, sound scientific research, information dissemination, market modifications, and governmental restructuring.

Reformists acknowledge the pivotal role of government in driving SD, arguing that the private sector requires regulation, tax and subsidy reforms, directed research funding, and public information campaigns to align with sustainability goals. This approach also entails political reforms to enhance democratic processes and public participation. However, influential voices within this school, such as Schumacher (1993), contend that reforms should ultimately aim for transformation, advocating for an economy ―run as if people matter.‖ This approach parallels Nigeria's experience with the Structural Adjustment Programs (SAP) under the Ibrahim Babangida regime in the 1980s.

The third and final approach to SD is **transformation**. Transformists argue that contemporary environmental and social crises are rooted in the foundational structures of modern society and the nature of human-environment interactions (Hopwood et al., 2005). They posit that a fundamental transformation of human societies—one that prioritizes ecological integrity is imperative to avert future collapse. For transformists, mere reform is inadequate. They call for comprehensive social and political mobilization that includes groups traditionally excluded from power, such as indigenous communities, the poor, the working class, women, and children. Leading theorists like George (1999) and Rees (1995) maintain that social and environmental systems are so profoundly interconnected that without radical change, the entire socio-ecological system risks catastrophic breakdown. Thus, transformation ideology is fundamentally committed to social equity, ensuring universal access to livelihood, health resources, and meaningful participation in economic and political decision-making processes will guarantee sustainable development (SD). Where these are lacking, however, inequality and environmental degradation are inevitable (Hopwood et al., 2005), as is evident in our present society.

Oyeshola (2008) recommends a transformation model that builds a systematic relationship between population, resources, and sustainable development. Transformation must be holistic, all-embracing, and less destructive, incorporating measures that build peace and prevent conflict. This approach serves not only to reduce poverty but also to prevent its infliction on the most vulnerable members of society, such as women and children.

It is worth recalling that this model was adopted by the Federal Government of Nigeria in its "Transformation Agenda" (2011-2015) for implementing the Millennium Development Goals (MDGs). The MDGs have since given way to the more universal Sustainable Development Goals (SDGs) of the UN's Agenda 2030, which comprises 17 global goals. Unlike the MDGs, which targeted developing countries, the SDGs apply to all nations. The SDG agenda, with its 169 targets, builds upon the MDGs and strives to complete what was not achieved in the previous 15 years. A pertinent question for this forum is: How can our science education programs are aligned with these well-articulated global goals to achieve sustainable development for our dear nation, Nigeria?

Issues and Challenges to Science Education and Sustainable Development

Issues and challenges in science education can be viewed from two perspectives. The first is the global perspective, arising from the globalized nature of sustainable development issues within socio-cultural and environmental contexts. Global issues include climate change, water scarcity, the energy crisis, biodiversity loss, and population explosion. These challenges require global action and strategies, in contrast to local issues such as community clashes (e.g., farmer-herder conflicts), religious practices, and political and social issues, which may be exacerbated by global pressures.

Global issues can be addressed through science education as an instrument for sustainable development (SD), empowerment, and social transformation. The goal is to cultivate an informed, ecologically literate, thoughtful, and empathetic citizenry. This is the core purpose that scientific literacy content in our science education programme is designed or should be designed to achieve. However, it must be noted that this perspective is not yet widely popularized nor clearly understood by science teachers. Furthermore, there are no textbooks deliberately written to address these global sustainability issues. In contrast, local issues must be addressed through Local Community Development (LCD) initiatives involving science actions related to poverty alleviation, reducing inequality, fostering economic growth, and promoting civic and cultural orientations. More specifically, applied to our science education efforts in Nigeria, we face profound local challenges. These include:

- Inadequate funding
- A lack of instructional and infrastructural facilities and materials
- Gender inequality
- The use of ineffective instructional strategies and methods
- Poor motivation and incentives for science teachers
- Weak policy implementation
- Political and religious resistance to cutting-edge science teaching, learning, and ICT integration
- Rampant examination malpractice

These, among several other local issues of SD, must be addressed through local and national action rather than global initiatives. A central question by this paper is: How can our science educations programs rise to these challenges to play a significant role in Nigeria's sustainable economic growth, poverty reduction, and human capital development?

Prospects of Science Education for Sustainable Development and the Way Forward

Science and its education, experts claim, hold the greatest potential for delivering the dividends of sustainable development (SD) at global, national, and local levels. This is because its primary focus and catchment are the youth. Keyle (2020) asserts that educational discourse oriented toward addressing the SDGs should focus on the youth their goals, aspirations, desires, and needs. The author notes that youth (ages 10–24 years), who currently number over 1.8 billion (24% of the world's 8 billion population), represent the largest segment that is underserved. The active engagement of youth in SD efforts is therefore imperative for achieving the goals of the 2030 Agenda.

Youth are not only beneficiaries of the Agenda but are also critical stakeholders with essential roles to play in the implementation of the SDGs. Onwu and Keyle (2011) categorically state that youth represent the future, which offers new opportunities for:

(i) Education, entrepreneurial, and skills development initiatives

(ii) Community development and social transformation

(iii) Equitable and sustainable economic growth and

(iv) Addressing the many global challenges facing humanity.

In addition, science as a human activity is underpinned by values that align with other fundamental human values. The strength and safeguard of science rest on the principles of freedom, notably: free inquiry, free thought, free speech, tolerance, and cooperation. These principles are hallmarks of respect for human rights, freedom, and democracy. Science learners should be trained to exercise creativity, engage in debate, and express dissenting views in the process of learning science. Through experiencing such an education in science, Keyle (2020) posits that youth may acquire important insights into social change, systems thinking, citizenship, and democracy.

At our national and local community level, Nigeria has a youth population of over 30 million within its total population of over 200 million people. This represents 15% of the population in the active school-going age range of 10 to 24 years. This is a huge demographic with immense potential for driving positive change and action toward the attainment of the SDGs, provided it is systematically targeted through a progressive and pragmatic science education programme. The demonstrated role and impact of youth during the last (2023) presidential elections speak volumes about the influence they can exert in our society when properly and adequately mobilized.

The way forward for attaining the Sustainable Development Goals in Nigeria is, therefore, to harness science education to mobilize the youth. We should consider and apply what Dewey (1900) calls progressive education by orienting our science instruction toward real-world, experiential, and context-based approaches to teaching and learning. The barrier created by the lack of connection between science and learners' day-to-day lived experiences, which diminishes the relevance of science in their lives, must be removed. This can be achieved by integrating Indigenous Knowledge Systems (IKS), ethno-cultural activities, and local resources into our science teaching and learning.

We must teach science in a way that demonstrates that a full understanding of scientific findings is incomprehensible outside the socio-cultural settings that offer purpose and meaning to the science learner.

Conclusion

This paper has critically examined the imperative of aligning science education with the goals of sustainable development (SD) in Nigeria. The analysis reveals a persistent tension between the transformative potential of science education and the formidable challenges that constrain its historical legacies of colonial and missionary education, infrastructural deficits, outdated pedagogical practices, and systemic barriers to effective policy implementation.

Despite these challenges, the prospects for reform are significant and hinge on a fundamental reorientation of purpose and practice. The findings underscore that science education must transcend its traditional role of producing scientists and instead focus on cultivating a scientifically literate citizenry equipped to address complex socio-ecological problems. This

necessitates a pedagogical shift towards experiential, context-driven approaches such as problem-based learning, service learning, and the integration of Indigenous Knowledge Systems (IKS), which connect learning to students' lived experiences and local sustainability challenges.

The pivotal role of Nigeria's youth, a substantial demographic cohort, emerges as a central theme. Harnessing their potential requires designing science education that fosters critical thinking, ethical responsibility, and active citizenship, ultimately empowering them as agents of change in achieving the SDGs.

Therefore, the transformation of science education is not merely an educational objective but a prerequisite for sustainable national development. This demands concerted efforts in curriculum redesign, teacher professional development, and strategic policy implementation. Future research should focus on empirically evaluating the impact of these transformative pedagogical models and developing scalable frameworks to integrate education for sustainable development across diverse Nigerian contexts, ensuring that science education fulfills its critical role in securing a sustainable and equitable future.

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