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Status of Science, Technology, Engineering and Mathematics (STEM) Education Pedagogies in Nigeria

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Abstract

This paper examines the status of Science, Technology, Engineering and Mathematics (STEM) education pedagogies in Nigeria as including the solutions to many societal problems like the depletion of natural resources and issues related to climate change. STEM was earlier known as STM, SMET meaning Science, Mathematics, Engineering and Technology, it was later changed in the 1990s by the National Science Foundation (NSF) to promote and create awareness for the direction that the technological development of this present time is taking us which created a need to prepare, sensitize, motivate and promote the study of STEM and now STEAM is currently given attention in the area of Learners of Art and humanities inclusiveness. STEM education in both developed and developing nations recognized STEM field as economic drivers which could motivate the Nigeria youths to contribute their quotas skillfully towards technological development of Nigeria as a nation. STEM education is a vehicle for developing the 21st century students which could bring the desired for competences. Therefore, the underlying questions linger as how to teach STEM, what are the challenges with STEM education and what solutions do the future hold. This paper seeks to explore the answer to these questions and how best to make STEM education teaching and learning effective in Nigeria.

Keywords: STEM education, Teaching, Learning, Education Pedagogies.

Introduction

Science, Technology, Engineering and Mathematics (STEM) edification is unchallengeable as well as a strong driver of competitive national economies. However, the whole world is busy spending money, time and energy in STEM education with the hope of mentoring inventory minds to leading in the development and sustainable growth of their economies. Bashman, Israel and Maynard (2010) noted that STEM education are considered as very important in equipping students with 21st century aptitude such as knowledge, skills and values. The significant feature of STEM education is to prepare the 21st century teachers with STEM education and its related activities so that students can take what they learn in the classroom and apply it in future and in the real world. According to Holmes, Gore, Smith, and Llyod (2018), the 21st century competences include problem-solving, creativity and having entrepreneur skills that are prerequisite to students' further studies in STEM educations. Therefore, taking up of relevant careers in STEM education and engaging in entrepreneurship leads to discovery of new things.

The construction of new school contexts with different STEM fields in classrooms requires teachers who hold knowledge and right pedagogies (Furner& Kumar, 2007; Pimthong & Williams, 2018). The curricula should be developed by team such as educators, business community and industry, who are to work in group so as to enhance their expectations. More important, aside from the development of the curricula, the cooperation between schools and the professional bodies in the industry should include mentoring, internships and the delivery of hands-on activities in the classroom to introduce the students to careers across STEM fields and fundamental skills. Stohlmann and Moore (2012) affirmed that it is imperative to ascertain that teachers teach STEM effectively because of all the possible benefit. STEM education is a meta-discipline and which means the creation of a discipline based on the integration of other disciplinary knowledge into a new whole rather than in bits and pieces.

The National Science Teaching Association (NSTA) provided strong supports to STEM education that gives students an interdisciplinary approach to teaching and learning. STEM education makes teaching and learning more realistic and provides students with the opportunities to see the nexus between the content they are learning and the application of the content in reliable and applicable ways. STEM education is an experiential learning with the application of knowledge and skills which are coordinated through ascertaining projects or problems focused on learning outcomes restricted to the development of important college competencies and career readiness.

The research carried out by Renninger (2000) and Tai, Liu, Maltese and Fan (2006) suggested that enthusiasm, experience and personal interest are important in the supporting of children science learning and this can be an improvement for long-term and sustained interest into adulthood. Therefore, many important decisions of the 21st century will require the abilities of all the citizens to adapt scientific questions relevant to their interests; seek out relevant data and scientific argument; and communicate their understandings and arguments to other evaluate complex social, civic, economic, political, and personal issues.

Statement of the Problem

Nigeria, as a nation, has benefited tremendously from STEM education since the period of liberation. As stressed in the National Policy on Education, science and technology's position in the Nigerian education system is unmistakeable. Holmlund, Lesseig, and David (2017) noted that in spite of the increasing interest to STEM education nationwide, the stakeholders in specific educational classroom practitioners and institution managers are still struggling to come into terms with what STEM education is made up of and how it can move to classroom settings.

Mathematics Education is considered as science of counting, measuring and describing the shapes of objects (Majasan, 1995; Augie, 2013; Suleiman & Abdullahi, 2018). The subject deals with logical reasoning and quantitative calculation and involves the science of structure, order and relation. The subject provides basis for scientific and technological

advancement which is a necessary ingredient to the economic growth of any nation (Augie, 2013).

The Need for STEM Education

The incorporation of Science, Technology, Engineering and Mathematics (STEM) education is an approach to teaching and learning of special skills and the development of students in various creative works which could provide them with special skills such as being creative, problem solver, critical analyst, work cooperatively, initiative, communication, digital literacy and independent scholar.

Researches carried out by scholar such as; Cahill, et al (2014); Freeman, et al (2014); Prince, 2004) showed that active learning in the classroom not only increases student engagement in special skills, but also results in profound conceptual understanding and long-term memory of knowledge. These active learning and participation can increase students' persistence and success in STEM education. Pimthong and Wiliams (2018); Johnson (2012); English (2016); Bybee (2013) stated that different STEM education approaches have been adopted in different educational contexts even within the same nation. Today, the field of study approach in STEM education is commonly accepted nationwide. STEM education pays special attention to the matching of what it taught and learnt in the classroom to the real world.

The research conducted by English (2016), revealed that the main source of confusions, misunderstandings and misconceptions in STEM education is among teachers. Ejiwale (2013) noted that the confusions and misconceptions are ripple affected by many other barriers to STEM education. The approach progresses nations towards STEM-literate societies which are compatible with the 21st economies. According to Tsupros, Kohler and Hallinen (2009), all students of STEM education are to make connections between school and the society.

The importance of STEM education to our nation's future cannot be overstated. As elaborated by the National Science Foundation (NSF, 2007) report A National Action Plan for Addressing the Critical Needs for U.S. Science, Technology, Engineering, and Mathematics (STEM) Education System, in the 21st century, scientific and technological innovations have become increasingly important as we face the benefits and challenges of both globalization and a knowledge-based economy. To succeed in this new information-based and highly technological society, students need to develop their capabilities in STEM to levels much beyond what was considered acceptable in the past (NSF, 2007). Modern STEM education promotes not only active skills such as problem solving, higher-order thinking, critical thinking, inference and design, but also behavioral competencies such as adaptability, cooperation, perseverance, responsibility and organization (NSTC 2018).

STEM education should not replace by other subjects and not a single subject. Students need to learn how to solve problems through engineering design challenges and also learn the same skills and concepts in science and mathematics as they do before. STEM education experiences must be established in a framework for all levels of Science

Education and articulated in the Next Generation Science Standards (NGSS) as well as support and connected to the goals of state science standards, by providing students the opportunity to experience and grasp the relevancy of what they are learning. According to Corlu, Capraro and Caprar (2014), the integration of STEM education requires an interconnected existence of disciplines with a strong cooperative connection to life. STEM education directs teachers to teach the incorporated discipline as one coherent entity and the spread of a pattern of knowledge, skills, values and language differences. In so doing, teachers and students need to interact in order to take the center stage and enable them to collaboratively construct new skills, knowledge and beliefs at the juncture of more than one STEM subject area.

Motivating the interactions between students and teachers in the classrooms requires that teachers understand STEM education contents and attain uphold pedagogical content knowledge explicit to their subjects as well as working knowledge in another (Corlu, Capraro & Caprar, 2014). The integrated approach proves that the real-life application of STEM eeducation is naturally integrated. STEM education is not a curriculum but rather a way of organizing and delivering instructions to students. STEM education is a recipe for helping students apply their skills and knowledge, collaborate with their peers, and not an ingredient in the lesson soup and understand the relevance of what they are learning. This gives students the ability to know how they can apply the content they are learning and does not de-emphasize the teaching of important ideas in STEM education. STEM education should enable students to be:

- analytical and critical thinkers;
- increases science, mathematics, and technology literacy;
- fosters the next generation of innovators and entrepreneurs;
- provides opportunities for students to engage in 21st-century skills of teamwork, collaboration, problem solving, communication, and creative thinking; and
- Offers learning experiences in which students apply what they are learning in relevant, meaningful ways (NSTA, 2020).

Status of STEM Education in Nigeria

Teachers have a vast influence on students' decision to pursue STEM education career or their choice of subject matter and student motivation can be an enormous problem for even the best of teachers. Also, teachers can face a lot of challenges when it comes to STEM education. Here are the top challenges that most teachers face and a few suggestions for how to tackle them:

1. **Teaching of STEM to Students When Young:** Students lack of interest in science is a huge challenge faced by most teachers. Research suggests that most students lose interest in Science between 12–13 years of age. A good way to hinder this challenge is to instill love for science earlier in the students' life. Early educators can incorporate STEM education learning into the curriculum so that the children will develop a

stronger understanding of the skills involved early on. Most young children already engage with science without understanding. For example, when children stack playing blocks together, they are essentially learning laws of physics. Similarly, when they run off on nature walks to explore a fallen nest or flower, they are observing the biological world. Teachers can use this curiosity to direct the students in a more focused manner.

2. **Innovative Teaching Strategy:** The teaching and learning of science can be boring if it does not serve as an example to the effects of classroom principle in the real world. According to a study undertaken by the Institute of Engineering and Technology, most students sees science curriculum as boring and irrelevant to life outside school. Studies showed that practical activities enable students to build a bridge between what they can see and handle and the scientific ideas that account for their observations. Practical activities also enable group communication, peer-to-peer interaction, discussions and teamwork, all of which are the most important 21st century skills.

3. **Topics in Science Subjects:** Most children struggle to understand the importance of science because they cannot see the connection between what they were been taught in classroom and what is happening in the real world. Students also have a perception of science subjects being either too difficult or too boring. Introducing current interest in science in the classroom can help students understand the relevance of science in everyday life. A typical STEM education teaching and learning usually involves four basic steps which are; identifying a real-world problem, asking questions in order to explore problem and potentially solve the problem, developing solutions and exploring a hands-on activity.

4. **Digitalized STEM:** most of the teachers teaching STEM education struggles with a huge workload which does not give room for much time or energy to plan complex or detailed STEM education learning. With the use of technology, this can be of help in this aspect.

5. **Gender Bias:** The ratio of men to women in STEM education fields is greatly imbalance, with men outnumbering women. Efforts are now underway to include more girls in STEM. This is a challenging task, as most girls unfortunately grow up with a lot of bias mind, even if it is unintentional. Teachers can do lots of things to help their female students overcome these biases and nurture their STEM education dreams which include encouraging female students to participate more, introduce the female students to more female role models or be a role model yourself. Most students look up to their teachers, so sharing your own experiences as a science teacher can be incredibly encouraging to your female students. Teachers can also

introduce their female students to the various initiatives that advocate women's role in STEM fields. (Retrieved online)

Elucidations on the Teaching and Learning of STEM Education Challenges

Educators must surpass the fields of study beyond just a combination of the four disciplines of STEM education to include the arts and humanities (i.e., STEAM) and continue to widen and deepen the scope of STEM education. Students need to have a strong foundation in language and creative arts in order for them to have the ability to communicate ideas in writing and speech with precision and clarity, think creatively, to formulate and defend arguments based on evidence, and to create visual or digital models that convey evidence clearly and concisely. The ability to fully understand the global issues demand that the students can admit and appreciate the important social biases, cultural norms, and history of other countries and peoples' fulfillment. The combination of all these factors motivated the innovation and the technological advancements of the STEM education.

According to Ogunode (2019) the objectives of education in Nigeria includes: skill acquisition, development and inculcation of the proper value positioning for the survival of the individual and societies; the development of the intellectual capacities of individuals to understand and appreciate environment; the acquisition of both physical and intellectual skills which will enable individuals to develop into useful members of the community; the acquisition of an overview of the local and external environments (FGN, 2004). The National Policy on Education again stated that educational institutions should pursue these goals through: teaching, research, the dissemination of existing and new information, the pursuit of service to the community; and by being storehouse knowledge (FGN, 2004). The Nigeria educational system comprised of universities, polytechnics and colleges offering programmes in teacher education and agriculture pedagogies.

Furthermore, teachers and other education leaders representing the entire educational system should consider redefining what learning success looks like for STEM education. This includes peer discourse, re-evaluating how the structure of the classroom should look like, and engineering design innovations; actively promoting diversity in STEM education for all students; making it a responsibility to advocate for a broad STEM education that begins in preschool and continues post–high school. STEM education should provide opportunities to unite communities by engaging multiple stakeholder groups, including teachers, policy makers, parents, students and business leaders, in working toward common goals. The involvement of all these stakeholders of the community should play a critical role in shaping the STEM education vision, promoting its importance economically, creating an environment of shared values and supporting its implementation through active participation like mentoring. Such community advocacy can improve opportunities for many community members and raise the standard of living for all citizens.

National Science Teachers Association (NSTA, 2020), is one of the leading organizations for science teaching and learning, affirm that administrators, educators, parents, and all other

stakeholders should consider the following recommendations as they develop and refine STEM education programs:

- STEM education programs should be grounded in the principles of constructivism supported by the findings of three decades of cognitive science. Integrated STEM education occurs when learning is viewed as an active, constructive process, and not a receptive one;
- student motivation and beliefs are integral to cognition;
- social interaction is fundamental to cognitive development; and
- knowledge, strategies, and expertise are contextualized in the learning experience (NSTA, 2020).

The elevation and advocacy of STEM education should focus on the following:

- School administrators, school boards, Teachers and school and district leaders should identify common objectives and footpaths to create a shared vision and definition of the teaching and learning of STEM for their communities;
- Teachers of STEM education should be provided with necessary resources to implement quality STEM education in their classrooms, including opportunities for professional growth and learning through continual and sustained mentoring, training, and support services, as they plan, develop, and execute their STEM lessons and units;
- Schools should continuously provide access to materials, tools, technologies and resources to facilitate the application of integrated teaching and learning of STEM education;
- Schools should recognize that STEM education begins as early as preschool and provide accessible educational experiences that span to the post-high school. This includes creating new definitions of learning success, embracing new approaches to STEM teaching, and considering new ideas about the physical structure of the educational environment so that it is more inclusive and conducive to discovery, exploration, and design repetition;
- Schools should implement models of professional learning and give support to sustain changes in pedagogy, including instructional methods that promote learning for adults that mirror the methods to be used with students
- Schools, districts, employers, the community at large, and all interested stakeholders should seek opportunities to build a capacity for job shadowing, joint learning, and mentoring of students to support students' transition into the workforce and
- Schools, districts, employers, the community at large, and all interested stakeholders should help promote, facilitate, and financially support STEM educator training so that all teachers can enhance their cross-disciplinary skills and knowledge, and provide for or increase the necessary collaboration time for educators to plan, learn, improve and share their integrated STEM instructional units. Adopted from the NSTA Board of Directors, February 2020.

Conclusion

Although, the amendment of STEM education depends on many factors, the most important factor of this achievement is the teacher classroom practices that provide the development and use of the 21st century competences. This depends on the understanding, quality of the teachers and their and competencies in STEM education. The teachers will require a lot of support in terms of guiding frameworks, professional development, material development and many other resources for the successful implementation as well as effective teaching and learning of STEM education.

Suggestions

1. There is need to improve on the quality of Science, technology, engineering and mathematics teaching in schools so that learners can gain knowledge, skills and competencies needed for the graduates through training and re-training of the stakeholders in education.
2. The government should avail the general populace with sound STEM education, for in that; pedagogies of educational development can be achieved.

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