



Secondary Education STEM Curriculum Implementation in Nigeria: Prospects and Challenges

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Abstract

Nigeria's secondary education STEM curriculum plays a vital role in shaping the minds of future generations through science, technology, engineering and mathematics oriented subjects. The discourse was on ways to improve Nigeria's secondary education STEM curriculum for the benefit of her students and the nation as a whole while exploring both the promising possibilities (prospects) and the current obstacles (challenges) faced by this curriculum. Furthermore, it examined how a well-designed STEM curriculum could equip students with the 21st Century skills such as problem solving, creativity, critical thinking, collaboration, communication skills for industrial and societal development thus enhancing global competitiveness. The paper also unraveled the challenges that hinder effective implementation of STEM curriculum viz: inadequate funding, paucity of qualified teachers, school facilities, instructional materials and student population explosion. It was concluded that students only garner hard skills from the secondary school STEM curriculum in Nigeria and were deprived of soft skills which ought to make them to be imbued with employable and transferable skills. Hence it was suggested that STEM methodology in secondary schools must be reengineered to incorporate hands-on exploratory and inquiry mode of teaching-learning processes so as to incorporate the 21st Century skills for a greater Nigeria with a brighter future for her citizenry.

Keywords: Secondary Education, STEM Curriculum, Prospects, Challenges, Pedagogies, Nigeria.

Reference to this paper should be made as follows:

Amie-Ogan, O. T., & Oguru, C. (2025). Secondary education STEM curriculum implementation in Nigeria: Prospects and challenges. *International Journal of Scientific Research in Education*, 18(2), 204-212.

INTRODUCTION

Education is a tool for nation building, economic empowerment, stability, sustainability and empowerment (Amie-Ogan cited in Amie-Ogan & Diepiribo, 2016). On this premise it was highly rated as an instrument par excellence for effecting national development (FRN, 2008). No wonder, Jhingan (2007), averred that only the educated and trained labour with high productivity and efficiency could lead to rapid economic developments and that the most important requirement for rapid industrial growth is people. This infers that knowledge, skills, abilities and competencies acquired through the levels of schooling and the curricular is a function of the level of productivity of such graduates in the future.

It is worthy of note that industrialization is key to any nation becoming a developed nation. This is achievable through education curricular that are tailored towards science, technology, engineering and mathematics (STEM) at the primary, secondary and tertiary levels of education.

The acronym STEM stands for Science, Technology, Engineering and Mathematics. STEM education focuses on practical learning to develop the necessary skills in students so that they are prepared for the rapidly developing real world. The term 'STEM' was first used by the National Science Foundation, an American Government Agency that promotes research and fundamental education in the non-medical field of science and engineering to encourage students' interest in scientific and technical careers. Its' theoretical framework is based on a formulation by a Mathematician called Seymour Papert who designed a logo and a programming language (turtle language) for didactic purposes which was to aid children to develop logical-mathematical thinking from their early developmental ages. The main goal of STEM is to make students to think critically, prepare them for careers and create professionals that can work across scientific disciplines to solve challenging problems. Generally, STEM integrates multiple disciplines and trains students to use cross disciplinary knowledge to solve problems (techtarget.com).

However, the focus of this discourse is on secondary education. Secondary education is the bridge between primary education and tertiary education. It has duration of three (3) years for Junior Secondary School and three (3) years of Senior Secondary School totaling six (6) years. The government through her National Policy on Education, FRN (2014), gave direction on how the STEM curriculum could be implemented. Hence, secondary education is bifurcated into two sections namely: Junior Secondary Education and Senior Secondary Education. Junior secondary education is the education which a child receives immediately after primary education. The teacher-students ratio is supposed to be 1:35 as against 1:100-150 that is obtaining in most public secondary schools in Nigeria. One of the core objectives of junior secondary school is to provide the child with diverse basic knowledge and skills for entrepreneurship and educational advancement. In pursuance of this objective, its curriculum has the following STEM subjects such as Mathematics, Basic Science and Technology (Basic Science, Basic Technology, Information Technology and Physical and Health Education) and Prevocational Studies (Home Economics and Agriculture).

Again, government in her magnanimity was also to provide the following educational services for Basic Education level and they are: School Libraries, School Health Services, Guidance and Counselling, Educational Resources Centres, Laboratories and Workshops. In the same vein one core objective of the Post Basic Education/Senior Secondary Education is to offer diversified curriculum to cater for the differences in talents, disposition, opportunities and future

roles. Hence the senior secondary education curriculum consists of the following fields of studies namely: Science and Mathematics; Technology; Humanities and Business Studies.

The STEM curriculum of senior secondary education consists of Biology, Chemistry, Physics, Further Mathematics, Health Education, Agriculture, Physical Education and Computer Studies under Science and Mathematics. Under Technology the curriculum consists of Technical Drawing, General Metal Work, Basic Electricity, Electronics, Auto Mechanics, Building Construction, Woodwork, Home Management and Food and Nutrition. Again the teacher-student ratio was designed to be 1:40 students for a hitch-free implementation of the curriculum. Unfortunately population explosion as a result of inexorable rise in students' enrollment continues to truncate proper result-oriented curriculum implementation. Secondary education must observe the teacher/students ratio if the STEM curriculum must be implemented. This is because the STEM class is required to have fewer students for exploratory and inquiry classes where team work and collaboration motivates and engages students in their work thereby fostering the 21st century skills needed for individual, industry and societal gains.

STEM education focuses on practical learning to develop necessary skills in students so that they are prepared for the rapidly developing real world (Circuit, 2024). It was reiterated that STEM learning promotes critical thinking, curiosity, persistence, decision making leadership, entrepreneurship, acceptance of failure and more. These enumerated qualities are meant to prepare youths for their future career paths. The question now is, is secondary STEM curriculum and methodology such that can prepare students for the 21st Century world of work? It is against this background that this paper determined, 'Secondary Education STEM Curriculum Implementation: Prospects and Challenges'.

STEM CURRICULUM

The word curriculum is derived from the Latin word 'currere'. 'Currere' in Latin denotes curriculum. Other researchers also think curriculum is from the Latin word 'currer' which means 'horse racing arena'. This suggests that the curriculum gives impetus to academic programmes to be implemented from one stage to the other until learning objectives are achieved at the end of an academic session.

The acronym STEM stands for Science, Technology, Engineering and Mathematics. The term is a web that connects the disciplines of science, technology, engineering and mathematics noting their relativity to enhance societal development. In the secondary school system, it is highly associated with the school curriculum otherwise referred to as the secondary school STEM curriculum. A curriculum could be referred to as subjects taught in school as well as their contents. Curriculum has also been defined as what is taught in a given course or subject. It also refers to an interactive system of instruction and learning with specific goals, contents, strategies, measurements and resources with desired outcome of successful curriculum transfer and/or development of knowledge, skills and attitudes (R I.gov, 2024). In a related view, curriculum is a standard-based sequence of planned experiences where students practice and achieve proficiency in content and applied learning skills. It therefore serves as a guide to educators as to what is essential for teaching and learning thus enabling students to have vigorous academic experience (RI.gov, 2024). It is the totality of student experiences that occur in the educational process (Rao, Rao & Chalurarayaswamy, 2021).

According to Asolusam (2019), a curriculum is the totality of the learning experience organized for students under the support of the school. Mizan et al. (2022), stressed that the term

curriculum is a dynamic and complex concept that encompasses various dimensions and implications. Furthermore, it was said to be the content design, delivery and evaluation of educational programmes. The curriculum is importantly required in any educational system as a roadmap to shape the type of education a nation desires for her citizenry's social, political and economic development with an intent of increasing such a country's (GDP) Gross Domestic Product. The term refers to the academic content and lessons taught in a school or educational institution or in a specific course or program. It is said to be a well organised plan for conducting educational activities.

CHALLENGES OF STEM CURRICULUM IMPLEMENTATION

The following are some notable challenges militating against secondary school STEM curriculum implementation in Nigeria:

Non Participation of Teaching Staff in Curriculum Planning: Teachers are usually not incorporated in curriculum planning in spite of the key role they play in the functionality of the secondary school curriculum. It is therefore advisable that Heads of Departments and high caliber teachers of STEM subjects should be incorporated into the STEM curriculum committee to effectively plan an implementable STEM curriculum wherein the 21st Century skills are achievable for students future workplace needs. This view was supported by Esu (2006) who opined that until teachers are allowed to fully participate in the curriculum development process, the curriculum, no matter how planned, is likely to be misinterpreted.

Non Completion of Curriculum Development Stages: There are lapses on the part of the government in completing the required stages of curriculum development. Ivowi (2009) stated that the massive testing of curriculum materials before being developed were abandoned from 1985 till date. By this act, the essence of pilot schools for testing of curriculum materials was lost thus causing a major setback to curriculum development.

Lack of Qualified Teachers: Teachers are needed in quality and quantity to drive the implementation of the STEM curriculum but unfortunately the nation lacks teachers in the STEM subjects. This trend has continued to produce "half-baked students" from secondary schools. Unqualified science teachers teaching in secondary schools find it difficult to explain some concepts to students and practically avoid conducting science practicals for the examination classes; thus leaving the students to their fate. In agreement Gaji (2014), in an independent study found that teachers with deeper knowledge of subject matter produced better students than those with shallow knowledge of subject matter.

Lack of STEM Facilities and Materials: Secondary schools in Nigeria generally lack STEM instructional facilities such as laboratories, workshops and libraries. Most of the schools lack laboratory and workshop equipment such as conical flask, test tube, beaker, microscope, bunsen burner, thermometer, funnel, graduated cylinder, burette, tongs, wash bottle, magnifying glass, ammeter, crucible, dropper, spring balance, watch glass, spatula, glove, brush, balance, petri dish, autoclave spectrophotometers, centrifuge, incubator, clinostat, water bath etcetera. The President of Nigerian Academy of Science (NAS) Professor Ekanen Braide upbraided the Federal and State governments for their failure to buy modern science equipment in public

schools across the country which was delaying Nigeria's socio-economic growth (Adaramola, 2022). Similarly, Eya and Elechi cited in Abidoye and Adedeji (2022) stated that some junior secondary schools lack laboratory equipment and materials to learn Basic Science. Also Oloibi cited in Amie-Ogan (2020) posited that facilities and workshops for the practical application of trade and entrepreneurial education was found to be very inadequate. Paucity in facilities would readily lead to poor performance of STEM students in secondary schools.

Poor Funding of Education: Poor funding of the education sector is worrisome to STEM curriculum implementation. This is because the building of laboratories, workshops and libraries require funds. In addition funds are required to procure science equipment and materials so also to obtain science teachers in quality and quantity. The trend of poor funding in Nigeria's education sector could be traced to non-compliance to the 26% budgetary allocation to education by UNESCO. Amadi (2023) in giving credence to the afore, gave the budgetary allocation in percentage to education in the immediate past five years as follows: 2019 – 7.09; 2020 - 6.70; 2021 - 6.60; 2022 - 4.10 and 2023 - 5.40 respectively. These figures confirm that the education sector is grossly underfunded in Nigeria.

Methods of Teaching STEM Curriculum in Secondary Schools: Didactic method of teaching is mostly used in secondary schools in Nigeria. This has orchestrated mass failure in the sciences and enhanced gross examination malpractice in schools. Since didactic method of teaching relegates the student body to mere receptacles of knowledge without being able to apply knowledge in practical terms, the implementation of the STEM curriculum needs pedagogies such as project based learning, problem based learning and experimental learning strategies that involve students' engagement.

Paucity of Digital Instructional Materials: An instructional facility such as the Interactive White Board should be part of STEM classrooms to facilitate the achievement of the STEM curriculum. The 21st century classroom is one with a difference because of integration of technologies for constructive learning of students as well as facilitation of teaching and learning process in schools (Amie-Ogan, 2015). A study conducted by Amie-Ogan and Osuji (2016) found paucity of digital instructional materials in secondary schools viz: scanners, tablets, examination scoring machines, printers, multimedia classroom (audio-visual), close circuit television, video players and tapes/CD, audio players and tapes/CD, digital cameras, video games, webinars, digital library, talking calculators, interactive/smart boards, optic fibres, CD-Rom, MP3 Players, electronic dictionaries, digital textbooks, Powerpoint media, projectors, recorders to record dialogues and presentations in class and flipped classroom models. The availability of the instructional aids enumerated is key to achieving the benefits of the STEM curriculum which the world of work and society yearns for over the years in most developing countries such as Nigeria.

Lack of Staff Development and Training Programmes: Quality education hinges on adequate provision of instructional facilities and aids, qualified teachers with good content knowledge and adequate supply of funds for procurement of school infrastructure, obtainment of qualified staff, staff development programmes and training to keep the staff abreast with trends in knowledge in their areas of specialization and adopting new pedagogies for global competitiveness. Where the reverse continues to be the case then the message at the gate of a University in Uganda with the

following message as cited by Ajienska (2022:32) stirs at the nation to come out of the doldrums of non-implementation of the secondary STEM curriculum and it states thus: ‘Destroying any nation does not require the use of atomic bombs or the use of long-range missiles. It only requires the lowering of the quality of education and allowing cheating in the examinations by students. Patients die at the hand of doctors. Buildings collapse at the hands of such engineers. Money is lost at the hands of such religious scholars. Gossip and bringing down others is built. Justice is lost at the hands of such judges... The collapse of education is the collapse of the nation.’

PROSPECTS OF SECONDARY EDUCATION STEM CURRICULUM IMPLEMENTATION

Despite the challenges, the paper also discussed some eminent prospects of secondary education STEM curriculum implementation in Nigeria. This brings to fore what pedagogies to use for effective STEM curriculum implementation. The best pedagogical approaches to STEM teaching which secondary schools should imbibe include: active learning, personalizing instructions, engaging learners, providing feedback, building learning community, clarifying learning objectives, and using project based learning. These approaches have been proved to improve students’ achievement and interest in STEM fields. Also the use of in-class formative assessment such as quizzes and oral exams and online automatic assessment environments for self-assessment can also support students learning.

Project based learning (PLB) is a collaborative, learner-centered instructional approach where students work in groups to construct their knowledge and gain mastery of the course content. Examples are security gadgets such as: fire alarm and metal detector problem based learning.

Project based learning involves the use of artefact by students to demonstrate their mastery of content knowledge while in problem-based learning students strive to give a solution to an impending problem posed on them. Problem based learning is a self-directed learning which enhances students’ ability to learn independently, collaborate, think critically and solve problems (Okeke et al., 2008). PBL is based on constructivism as students acquire new knowledge through a stated problem, which creates knowledge gaps for them to fill. This process enhances students’ engagement, motivation and competence skills which supports the 21st Century workplace. According to Wrigley and Straker (2015), traditional educational system may no longer be able to supply companies with graduates with the appropriate mix of skill and experience.

Project based learning (PBL) is a student-centered pedagogy through which students are exposed to gain insight to new knowledge through exploring real life problems. It involves active learning and inquiry based learning which is in contrast with rote memorization, paper based, or teacher-led instructions that presents established facts or portrays a smooth path to knowledge by instead posing questions, problems or scenarios (Yasserli et al., 2018).

Experimental learning is known as learning through action; learning through doing, learning through experience and learning through discovery and exploration. These definitions are in tandem with the following maxims:

- I hear and I forget, I see and remember, I do and understand by Confucius 450 BC; and

- Tell me and I forget, teach me and I remember, involve me and I will learn by Benjamin Franklin, 1750 (NIU, 2012).

STEM indulges most on experimental learning, thereby building competencies in students through their development of critical thinking, problem solving and collaborative skills amongst others. Rather than based on repetitive learning, it is based on innovation, logical and analytic thinking. Science taught using play/drama as methods enhance motivation of students in and outside the classroom environment and builds confidence in such students. When students are actively involved in practicals and debates in STEM, it encourages their engagement which fosters not just learning but other skills such as collaboration, communication or conflict resolution.

In the place of work STEM methodology prepares students for an innovative work environment where problem solving, critical thinking and communication skills are needed for the achievement of organizational goals. Thus STEM methodology aids students to be imbued with both employable and transferable skills for the world of work and societal development. In collaboration, White and Amie-Ogan and Osuji (2016) opined that the main objective of the integrated STEM education approach is to equip students with 21st Century life skills such as critical thinking, creativity, communication, collaboration, problem solving and digital literacy that may lead them to be more marketable in future workplaces.

STEM gets involved in current researches, which gives students the opportunity to develop diverse skills from the tremendous experiences and knowledge got from older scientists, technologist and engineers from their wealth of experience. This enables knowledge transfer from one generation to another.

The spate of creativity and innovation which is empowered by technology in the world today places a great demand for STEM graduates. Moreso, the technology driven organizations and industries seek STEM graduates in their employment especially for Artificial Intelligence, software development and data analysis.

STEM help students' to develop transferable skills needed for their day to day living. These skills are not only useful at the workplace or society but at home for the day-to-day activities of individuals. These skills are problem-solving, creativity, collaboration and communication. STEM subjects also develop the brain in creativity as students' are enabled to think outside the box.

CONCLUSION

The STEM curriculum is supposed to implore a disciplinary approach to the teaching of subjects related to Science, Technology, Engineering and Mathematics using practical approaches such as project based learning, problem based learning and experimental learning. These forms of STEM methodology are required to build such skills as problem solving, critical thinking, creativity, collaborative, communication and digital skills which are both employable and transferable skills needed for the world of work and societal development but secondary education in Nigeria has not come to this limelight as the 'STEM' subjects are taught in a manner that students only garner 'hard skills' through the concepts which are not accompanied with soft skills. Therefore STEM methodology in the secondary schools must be reengineered to incorporate the 21st Century skills for a greater Nigeria with a brighter future for her citizenry.

Suggestions

- STEM curriculum supportive pedagogies such as project based learning, problem based learning and experimental learning should be adopted for students' engagement and the development of problem solving, creativity, critical thinking, collaboration and digital literacy skills.
- Government should provide adequate funds for the education sector so as to implement the STEM curriculum.
- There should be adequate provision of facilities, equipment and materials for the implementation of the STEM curriculum in secondary schools.
- Staff development programmes and trainings should be organized for STEM teachers to update their obsolete skills and be prepared for today's work.
- Adequate qualified teaching and non-teaching staff of secondary education STEM curriculum should be obtained for effective curriculum implementation.

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