CHAPTER 8
The Role of STEM in Curriculum Change

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Introduction

Science, Technology, Engineering and Mathematics (STEM) in the 21st century is keyed to curriculum change because of the dynamism of the global village through technological and developmental processes. As a result of this, the STEM curriculum is essential to produce graduates that have an integrated knowledge of science and technology which the 21st century society and industries need for proper technological and developmental growth of the global village.

STEM curriculum is an integrated and the total of all the learning experiences, through activities and experimentation which the learner is provided with, or acquires at school. This STEM curriculum drives the learning processes of the students to cover equally, the affective, cognitive and psychomotor domains of learning, thereby making the education of the students to be functional. Functional Education (FE) is the type of education that is supposed to produce graduates who are job, and wealth creators and not job or wealth seekers.

The integrated STEM Curriculum processes involve the development, revision and updating and upgrading of a curriculum which involves several steps in a procedure called the curriculum integration processes. The steps of the curriculum integration process, among others are:

- Selection of integrated themes/topics
- Statement of integrated objectives
- Selection of integrated learning experiences
- Selection of integrated content

Africa is endowed with vast natural resources but yet the poorest in economic development. It is evident from the current school graduates that African education is struggling to prepare youths for the labour market requiring STEM skills needed to turn raw materials into finished products and wealth. The importance of STEM education in the world is traced to the history of the reform in the world right from the 2nd world war. The reform of STEM is responsible for profound and multifaceted changes occurring in the world today. The position of STEM teachers in education reforms in the Nigeria and Africa as a continent revealed the neglect and non-involvement of the government by recommending and providing the financial and materials resources that STEM teachers should be informed, trained and should participate actively for overall success of STEM education in Nigeria and Africa at large.

Currently, African education is undergoing through transition from an objective-based to learner outcome/ competence-based curriculum. In an objective-based curriculum, teachers were at the center of the learning process, defining a problem, explaining the causes of the problem, and giving a variety of examples and learners were at the receiving end to memorize and assimilate the teachers' knowledge. In the outcome-based curriculum, it was expected that learners would take a central position during the learning process to promote STEM education that focuses on the development of a learner which is the learning paradigm shift from the curriculum that is teachers centred to a curriculum that learners centred with vigorous psychomotor activities which are among others the principal roles of the STEM education in the curriculum change. In a nutshell, the integrated STEM curriculum stimulates the learners during the learning process to among others be:

i. critical thinkers
ii. Creative and innovators of concepts using scientific principles
iii. Relate thinking to real-life situations
iv. Problem solvers
v. Responsible citizens
vi. Creators of jobs and add value to raw materials as finished products
vii. Initiators of productivity and triggers of national development

This view has led many developing countries in Africa like Nigeria, Rwanda, and South Africa, among others to invest in STEM education with the hope of promoting economic, scientific, and technological development which are the prerequisites for national growth and development.

The role of integrated STEM curriculum in educational change

The role of STEM education is increasingly perceived as being of crucial importance in increasing the efficiency of the global village. Thus, strong social support and resources are mobilized to advance the teaching of STEM in schools and higher institutions of learning to promote a scientifically literate society and to produce scientific manpower to meet the economic needs of society. The Nigeria situation was captured in an address by the then president of STAN, Lawrence Achimugo at the 51st Annual conference held at Benue State University, Makurdi in August 2010. According to him, we are making efforts to provide the type of STEM education that will ensure that we meet the challenges of the 21st-century knowledge-based society. He observed that the significant role played by STEM in the development of a nation in contemporary times stares us in the face and the worldwide movement towards STEM for all underscores this. However, in the communiqué for the 51st Annual Conference, STAN observed that the entire concept of STEM as it is used in daily practice is missing from conventional STEM education in

schools; the need for relevant curricula in STEM to be imparted to students properly; and the need to give students opportunities for guided inquiry and problems solving in STEM education is necessary.

STEM education reform occasioned by the 2nd world war was basically on two areas:

1. Updating of content to take care of the scientific development that had occurred during the war.
2. Methodological transformation that is, the substitution of the lecture method by the activity method where the laboratory method was preponderant.

The laboratory practical would involve the students in activities fulfilling the need to motivate them and help them to understand the concepts that made up the programme as well as the acquisition of process and procedural skills of STEM. Hence just before and after independence in (1960), Nigerian STEM education leaders were very critical of the colonial curriculum inherited from the British. The colonial curriculum was criticized for being too bookish, lacking in science, technology and psychomotor skills, and also awkward and Western-oriented that it lacked relevance to Nigeria's environment. There was general agreement that salvation lay in reforming the curriculum to give STEM its rightful place. STAN also observes that educational innovations in the country have rarely lived up to the expectations of their proponents (Oloruntegbe et al., 2010). However, the need to revise and update existing educational curricula in response to profound and multifaceted changes occurring in the world today is widely recognized. Thus, reform is inevitable; it is a part of life. By the time Sputnik I was launched in 1957, which occasioned the landing of the first human on the moon by Russia, developing and developed countries had begun to realize that a new science age had begun.

The enthusiasm for STEM was further enhanced as a result of the competitive spirit between the United States and the Soviet Union. Thus, by the time the benefits of STEM were beginning to be realized in African countries, another event self-rule, catapulted the enthusiasm for science into reality (Jegede 1988 & Ali 1998). According to Ali, a sudden Spurt of attention and interest came from government, industry, schools, and indeed society such that the science educator became involved with curriculum planning, development, implementation and evaluation. The first major attempt at reforming the educational programme of the country (STEM inclusive) took place in 1969, through a curriculum conference held in Lagos. The conference brought about radical changes in the country’s educational system, (Fafunwa 1974 reported in Yusuf and Yusuf 2009). This led to the first independent policy, tailored to meet the local needs of the nation. Thus the National Policy on Education (FRN, 1977) revised 1981, 1998 and 2004 made radical departures from the educational policy inherited from the British colonialists.

Thus, an added impetus to the STEM curriculum development in Nigeria came from.

1. The apparent dysfunctionality of the inherited educational programmes that were largely imported into the country through colonialism

2. The experience some members of the Nigerian scientific community gained by their sojourn abroad in search of further education, and
3. The prevailing climate of political independence which by implication, extended to other areas of the country's aspirations (Jegede, 1988 P 400)

Worthy of note is that although the STEM reform programmes departed significantly from the factual and expository method of teaching to a more progressive method of teaching, which makes the learners learn what science is and how scientists work, and even though the National Policy on Education appears to project the modern aims and objectives of STEM education, example inculcating in the child the spirit of inquiry and creative thinking, only minimal changes have been noticed in the learner and the system as a whole (Jegede, 1988, Bozimo,1985). It is observed that the STEM teachers are neither positively disposed towards, nor more effectively trained to cope with the demands of the new curricula. As summarized by Jegede, Okebukola and Adeniyi (1987) in Jegede 1988, by and large, the teaching of science has been by the didactic practice essentially on the 'new' concepts on which some practical laboratory hours were spent undertaking presumably confirmatory trips dictated by the teacher. This is despite the daily Sermon over the traditional rote learning method.

The Present Status of the Reform

The major changes from earlier educational policies are enunciated as follows: First the nine-year basic education eliminates disconnection between the primary and the junior secondary school thereby ensuring a continuous curriculum (Obioma & Ajagun, 2006). It is structured into three levels: lower Basic (Primary 1-3) where 9 core subjects and a maximum of three electives are offered; Middle Basic (Primary 4-6) where 9 subjects and a maximum of three Electives are offered; and Upper Basic (junior Secondary 1-3) where 10 core subjects and a maximum of three electives are offered. Secondly, the need to reform secondary school education is supported by several UNESCO researches which emphasized the need to take secondary school education beyond the general Secondary Education, (Yusuf and Yusuf, 2009). This is to incorporate Technical and Vocational Education Training which is called the convergence of knowledge and practical skills. Thirdly, the consolidation of tertiary institutions. Merging of tertiary institutions, which is the merging of Colleges of Education and Polytechnics with Universities, was envisaged. Other basics include the merging of educational commissions and agencies from over 30 to 11 targeted at reducing redundancy and ensuring quality service delivery.

The Position of STEM Teacher

The teacher has become the focus of attention in the modern world as it becomes increasingly clear that no nation can rise or develop without the caliber of teachers (FRN, 2004). It is equally recognized that whatever levels of development a particular nation passes through will largely be a true reflection of the caliber of the STEM teachers. Today, teachers gained more prominence not only in teaching but also in the development of learning materials (curriculum) for

students. As regards the roles of teachers in curriculum development, implementation and change, (Oloruntegbe et al 2010), posit that the responsibility of the teachers is now more extensive than in the past. It is observed that their roles have been situated along major development indices that resonate between classrooms and the larger community which have been described variously by scholars as "critical connections" and "extended professionals", "principal role-players", "sole implementers", researchers, trainer and curriculum workers, (Oloruntege et al 2010).

Researchers have, however, revealed the neglect or non – involvement of teachers in curriculum reforms. Carl (2002) in Oloruntegbe et al (2010) affirmed that the "voice" of teachers is to a large extent ignored or not heard. According to Yigzaw's study reported in Oloruntegbe et al (2010), 85% of the 110 subjects stated that they had not been involved in the development of curricula. Even in the implementation, 63% reported that the most serious problem in this area was that materials were usually not sent to them on time or that they were not informed of the innovations beforehand. Thus, while teachers were not recognized as sole implementers of curriculum change, many times, they received little or no orientation on innovations. Hence, one can see why teachers often resisted, were reluctant, or were slow to implement innovations.

It is observed that most curricula innovations in Africa were initiated "top-down", through power coercive" or "unilateral administrative decisions" in utter negligence of the much powerfully-embraced" grassroots' (Oloruntegbe et al, 2010, Rogers, 1995), or the "normative re-educative", "rational – empirical" or bottom-up approach. These according to observers further inform the reasons for teachers' reluctance. It is suggested that innovation must be locally driven and collaborative (Nomdo, 1995), to make it widely acceptable. Collaborative efforts (Oloruntegbe et al, 2010) were observed in the National Curriculum Project (NCP) in Australia and Curriculum 2005 of the Gauteng Department of Education in South Africa and they were very successful. The NCP frameworks are "intended as teacher–development tools as much as curriculum planning tools" and the project is a form of curriculum consciousness rousing for teachers. These ideas are summed up in Sttenhouse's (1980) writing as 'No curriculum development without teacher development" and that "curriculum development is about teacher development". In the case of curriculum 2005, there was a development programme for "foundation phase teachers "(Ramparsad, 2001). This was done to enhance teacher's involvement in the design, dissemination, and evaluation phases which according to Ramparsad was initially not emphasized. Kennedy and Kennedy (1996) submit that change is complex and that part of the complexity is teacher's attitudes in the implementation of change. Furthermore, the sustainability of reform initiatives relies on teachers (Cohen and Hilts, 2001) maintaining alignment with the intent of the initiative.

Thus, curriculum reform can only be successful if teachers of STEM are involved in the development and implementation of curriculum and structural changes, for expecting teachers to embrace new instructional approaches without sufficient training and information on why such changes are necessary or warranted, often results in inadequate adoption of the curriculum mandate. Combs (1968) reported in Igunnu (2001) that the educational system will not be modernized until the whole system of STEM teacher training has been drastically overhauled,

stimulated by pedagogical research, made intellectually richer, more challenging, and extended far beyond pre-service training into the system for continuous professional renewal and career development for all teachers. Unless the programed of training and retraining of STEM teachers is invigorated alongside substantial motivation and remuneration, our guest for a technological breakthrough in Nigeria will remain a Mission unfulfilled. The success of any curriculum reform therefore rests largely on the availability of highly motivated, conscientious, and efficient classroom teachers who are both intellectually and profoundly equipped to teach the curriculum content in the classroom and laboratory situations. Again, the curriculum operated in Nigeria primary and secondary education systems are developed centrally by the Nigeria Educational Research and Development Council (NERDC). They were purchased by the Federal and State Ministries of Education and distributed to schools. However, there are other agencies such as Nigeria Union of Teachers (NUT), National Teachers Institute (NTI), subject associations like the Science Teachers Association of Nigeria (STAN), and others who have variously engaged in curriculum development, implementation, and change, (Oloruntegbe et al, 2010).

Position of the Teacher in the Reform of STEM Education in Nigeria

Oloruntegbe et al carried out a study using 630 secondary school teachers drawn randomly from six South Western States of Nigeria in the involvement in curriculum reform in Nigeria. The results show Nigerian teachers' several and mixed usage of the national curriculum and the syllabi of the various examination bodies in the country. 95% of the teachers agreed that teachers should be involved in curriculum development but only a few 38% claimed that they were ever involved and their involvement was through seminars meant to introduce the NERDC curriculum to them. The majority implemented the versions prepared as syllabuses by examination bodies like WAEC, NECO, and NABTEB. A large number of the teachers used the NERDC version modified by ANCOPSS. Thus, there was no commitment to the implementation of the national curriculum. Several teachers 30.4% claimed that the curriculum they implemented could not get the nation anywhere which means that they were not convinced of the change inherent in the implemented curriculum. This agrees with the observation that there are two major causes of failure for the NERDC curriculum to achieve its declared goals concerning students' understanding of STEM:

1. STEM teachers' inadequate views about the nature of STEM.
2. A degree of confusion in the philosophical stance implicit in many contemporary STEM curricula.

It is either that the teachers were reluctant to implement the change as noted by Kennedy and Kennedy (1996); they were unsure and uniformed or they were in a way calling for change in the existing curriculum.

Conclusion

The conclusion is that STEM teachers in Nigeria, and Africa at large, are seldom involved in the process of curriculum development and reform and that may account for the reluctant in implementing any reform.

Recommendations

The following recommendations are hereby made:

1. There is need to appreciate the double role of the STEM teachers in the curriculum enterprise both as a developer and as autonomous implementers.
2. The overall success of STEM reform programmed development should be initiated at the teacher level and should involve active participation in decision-making, research, and development work.
3. During the period of reform STEM teachers must see the need for change and understand the basis for the proposed reform. Otherwise, they may resist the reform. In this regard, STEM teachers should be informed trained, and actively involved in the reform which should be initiated from the grassroots bottom-up. Curriculum reform emerging from this process will be more acceptable. The question of STEM teacher's reluctance to implement the reform will not arise.
4. Furthermore, during the period of reform, it is important to organize in-service training for STEM teachers in the form of seminars, workshops, conferences, vacations, and week end programmes regularly till the reform takes root properly.
5. Again, during the period of reform, international collaboration towards the improvement of STEM should emphasize reflections on the problems involved, the training of human resources, and the development of work methodologies and new ideas as well as the production of materials for use.

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