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PEDAGOGICAL CHALLENGES IN SCIENCE EDUCATION CURRICULUM IMPLEMENTATION IN NIGERIA: DIGITALIZATION OF INSTRUCTION TO THE RESCUE

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Abstract **-** The effectiveness of science education curriculum implementation depends on several factors including pedagogical practices. Pedagogical practices including planning, instructional delivery, and assessment greatly impact on the nation's educational system. Pedagogical practices involving the deployment of traditional methods hinder the successful execution of the curriculum due to certain challenges. These challenges can be categorized into three: planning including catering for diverse student needs, resource and time limitations; delivery encompassing inadequate teacher content mastery, ignorance of pedagogical innovations, overcrowded timetable and classrooms; and assessment including large classes, inadequate assessors, inclusion, measurement issues, accessibility issues, plagiarism and poor feedback mechanism. This paper addresses the identified challenges, suggesting the digitalization of instruction as the way out. Due to its crucial roles in revolutionizing the classroom pedagogical practices, there is need for the government to formulate friendly policies that support the seamless adoption of digital tools in schools. Additionally, capacity building training should be organized periodically to train and retrain science teachers on how to integrate emerging technologies into classroom instructions to support instructional planning, delivery and assessment.

Keywords: Pedagogical challenges, science education, digitalization, digital tools

Introduction

Science education is a vital component of any educational system, playing a multifaceted role in supporting human capital development and technological advancement. In today's competitive era, science education plays a crucial role in shaping the future of developing nations towards meeting sustainability goals. Badmus and Omosewo (2018) opined that developed nations attribute their success to advancements in science and technology which are closely tied to socio-economic development. This suggests that a country's scientific and technological development is a key indicator of its overall advancement and global standing. Nigeria, as a developing country, recognizes the importance of science education in driving economic growth, and global competitiveness. Regrettably, science education which encompasses the teaching and learning of science has been associated with gross inadequacy in Nigeria (Kola, Gana, & Olu, 2019). This includes a decrease in students' enrollment in

science, poor learning outcomes, inadequate teaching methods and learning resources, lack of access to and unequal gender participation in science.

Amidst the importance of science education in advancing socio-economic advancement rationalizing the need for structural and content reforms, there are numerous issues confronting the full implementation of science education curriculum in Nigerian schools. Among these outdated curriculum content, distorted academic calendar, inadequate funding, lack of science textbooks and laboratories for experimentation, shortage of qualified science teachers, lack of teachers' motivation, pedagogical challenges and curriculum overload occupy the stumbling block to effective implementation efforts (Ezechi & Ogbu, 2017). Additionally, the disparities of access to education by marginalized groups also truncates the full realization of the objectives of science education in Nigeria (Babajide, 2015). Addressing these concerns becomes pertinent to improving science education curriculum implementation across all levels of education in Nigeria. Hence, there is a need to revisit the science education curriculum through critical revision and reform to produce new science curriculum frameworks, aimed at repositioning the quality of science instruction in line with current trends.

Refocusing science education to address societal needs is crucial in an era of technology. Refocusing science education curriculum involves reviewing the curriculum to accommodate innovative areas of needs such as computer literacy, robotics, information technology, sustainable chemistry, population studies, global warming, science technology and society education, science technology art and mathematics education, science for disadvantage groups, ethnoscience, and science for all. Additionally, the use of learning facilities like zoom, google meet, and WhatsApp can provide alternative access to education (Subagia, 2023). These innovations can also address marginalization and promote access to science education, resolve environmental pollution, provide security solutions, promote global competitiveness and advance economic growth. Therefore, given the critical role of science education in preparing students for problem-solving, technological advancement and global engagement in a rapidly changing technological landscape, it is essential to align the science education curriculum with international best practices to achieve national objectives.

Therefore, this paper focuses on pedagogical challenges, succinctly exploring digital solutions to curb the situation to ensure the effective implementation of science education curriculum at all levels of education. Digital solutions involve the integration of science education curriculum with digital tools for improve efficiency of pedagogical and content delivery. Through digitalization of instruction, teachers and students can seamlessly navigate the teaching and learning environment to achieve the expected outcome using various digital technologies to foster collaboration, real-time presentations and sharing of contents, plan class activities and provide real-time assessment and feedback.

Concept of Science Education and Science Education Curriculum

Science education is one of the critical fields of study in the Nigerian educational system. Science education involves disseminating scientific processes in the form of methods and products encompassing theories, principles and laws to learners who are not considered traditional members of the scientific community. Simply put, Science education involves the teaching and learning of science. Aina and Ayodele (2018) conceptualized science education

as the teaching and learning of science with the goal of applying the scientific knowledge to benefit the society and promote sustainable development. Similarly, Adolphus (2020) noted that science education involves the training of future scientists and teachers who would be equipped with relevant skills and knowledge to effectively communicate the principles and applications of science to learners. Through science education, the knowledgeable members of the scientific community (science teacher) share the scientific knowledge with the students, thus empowering them to contribute to the development of society. Therefore, science education aims to provide students with a deep understanding of scientific concepts, enabling them to apply the knowledge to solve real-world problems and promote sustainable development. The primary objective of science education is to promote inquiring and critical thinking, nurture scientists and equip students with scientific literacy, enabling them to navigate everyday life, and to contribute to the nation's economic, environmental, and social development. Adolphus (2020) opined that science education is seeks to equip younger generation with the right values, knowledge and skills necessary to drive community and national development. According to the National Policy on Education (2004), the goals of science education are:

- To foster the acquisition of knowledge and understanding of concepts, principles, and laws through systematic investigations.
- To facilitate the acquisition of a range of cognitive, affective, and psycho-motor skills and processes which results in direct involvement in science activities, procedures, or applications in the laboratory or the field.
- To foster the utilization of scientific knowledge and processes in the pursuit of further knowledge couple with the ability to function autonomously in an area of study to solve practical problems and to communicate findings to others.
- To foster the attainment of a certain view of the world, together with understanding how it complements and contrasts with other's views in organizing knowledge and inquiry.
- To enable the attainment of a basic understanding of the interaction between science and society and society.
- To provide manpower in the pure and applied sciences.

Although the policy goals seem attractive, there is a mismatch between policy statements and implementation of the science education curriculum in Nigeria due to challenges leading to implementation gaps. Science education curriculum in Nigeria has been structured into two components, comprising Basic science and Core Sciences. According to the Nigerian 6-3-3-4 system of education under operation, the implementation framework for science education curriculum begins at the primary school (lower basic) level where the content of science is taught as an integration of the elements of physics, chemistry, and biology with increasing complexity up to the junior secondary school (upper basic level) by science teachers who possess at least the Nigerian Certificate in Education (NCE) in Basic or Integrative science options. The science education curriculum design under the 6-3-3-4 educational system for senior secondary level is delivered as core subject disciplines namely, physics, chemistry, and biology, ideally by qualified teachers (possessing at least a university degree in content area) who are specialists in respective subject areas. Regrettably, due to the

shortage of qualified science teachers, and poor funding, teachers other than the core subject specialists are allowed to teach the core science subjects in school. These teachers lack the pedagogical content knowledge (PCK) needed to effectively facilitate students' conceptual understanding and real-world application of the disciplinary concepts, thereby posing pedagogical challenges in curriculum implementation.

Pedagogical Challenges in Science Education Curriculum Implementation

The concept of pedagogy in curriculum implementation extends beyond the mere concept of teaching methods to the instructional design or planning, delivery and assessment. In classroom implementation of the science curriculum, science teachers are expected to plan the lesson, follow the plan to deliver the content to students, and access the outcome of the lesson to determine its effectiveness.

Instructional Planning

Instructional planning is a complex process that clearly indicates how teachers design their instructions (Hatch & Clark, 2021). Planning requires identifying the topic, specific objectives, and teaching method, strategy or approach, selecting the resources (instructional materials), determining the assessment type and the method of providing feedback. Although planning is a critical component of classroom pedagogical practice, several challenges hinder its effectiveness leading to science education curriculum implementation failures. These challenges include:

- **Insufficient Resources**: science instructions require practical application. Inadequate resources needed to facilitate instructional delivery can mar the process. Adeyemi (2019) noted that limited access to resources such updated science textbooks and functional laboratory resources can hinder instructional planning and implementation.
- **Overloaded Curriculum**: The science curriculum is often crowded with many contents to be covered over a short period. The overly broad or dense curriculum could be challenging for teachers to plan the lesson (Badmus & Omosewo, 2018). This can greatly affect its implementation negatively.
- **Time Factor:** In Nigerian schools, especially government own schools, the teacher to student's ratio policy is not implemented, teachers struggle to teach multiple classes with large class sizes. Hence, plan several lessons within the limited available time. This can lead to implementation challenges (Eze, 2019).
- **Lack of qualified teachers**: Unqualified teachers generally struggle with lesson planning. This challenge hinders the full implementation of the science curriculum. This is because ineffective planning leads to poor delivery and assessment.

Instructional Delivery

Instructional delivery involves the step-by-step presentation of the lesson according to the plan using specific teaching methodology to achieve the behavioural objectives. This process is usually affected by various challenges. Some common challenges that science teachers face in the classroom during lesson delivery include:

- **Large class size**: Teachers often struggle to engage and support all students in a large classroom, making it challenging to effectively execute the lesson plan.

- **Overcrowded curriculum**: Science curriculum has too many contents to be covered within a shorter period. This makes the traditional teacher to be unsupportive in delivering the lesson. Hence, mar the implementation process.
- **Lack of teacher motivation:** poor working conditions and learning environment can hinder effective delivery. For instance, teachers tend to be poorly committed to teaching where resources for teaching and learning are unavailable.
- **Lack of classroom management and engagement**: It is practically impossible to engage a large student population and control unwanted behaviour while presenting a lesson effectively within the limited period.
- **Inappropriate pedagogical methods**: science curriculum implementation is highly affected by poor teaching methods. Traditional methods often lead to increased misconception load and rote learning by students.
- **Examination focused instruction**: science education curriculum implementation is greatly influenced by examination-purpose driven instructional delivery.

Instructional Assessment

Assessment is an appraisal of students' understanding, achievement, and competencies, to provide feedback needed to make informed decisions (Mustamin, 2024). Assessment is crucial to determine if the stated specific behavioural objectives for a given instruction have been achieved. Whether formative or summative (Ismail, Rahul, Patra, & Rezvani, 2022). Current assessment practices in Nigeria do not align with the objectives of science education. The challenges include:

- **Time constraint**: Limited time allotted for science instruction in the crowded timetable affects the quality of instructional assessment. Teachers tend to utilize traditional assessment methods which are knowledge-based.
- **Lack of Access to Education**: summative assessments usually suffer setback due to distance between the place of examination and the students' location. This severely influences the level of science education curriculum implementation.
- **Poor assessment methods and tools**: poor assessment tools produce unreliable results. Many teachers utilize obsolete assessment methods such as paper and pencil methods which often test students' knowledge of the concepts rather than problem-solving skills.
- **Poor data management systems**: the system usually suffers from poor assessment data management systems. Data banks are useful for making references and retrieving important data for supporting on-going or summative assessments. Therefore, science curriculum implementation suffers setbacks due to the unavailability of functional data management systems.
- **Poor feedback mechanism**: providing feedback aid quality instructional decision making. This feedback could potentially strengthen continuous assessment. Therefore, poor feedback on students, teachers or pedagogical methods can hinder effective science curriculum implementation.
- **Subjectivity and bias**: overcoming subjective influences in assessment is key to improving curriculum efficiency. Many traditional assessment techniques lack objectivity

because they contain validity and reliability traits arising from assessor's bias in scoring and grading students' tests, activities or reports.

- **Plagiarism**: Plagiarism is a major concern in school assessment. Due to large class size and teachers' burnout, teachers find it difficult to curb plagiarism with manual methods. Therefore, the need for advanced techniques.

Digitalization of Instruction as Solution to the Pedagogical Challenges

Digitalization is the process of developing processes and changing the methods or workflows to enhance the manual system. It primarily focuses on integrating digital technologies to transform manual operational approaches for increased efficiency (Gradillas & Thomas, 2025). In education, digitalization involves the integration of digital technologies into everyday teaching and learning. In contemporary era, the use of traditional teaching materials and methods are becoming obsolete because they do not support science students' acquisition of 21st century skills. Therefore, the need for the digitalization of instruction involving the integration of digital technologies into planning, delivery and assessment. The following digital tools can be integrated into science education curriculum delivery to improve their implementation effectiveness and efficiency:

1. **Instructional planning tool:** Several digital tools have been developed to support lesson planning. They include:
   - Eduaide: this is a teacher-created platform that uses AI to assist the teacher to create interactive lessons designs, plan lessons, and generate content.
   - Lesson plan generator: this is a versatile AI powered tool that is designed to help teachers to speedily develop well structured, engaging and customized lesson plans that match subject specific areas, educational standards and learning objectives.
   - AiPlanbook: this is an AI powered tool that has been designed to assist teachers in planning and organizing lesson activities.
   - Open Educational Resources (OER): these are educational materials (including lesson plans, journals, textbooks etc.) that are freely accessible, openly licensed, and can be used by teachers to develop lessons content. Examples include OER commons, open course library, open education consortium, wikibooks, college open textbooks etc.
2. **Digital tools for instructional delivery:** several digital tools have been invented to support teaching in our schools. They include:
   - Interactive whiteboards: these are touch-sensitive display boards that allow teachers to draw, write, and annotate on display content. It also allows teachers to engage students and facilitate brainstorming.
   - Video conferencing technologies: these are digital platforms that allow the teacher to deliver lessons to students remotely. Platforms such as Zoom and google meet have been used to deliver lessons and receive feedback virtually.
   - Gamification tools: gamification is the creative process of integrating game element into teaching and learning to motivate, engage and enhance students' academic achievement (Li, Ma, & Shi, 2023). Examples gamification tools include EdPuzzle, ClassPoint, and Breakout EDU.

- Schoology and Edmodo: these digital tools have been developed to enable sharing, collaboration and communication between teachers and students for foster teaching and learning.
- Augmented reality (AR): these are technologies that animatedly blend real-world environments and context-based digital information. Today, mobile AR Apps use head mounted displays, cameras, GPS sensors, and internet access of smartphones and tablets to overlay real-world environments with dynamic, context-based, and interactive digital content. These technologies can be used to facilitate effective teaching and learning of science.
- Virtual reality (VR): these are technologies that can display objects as if they were in the real world (Ningsih & Firmansyah, 2020). VR brings users to be able to enter a state that is visualized as if it were real or happening in front of them and has been applied to support student learning (Fitria, 2023).
- Virtual laboratories: these are interactive science digital simulations of activities that naturally occur in physical laboratory situations. These platforms tools simulate the tool, equipment, tests, and procedures used in chemistry, physics, biology and other subject disciplines. Virtual labs can replace physical labs in situations where the latter are not readily available.

3. **Digital tools for assessment**
    - Google classroom: this is a digital platform that makes learning interesting. This platform can be used by teachers to send and receive assignments, provide feedback and manage time communication between teacher and students.
    - Google forms: these are online forms that are transmitted electronically. Teachers can use google forms to carry out surveys, provide assessments and feedback to students (Ulum, Basuki, & Eliasa, 2023). This enables teachers to maximize time and reduce burnout.
    - Blackboard: this is a digital tool that can be used to create a variety of assessments including tests, quizzes, and assignments. Assessment using Blackboard tool is easy to implement and allows teachers to quickly provide feedback. Students can answer an essay question with a video, a link to a website or other channels.
    - Socrative: This is a digital assessment tool designed for teachers to create quizzes, polls, and interactive activities for students. This tool is useful for teachers to curb plagiarism and reduce subjective influence in grading.

Conclusion

The integration of digital technology into science education can play a crucial role in promoting efficient and effective implementation of the science curricula. Integrating digital technologies offers an alternative route for transforming manual operational approaches in classroom teaching and learning for improved efficiency. Today, science educators can conveniently support their classroom pedagogical practices with various digital platforms and software to create attractive lesson designs, deliver effective lessons, assess students learning and provide feedback. Generally, research has shown that the use of digital tools such as Eduaide, lesson plan generator, interactive whiteboards, video conferencing technologies, gamification tools, AR and VR, Virtual laboratories, google classroom, blackboard and

google forms promote pedagogical practices and improve student' engagement, interest and achievement in science. Therefore, there is need for government and education stakeholders to make policy and curricula provision for seamless integration of digital technologies into Nigerian institutions to improve pedagogical practices for enhanced science curriculum implementation at all levels of education.

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