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EMERGING TRENDS AND CHALLENGES IN SCIENCE EDUCATION

ADESINA, ABIODUN EZEKIEL
ORCID Number: 0000000311500716

GABRIEL, ELIZABETH TOSIN
GENERAL STUDIES EDUCATION, DEPARTMENT SCHOOL OF EDUCATION
EMMANUEL ALAYANDE UNIVERSITY OF EDUCATION, OYO, OYO STATE

Abstract

Science education has been recording dismal academic achievement, skills and attitudinal outcomes in Nigeria. The students, right from the basic education to the tertiary level lack 21st century skills of critical thinking, creativity, collaboration, communication, citizenship, self-regulation, time management, knowledge construction, problem solving, digital literacy skills and many other positive skills expedients for proper employability and entrepreneurship. The conventional, didactic, non-heuristic instructional strategy adopted in teaching science education in the country is already dated at the face of Covid-19 and post-Covid-19 pandemic. The National Science Teaching Association (NSTA, 2012, 2020) of America recommended the Next Generation Science Standard (NGSS) as the trending path to science education productivity through technology integration and reflective thinking. Cybernetics, constructivism and behaviorism theories buttressed the integrating of technology and reflective thinking in science education. Empirical findings equally justify teaching science technologically and with reflective thinking. There are challenges to technological integration in science education, the FUD factors (Fear, Uncertainties and Doubts) about the use of technology in science education, Inadequate ICTs policies and programmes, insufficient technological infrastructures, low ICTs skills and knowledge, poor attitudes to change (status quo sustenance), poor finance, poor management cum maintenance culture, and many other impinging challenges to effective technological integration in basic science education. Public-Private Partnerships (PPPs) in ICTs infrastructural

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development in schools, adequate funding, training and re-training of science education teachers will allay major constraints to effective utilization of technology in basic science education for enhanced productivity.

Keywords: *Emerging trends in basic science education, Challenges in science education, Next Generation Science standard (NGSS).*

Introduction

Science is synonymous to knowledge. Knowledge that is verifiable, reliable, testable and falsifiable. It involves knowledge about nature, the solar system, birds, animals, rock, soil, oceans, air, atom and many other phenomena in nature. What makes the birds to fly, the ship to float on water, plane to fly in space, sun to give light in the day and moon to give illumination at night, offspring to resemble their parents, how living things (plants and animals) grow, reproduce, respire, move, transmits neurons (stimuli), circulate materials and many other events in the universe. The application of scientific knowledge brings technology which curtails drudgery, time and human energy expended in productivity.

The Latin word "sciencia" is equal in meaning to the Greek word "Episteme" which is the same in meaning to the German word "Wissenschaft", the Russian word "Nauka" all meaning that science is a systematic body of knowledge, a universal library of facts, concepts, hypotheses, theories, laws and principles that explain phenomena in nature. Nwankwo and Aniaku (2022) described science as the systematic study of nature and behavior of natural things and that the world development hinge on science and technological advancement. Science and technology have impacted transportation system, communication, agricultural production, commerce and industrial revolution, water development, educational advancement with some level of environmental degradation, which necessitate environmental sustainability.

As expedient as science education is too individual, nations and the instructional community development, students learning outcomes in cognitive, affective and the psychomotor domain of science education remains deplorably low in Nigeria. Research

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finding reveal that students have low academic achievement in Basic Science which triggers negative attitudinal disposition right from the foundational level of science learning. The secondary students in science. Physics, Chemistry, Biology, Agricultural Science, Mathematics and still performing at average level. The West African Senior Secondary Certificate Examination (WASSCE) results still signals those the students' academic achievement in sciences is yet to be at the optimum. At the tertiary level of education, science education still has issues with the development of the 21st century skills, skills like creative critical thinking skills, collaboration, communication, citizenship skills, problem solving, knowledge construction, self-regulation (metacognition) and some other vital skills expedient for employability and entrepreneurship.

Among the challenges of science education in Nigeria and many other nations of the world is the overdependence on the conventional traditional, non-heuristic, didactic instructional strategies adopted in science teaching and learning from the basic education to the tertiary institution of learning (Adesina, 2019; Adebiyi, 2019; Gambari, 2021; Okebukola, 2021; Obanya, 2021). The conventional was articulated of making the students of science less-thinkers, uncreative, poor knowledge constructors, highly competitive in nooks and cranny of scientific facts, concepts theories and laws (Dai, et al, 2021; Irwanto, 2022; Mogelvang & Nylehn, 2022; Adjei, 2022; Aidoo et al, 2022). Another challenge to effective and efficient science education in Nigeria and the world at large is the Covid-19 pandemic. The pandemic short down all institutions in the world including educational industries calling for a paradigm shift since education. The vacuum created by mouths of school closure in Nigeria has hampered, instructional engagement and interactions in science education. The menace of Covid-19 would not have caused havoc to science education had it been the Next Generation Science Standard (NGSS) of National Science Teaching Association (NSTA) of America that science should be taught with technology and reflective thinking (NSTA, 2012; 2020) Technology integration was reported of improving students' productivity in science education (Gambari, 2021; Obanya, 2021; Okebukola, 2021. Olagunju and Adesina, 2017; Adesina, 2022). This article thus discussed the emerging trends

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in science education, the Next Generation Science Standard (NGS) and the challenges in science education, advancing plausible solutions to challenges in science teaching and learning.

Science Education

Education is the process of constructing knowledge that change individual's social, physical, intellectual, emotional, spiritual and all spheres of life. Ehindero (2014) in Olagunju and Adesina (2017) opened that education enhance and empower an individual to use the Genetic Blue Print (GBP) to the fullest in the environment he/she find him/herself. Education makes individual teachable, learnable and skillful individual to meaningfully contribute to the society where he/ she resides (Kolawole, 2022; Akanbi 2022). Therefore, several aspects of education, sociology, philosophy, psychology, test and measurement, educational technology and many others are designed and taught to empower and enhance individuals to be strong and resilient in contributing significantly to the development of the environment. Science education is an aspect of education that instill in the recipients that are not members of science community the knowledge, skills and scientific attitudes expedients in unraveling the mystery in nature. Ige and Oke (2019) described science education as the process of acquainting learners with processes and products of science. The methods of constructing scientific facts, ideas, knowledge, concepts, hypotheses, theories, laws and scientific principles in the learners.

The National Policy on Education (FGN, 2004) stated that science education will emphasize the teaching and learning of science processes and principles. The goals of science education, according to the policy are to:

1. Cultivate inquiry, knowing and developing national mind for the conduct of a good life and democracy;
2. Produce scientists for national development.
3. Services study in technology and the cause of technological development, and
4. Provide knowledge and understanding of the complexity of the physical world, the forms and the conduct of life.

The policy position science education as an essential tool to produce all-round individuals capable of making enquiry, developing inquisitive and rational mind to enhance

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quality of life, utilize knowledge and technology to foster national growth and development.

Agommuoh and Ndirika (2014) opined that science education empowers individuals to use scientific process skills. The students would be able to empirically observe the phenomena around them, identify empirically the problems in the observed causes and effects, formulate workable hypotheses, conduct experimentation, collect valid data, analyze the collected data to make inferences from tested hypothesis, with the objectives of science education, learners of science should naturally develop the 21st century skills of creativity, critical thinking, collaboration, communication, citizenship skills, knowledge construction, problem solving skills, self-regulation, time management, digital literacy skills and many others (government, the students of science education right from the basic to the tertiary educational levels have low learning outcomes in the cognitive, affective and the psychomotor domains of learning in (Adebiyi, 2019; Adesina, 2019; Gambari, 2021; Okebukola, 2021, Obanya, 2021). The low learning outcomes perennial in science education reduces the chances of graduates of science education employability and entrepreneurship.

Emerging Trends in Science Education

One basic (trends in science education is the unprecedented social, economic and environmental issues relating to the creation of new ideas, invent new materials, innovating processes with technology. The speed of growth in data science, bio-technology, artificial intelligence is revolutionizing science teaching and learning in the whole world, will Nigeria be left out?

Blockchain technology is creating financial independence of local, national and regional levels making global value chains and a shared economy possible. The virtual and augmented realities are shaping information, communication and education in the whole world, online learning Massive Open Online Courses (MOOC), synchronous and asynchronous learning management system in cybernetic forms are advancing teaching and learning beyond space and time, Instructional System Design (ISDs), augmented and virtual realities and many other emerging treads in science education entails the computer system or machines been loaded or programmed with data to carry out intelligent functions rationally done by human. It can be exploited

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in laboratory activity, substituting for teacher-students science lesson interactivity and engagement, it has been documented using AI for experimental scientific research using scanning probe microscope (SPM), the AI uses a convolution neural network to assess the quality of data, deep SPM run for several days acquiring and processing data tirelessly in response to varying experimental condition (Krull, et al, 2020). Xue and Wang (2022) affirmed that teachers are being acquainted with common artificial intelligence products such as sound aids, graphics, identify, finger-print recognition, and many others technological applications that help intelligent classroom, robotic assistants which reduced teachers' workload, improving information and digital literacy for enhanced teacher professional development Xu and Quyang (2022) in a general system theory examined the application of AI technologies in STEM education in a systematic review from 2011 to 2021 found that AI holds a profound effects for enhancing STEM education for higher productivity.

In similar reviews by XU and QUuyang (2022), Quyang et al (2022) found that the applications of AI in education include prediction of learning status, performance or satisfaction, resource recommendation, authentic assessment and improvement of learning outcomes. The reported the use of traditional AI technologies as commonly adopted than the advanced AI such as deep learning, genetic algorithm and other advanced ones.

Biotechnology has made wave of impacts as a discipline in biological science education, touching techniques in cell and tissue culture, fermentation technology, cell fusion, embryo transfer, recombinant DNA (r DNA) or genetic engineering there has led to the production of viable and early maturing plants and animals, diseases and pest resistant organisms, closing of organisms (asexual reproduction in animals), test-tube babies (equaling barrenness) and many socio-economic benefits of biotech to the world. Dunham et al (2002) had reported the need for the inclusion of biotechnology into the biological science education curriculum as it provides the bases of techniques for advancement in biological experimentations, increasing understanding and comprehension of the application of technology in biological science. Despite the trending nature of technological applications in almost all field of studies, Chidobi and

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Menlati (2017) reported the low awareness level of senior secondary school students of biotechnological products and services in their environment.

Blockchain technology was first used in the cryptocurrency of bitcoins transaction between the block of cryptocurrency and the users. Blockchain technology find its importance in science education as a tool to facilitate document retention for scientific activities, accessing scientific facts, records of activities of scientists and protecting them from loss. It estimates the scientist's skepticism regarding scientists' experimental and knowledge of scientific concepts themes, laws and principles of science, maintenance of scientific data privacy and patency of scientific innovators and discoveries in science education. It provides database for present and future scientific investigation and empirical studies. Reis-Marques, et al (2022) reviewed in a bibliometrical analysis the applications of blockchain technology to higher education reported that blockchain technology can contribute the improvement of quality and safety of scientific academic activities, enhancing productivity gain, cost reduction and generation of money in scientific investigation, advancement of scientific programmes and activities digitalization and the digital transformation of businesses and scientific inventions. The authors thus recommended the interaction of blockchain technology, artificial intelligence, digital innovation digital maturity in scientific activities.

Because of the trending nature of blockchain technology in science education, Xing and Chang (2022) experimented with a project-based approach for learning blockchain technology by students found that students can comprehend blockchain technology using project-based strategy than the use of conventional teaching method. Min and Bin (2022) research on the online teaching research in university based on blockchain in an experimental study found the integration of blockchain experimental platform to be immersive and interactive course presentation and highly effective in raising students' learning outcomes. Ascione (2023) opined that blockchain technology holds the promise to change much of what plague educational activities today, engaging in real world problem solving, enhances students' motivation, attention sustenance and improve students' learning outcomes.

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Virtual and augmented realities are also trending packages in science education. Virtual realities (VR) are the use of computer technology to create a simulated environment or the term used to describe a three-dimensional, computer-generated environment that can be explored and interact with by science students. Students entices virtual world environment offers possibilities of sense stimulation in vision, hearing, touch even small turning the computer into a door way to an artificial world of virtual experiences. VR provides opportunities for testing and experimenting under number of conditions, they prompt the understanding of the safety rules during laboratory works, they solve the problems of like inadequate devices, instruments and tools in scientific experimentation, it equally solves the problems of time, space and high cost of maintenance and replacement resulting from damages in experimentations (Tsichouridis, et al, 2020).

Augmented reality (A.R) environments alter students' perception of an already existing real-world experiment. A.R was defined by Akcayir and Akcayir (2017) in Yilmas (2021) as a computer-generated image that overlays virtual objects (augmented components) into the real world. There are five major types of AR, viz; projection-based; recognition-based, location based, outlining and superimposition-based ARs. In science education, two main ARs are more common, the recognition (marker)-based and the location-based ARs. ARs have been used in science education to teach the invisible physics forces in dental education, for clinical training, teaching of astronomical concepts, atomic bombs manufacturing, flying a plane, interbalistic missile production, recombination in genes, pregnancy delivery and many other scientific procedures. The results of the qualitative study of Yilmas (2021) revealed that students learn more effectively the abstract aspects of science education using AR. Abdullah, et al (2022) in quasi-experimental study of augmented reality effect in students' achievement, satisfaction and interest in science education found that AR provide better virtual learning environment for pupils' significant development in academic achievement, interest and science-process skills.

In expository research, it was found that Augmented Reality (AR) combined with inquiry-based learning (IBL) can support learning 21st century skills, helping students

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the master and define problems, cognitive scaffolding, immersion and peer interaction cum collaboration leading to the development of high-level thinking skills and creativity. It was equally reported that the simplicity of AR presentation of facts, concepts, theme and laws in science education develops in learners' analytical skills which are expedient in self-regulation and knowledge construct skills (metacognition) (Lee, 2022). Densircioglu et al (2022) in quasi-experimental design determined the impact of augmented reality-based augmentation activities on middle school student' academic achievement and motivation in science classes the findings revealed that augmented reality-based augmentation activities were more effective in increasing students' achievement and motivation than the augmentation and traditional instruction in teaching astronomy.

Another trending issue in science education is the application of the technological software in managing instructions, assessment and instructional analysis known as Learning Management System (LMSs). LMSs enhances science students and instructional facilitation LMSs are public/open sources which are accessible freely while others are private close sources only available for use by payment of subscriptions. Common examples are canvas instructure, edmodo, zoom, docebo, formative, LMS talent, 360 learning, learn upon, Knolyx, Gyrus Aim, Cornerstone learning, etc. LMS has several features like modules, quizzes, games, assignment, collaboration, hangout, instructional analysis, synchronous and asynchronous teleconferencing and many other features that allows embedding of videos and audios facilities to designed instructional modules.

The adoption of Instructional System Design (ISD) like ADDIE (Analysis, Design, Development, Implementation and Evaluation) model in packaging science education contents succinctly presents the modules of instruction in a simple, easy to understand and comprehension instructional pattern. The embedded instructional games, quizzes, assignments, collaboration, videos, audios and many other features to the LMS enthuse and sustain learners' interest in learning, the Immediate Knowledge of Results (IKOR) serves as instructional reinforcement for increased interactivity, engagement and

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optimum learning outcomes (Adesina, 2022; Nguyen, 2021; Al-Sharan, 2021).

Many of their trending issues in science education are appropriately reported in raising the learners' outcomes in the cognitive, affective and the psychomotor domains of science education. The impacts of artificial intelligence, robotic science, blockchain technology, biotechnology, augmented and virtual reality as well as the learning management systems. However, the use, adoption and acceptance of these novel technologies in science teaching and learning in Nigeria is yet prominent in the instructional processes. Many constructs and challenges delimit the integration of these technologies, among are: FUD effects; Inadequate technical know how? Attitudinal barrier; Inadequate technological infrastructures; Psychological factors and Misrepresentation of technology integration in science education (Adesina, 2022; Obanya, 2021; Gambari, 2021; Okebukola, 2021).

OECD (2018) in the future of education and skills education 2030 in finding answer to two major questions that will empower countries of the world; what knowledge skills, attitudes and values will today's students' need to thrive and shape their world? And how can instructional system develop these knowledge, skills, attitudes and values effectively, OECD found that there three main challenges to the rapidly changing world: the environmental, the economic and the social challenges. OECD (2018) thus recommends need for a broad set of knowledge, skills, attitudes and values in science education through Instructional System Design (ISD) with technological integration and reflection this will be in tandem with the Next Generation Science Standard (NGSS) of the National Science Teaching Association (NSTA) of America.

Conclusion

Science education in the rapidly changing world where students have low learning outcomes, poor 21st century skills and deplorable level of employability and entrepreneurship need stringent and urgent actions to revolutionize the learners' outcome. The trending impacts of artificial intelligence, robotic science, biotechnology, blockchain technology, virtual and augmented reality, learning management system and other novel technological applications have been adequately reported in research, however, scanty reports were found within the Nigeria

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shore, due to fear, uncertainties doubts about technological efficacy, the inadequate technical know how? Negative and aversive attitudes towards technology, inadequate technological infrastructures and many other limiting factors to integration of the novel technological tools in education.

Suggestions

The following are way forward towards integration of the trending technologies in science education for increase product:

i. National, state and local government to formulate and share their policy designs and curriculum design experiences related to the integration of the novel technologies framework;
ii. Students, teachers, school leaders and parents to share practical and experiences as concrete examples of using the novel technological in science education;
iii. Experts and researchers in science education to engage more in the pedagogical, empirical and experiential interventional researches to validate locally the impacts of those novel trending technologies in science education;
iv. Professional associations like Science Teachers Association of Nigeria (STAN), Mathematics Association of Nigeria (MAN), Nigeria Union of Teachers (NUT), Colleges of Education Academic Staff Union of Universities (ASUU) and many other professional bodies to share practices of supporting student learning and creating appropriate learning environments for enhanced, integration of the novel technologies in science education Nigeria;
v. Interactional communities like United Nations Education, Scientific and Cultural Organization (UNESCO), United Nations International Children Emergency Fund (UNICEF), United State Ageny for International Development (USAID), Organization for Economic Cooperation and Development (OECD) and many others should consciously supports science education with infrastructures, technological gadgets and scholarships in Nigeria to boost the integration of these novel technologies in science teaching and learning in schools.

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