

QUALITY ASSURANCE IN SCIENCE TECHNOLOGY ENGINEERING AND MATHEMATICS EDUCATION (STEM)

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Abstract

Science Technology Engineering and Mathematics Education remain core to the development of any nation. It is crystal clear that countries developmental is tangential to their levels of development of STEM. The paper traces the development of western education in Nigeria from pre-colonial to colonial era, through independence and post-independence. It discussed the post-independence development of the education sector, the various attempts in the development of the Nigerian education system. It pinpointed the place of STEM in the Nigerian education from early childhood care education up to the University level. The paper also identified the various agencies responsible for Quality Assurance at all levels. Amongst others, the paper recommended adequate funding of the Quality Assurance activities at all levels.

I. INTRODUCTION

Education which serves as an instrument for the development of both the individual child and the society is not new to any race. Every society, irrespective of time, people or place has evolved one education system or the other. Before the introduction of Islamic and Western education respectively in Nigeria, there had been a traditional system of education.

Nigerian Traditional Education

Some of the basic characteristics of traditional education in Nigeria are that:

1. The education is a collective and social activity. In other words almost everybody is involved in the training of the child;
2. It is multi-dimensional in character in terms of its goals and the means employed to achieve the goals (methodology);
3. It is planned in gradual and progressive steps in order to achieve conformity with the successive stages of physical, emotional and mental development of the child;
4. The education relies more on informal instruction;
5. It has limited specialized training;
6. The education depends so much on oral tradition;
7. Traditional education is practical and general towards specific situations;
8. Religion, ethnics and education are inextricably related. They are interwoven and inseparable;
9. The education is basically conservative and opposed to change;
10. The education can take place at any time and place;
11. Traditional education is a lifelong process. (Amaele 2005 pp 6-7)

Methods

The methods of teaching in this education system include indoctrination, modeling, initiation ceremonies, reward and punishment, imitation, role play, oral literature, poetry, instruction, observation, intention, participation, apprenticeship. Emphasis is laid on practical knowledge, skills and character.

Stages in Traditional Education

1. Infancy: This covers the first five years of the child. The mother and father as well as the immediate members of the family.
2. Childhood: This covers the age's six to twelve. At this age, the child moves out for the discovery of the world around him beyond his mother and immediate family.

3. Adolescence: Adolescent stage of learning starts at the age of twelve. It is a period of renewed vigour in play and learning. Learning at this stage is done through folklores, riddles, proverbs, myths, legends, imitation, participation, initiation ceremonies, dos and don'ts, and so on.
4. Adulthood: Education in the traditional society is a continuous and endless one. Accordingly, the adult receives his education from either the parents and or parent-in-laws or any elder in the community. He also learns from the happenings within and outside his environment.

Islamic Education

Islam also recognizes the importance of knowledge of man and enjoins adherents to seek it. It recognizes two forms of knowledge; namely revealed and acquired knowledge. The religion and its education came to Nigeria through the ancient Kanem-Borno Empire, covering the present Borno (now Borno and Yobe), Bauchi (now Bauchi and Gombe) and part of Gongola (now Adamawa and Taraba) States (Fafunwa 1974, Abdulkareem 1990).

Aims of Islamic education

The major aim of Islamic education, according to Abdullahi (1982) is to “build up the individual who will act as Allah’s Khalifah (representatives on earth) or at least put on the part that leads to such an end”. In other word, Islamic education aims at producing Allah’s representatives who will do well to mankind on earth. Hence, it urges Muslims to imbibe the values of kindness, generosity, patience, steadfastness, honesty and so on.

Advent of Western Education in Nigeria

- The Early Missionaries and the Development of Education in Nigeria
- Colonial Government involvement in Nigeria Education (1872 – 1882)
- 1887 and 1916 Education ordinances
- The impact of Phelps-Stokes Commission on Education Development in Nigeria

There existed, in Nigeria, two highly developed education system before the introduction of western education. The two system of education, which are still relevant today are the traditional education and the Islamic education.

However, the 1842 Christian missionary entry into Nigeria was not the first, it is important to note that as early as 1472, the Portuguese merchants has visited Lagos and Benin. By 1485 they had started trading activities with the people of Benin. Consequently, by 1515 the Catholic Missionaries through the influence of Portuguese trades had established a primary school in the Oba’s palace for the children of the Oba and his chiefs and they were all converted to Christianity. The Catholic missionary activities also extended to Brass, Akassa, Warri where churches and schools were established (Fafunwa 1974: 74-75).

As it has been highlighted earlier, the mission’s schools aimed at leading the people to Christ through the following:

1. The training of indigenous manpower to carry out the evangelical work to the various local communities;
2. The training of lower manpower to serve as interpreters, messengers, clerks, cleaners, etc for the various missions and the British Businessmen.

The Findings of the Phelps-Stokes Commission

The commission made the following findings:

1. That the education given to the people was not adapted to the people’s needs;
2. That the education was too literal and classical to be useful to the people;
3. That the books and materials used in the school were not appropriate to the people;
4. That very few craftsmen and technicians were trained;
5. That agriculture should be taught in rural areas while industrial and technical skills taught in urban areas;
6. That schools were not well organized and supervised;
7. That education of the masses had been neglected;

8. That there was no clear-cut aim of education, except religion;
9. That children should be taught in vernacular;
10. That health education was required;
11. That higher education was necessary;
12. That women education should be emphasized (Fafunwa 1974 & Amaele, 2003)

Higher Education in Nigeria

Before the establishment of Yaba Higher College there were postsecondary education that offered sub-professional and vocational courses at Central Agricultural Research Station, Moor Plantation, Ibadan at Samaru near Zaria. Others were the Nigeria's Railway in Lagos center for engineering and Vom Centre for veterinary medicine. These did not satisfy the increasing demand for Higher education in Nigeria.

The Asquith Commission

The Asquith commission was set up in August 1943 to:

1. Look into the principles that guide the promotion of higher education, learning and research as well as the development of universities in the British Colonies;
2. Explore possible means through which universities and other agents in the United Kingdom can assist the institutions of higher education in the colonies to achieve the principles above.

The following recommendations were submitted by the commission:

1. Universities should be established in the areas as soon as possible, starting with university colleges;
2. Training of teachers should be giving the highest priority;
1. Facilities should be provided for the teaching of arts and science teachers to control the problem of lack of teachers in the grammar schools;
2. Research should be a very important aspect of university life;
3. Colonial universities should be autonomous like those in the United Kingdom;
4. Colonial universities should be assisted by London University so as to be awarded degrees of the university;
5. A colonial Grants Advisory Committee should be created;
6. Universities should be residential and open to both sexes and all classes (Osokoya 1989).

The Elliot Commission

The Elliot Commission was set up in June 1943 by the Secretary of State to report on higher education in British West Africa and this lead to the establishment of the University College Ibadan which started in Ibadan on 18th January 1948.

Ashby Commission (April 1959-September 1960)

The Ashby commission was the first Nigeria Commission set up on Higher Education in 1959 to investigate and recommend to the government, among others, on the needs for higher education in Nigeria. The major findings of the commission included:

1. Lack of continuity from primary to secondary schools. It stated that students were not well prepared for higher education, stating that three-quarters of the teachers were uncertificated;
2. That there were high drop-out rates leading to shortage of teachers;
3. That secondary education was too literal;
4. That few students were attracted to agriculture and technology;
5. That there was educational imbalance between the North and the South.

The findings and the recommendations of the commission assisted, to a great extent, the establishment of more universities in the country. For instance, in 1962, the number of universities in Nigeria rose from one in 1948 to five. These universities are:

1. University of Ibadan, Ibadan, 1948;
2. University of Nigeria Nsukka, 1960;
3. University of Ife, Ile Ife, 1962;
4. Ahmadu Bello University Zaria, 1962, and
5. University of Lagos, Lagos, 1962.

II. SCIENCE TECHNOLOGY ENGINEERING AND MATHEMATICS EDUCATION

Science Technology Engineering and Mathematics Education, with the acronym (STEM) is a term said to have been coined by Dr Judith Ramaley of the American National Science Foundation. In its early use, it was more or less a short hand for the four subjects in the acronym, but in recent years however, the definition has changed beyond being an acronym (Ubawuike, 2018). STEM now describes a 'meta discipline' which is a creation of other disciplinary knowledge into a new 'whole', achieved by bridging the gaps in the subjects' boundaries.

There are several definitions of STEM in literature coming from educators within and outside the STEM family. The difference in the definitions arises from the fact many do not share same view in the interdisciplinary and unified understanding of STEM (Breiner, Harkness, Johnson and Koehler, 2012; Brown, Brown, Rearden and Merrill, 2011). A few of the definitions will be considered here such as; Morrison (2006) sees STEM as an interdisciplinary approach to learning where discrete subject areas such as science and technology are taught by incorporating engineering and mathematics into their curriculum and this presents a paradigm shift from the traditional teacher centered classrooms which treat these subjects in bits and pieces. Another frequently cited definition of STEM is that of Tsupros, Kohle & Hallinen (2009), which defines STEM as the "interdisciplinary approach to learning where rigorous academic concepts are coupled with real world lessons as students apply science, technology, engineering and mathematics in context that make connections between school, community work and global enterprise, enabling the development STEM literacy and with it the ability to compete in the economy"

These definitions mention the use of integrative approach in the teaching and learning of the subjects rather than presenting them as separate subjects and real life application of STEM, and the cultivation of 21st century skills for solving life equations.

Ubawuike (2018) posited that:

- So far there is neither STEM education nor STEM curriculum in Nigerian Schools especially in its integrative form, either for the Primary, Secondary or the Universities;
- 'STEM education' in the secondary schools does not yet incorporate engineering and technology. Only science and mathematics are taught in silo manner approach in the primary and secondary schools;
- Cutting edge STEM skills (key and soft skills) for competitive 21st century workforce is missing at all levels of Nigerian education. This results in our graduates being unemployable, simply because they lack employable skills;
- There are no teachers qualified as 'STEM teachers' in Nigeria for now and no Universities training STEM teachers.
- Skeletal STEM activities such as workshops, seminars and trainings are been organised in Nigeria, such as the ones of benignantsteminnov.org, WAAW Foundation, the Brainiacs STEM & Robotics, and a few other NGOs coming from the diaspora.

STEM global initiative has attracted several countries of the world for its development. These countries believe that with STEM knowledge, they can rise above over-dependence on developed countries technological prowess. Presently, countries in the world are classified as; developed, developing and less / under developed. The difference between the developed, developing and under-developed countries however rests on the ability of the developed countries to convert scientific ideas to usable technology while the developing and under-developed countries are yet to do so effectively (Sulai, & Sulai, 2021).

Science is defined variously as: - knowledge about the physical world based on testing and providing facts, or work that results in gaining knowledge (Longman Active study Dictionary, 2006). According to Igboanugo & Egolum (2017), Science is universally regarded as an organized study of natural phenomena

Technology

Technology is viewed as application of knowledge for development and improvement of human life. It is science of mechanical and industrial arts which involves application of science in solving human

problems (Suleiman, Fagbemi, Oyebani & Suleiman, 2018). According to Alabede (2017), technology is a systematic approach of applying scientific or other organized knowledge to a particular task. It is about product and process. The process is the application, while the product is the outcome of application, which includes hardware and software materials. Technology is the practical application of knowledge especially in a particular area to achieve some results Technology simply means the practical application of scientific or other knowledge and a major source of economy expansion

Mathematics

Mathematics is seen by Inweregbuh (2015) as a branch of science which deals with numbers and their operations which revealed hidden patterns that help us to understand the world around us. To Guwam (2017), the knowledge of Mathematics is very useful in our daily life. Its usefulness is seen in the enhancement of the development of a critical mind which enables man to circumvent problems like poverty, unemployment and recession that abound in the society. Lending credence to this, Usman & Ojo (2014) pointed out that mathematics is the only essential tool that is applicable in many fields like natural science, engineering, medicine, finance and social sciences, which can be relied on to generate think – tanks that can launch Nigeria on the path of sustainable economic growth and development.

Engineering

Engineering is the branch of science and technology concerned with the design, building and use of engines, machines and structures.

The features of the separate disciplines in STEM are in an interconnected manner.

From the foregoing explication, it is evident that STEM education has relevance in fostering national development. Salman & Adeniyi (2012), Momoh, & Yusuf, (2012) and Olorundare, (2010). The world is rapidly developing technologically and of which mathematics is a required instrument because without mathematics there is no science and without science there is no technology and without technology there is no modern society.

Nigerian Education System

The Nigerian education system has been structured into:

1. Early Child Care and Development (0 – 4 years).
2. Basic Education (5 – 15 years): encompassing 3 years (lower Basic Primary 1 - 3); (3 years middle Basic Primary 4 – 6); and 3 years Upper Basic (JSS 1 – 3).
3. Post-Basic Education and Carrier Development of 3 years in Senior Secondary Schools and Technical/Vocational Colleges, and
4. Tertiary Education in Colleges of Education, Monotechnics, Polytechnics, Innovation Enterprise Institutions and Universities. (Federal Republic of Nigeria, 2014).

Science Technology Engineering and Mathematics Education cut across all the levels of education in Nigeria. This is more pronounced starting from the Basic Education level. This level of education is where a foundation for the overall development of the child is laid. According to Obioma () it the level that cater for the learning needs of young persons who, for one reason or another, have had to interrupt their schooling through appropriate forms of complementary approaches to the provision and promotion of basic education. It also ensure the acquisition of appropriate levels of literacy, numeracy, manipulative, communicative and life-skills as well as the ethical, moral and civic values for laying a solid foundation for lifelong learning.

Science Technology Engineering and Mathematics Education at this level include:

Mathematics

Basic Science and Technology

- Basic Science
- Basic Technology
- Information Technology
- Physical and Health Education

The Post-Basic Education and Carrier Development (PBECD) is the education children receive after successful completion of ten years of Basic Education and passing the Basic Education Certificate Examination (BECE). At this level, there is the:

1. The Senior Secondary Education whose curriculum mainly consist of compulsory cutting-cross subjects of:

- English Language;
 - General Mathematics;
 - Trade/Entrepreneurship Subject; and Civic Education; and
 - Fields of study subjects of Science Technology Engineering and Mathematics Education
2. Technical and Vocational Education and Training in Technical Colleges, Vocational Enterprise Institutes (VEIs) and National Vocational Qualifications Framework (NVQF) with variety of curricular subjects of:
 - General Education;
 - Theory and related courses;
 - Workshop practice
 - Industrial; training/production; and
 - Entrepreneurship training
 3. Mass and Nomadic Education comprising of:
 - Mass Literacy, Adult and Non-Formal Education; and
 - Nomadic Education.

Tertiary education

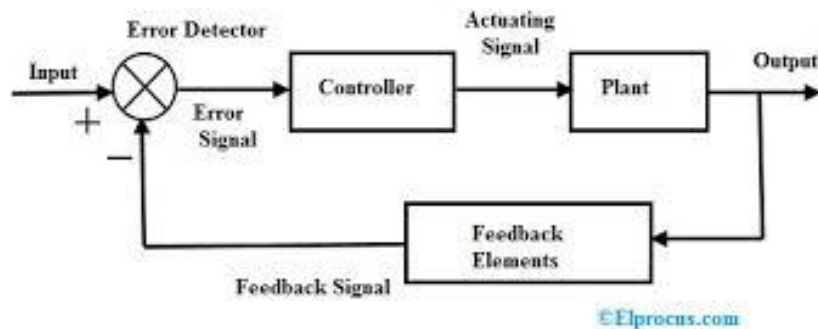
Tertiary Education is the education given after Post Basic Education in institutions such as Universities and Inter-University Centres such as the Nigeria French Language Village, Nigeria Arabic Language Village, National Institute of Nigerian Languages, institutions such as Innovation Enterprise Institutions (IEIs), and Colleges o Education, Monotechnics, Polytechnics, and other specialized institutions such as Colleges o Agriculture, Schools of Health Technology and the National Teachers' Institute (NTI).

III. QUALITY ASSURANCE

Quality Assurance refers to the systematic process of evaluating and maintaining the quality of products, services, or processes. It aims to ensure that they meet specific requirements, standards, and customer expectations.

Quality Assurance in education can be best likened to a simple closed loop control system. A closed-loop control system is a type of control system where the output of the system is fed back to the input to control the process. This allows for real-time monitoring and adjustment of the system's performance.

Where the input represents the processes of admission; the processes and control represents the all the resources and outputs involved; while the QA is represented by the Feedback.



Closed-loop control systems are widely used in various applications, including:

- Process control in industries (e.g., temperature control, flow control)
- Robotics and automation
- Automotive systems (e.g., cruise control, anti-lock braking systems)
- Aerospace engineering
- Medical devices (e.g., insulin pumps, heart rate monitors) their applications.

In various industries, quality assurance involves:

1. Testing and inspection
2. Process monitoring and control
3. Certification and compliance
4. Continuous improvement

Some common QA practices include:

1. Developing quality policies and procedures

2. Conducting regular audits and assessments
3. Identifying and correcting defects or errors
4. Implementing process improvements
5. Providing training and education

The EU has developed a common tool for quality and QA that will not replace the current QA systems and mechanisms implemented by the member states. It will act as a reference instrument to help member states to monitor improvement of their VET systems. The main tool was the Common Quality Assurance Framework (CQAF) that then became a European Quality Assurance Framework² (EQARF). The CQAF quality model is based on the four steps of the Deming-cycle (plan, do, check, act) and is thus a basic strategic management tool that is not designed specifically for quality and QA in VET but is applicable to all sectors (Masson & Seyfried, 2010).

Quality assurance in Science Technology Engineering and Mathematics Education in Nigeria will therefore involve Quality Assurance practice across the levels of education in the country as conducted by various regulatory agencies. That is:

1. Early Child Care and Development Education.
2. Basic Education.
3. Post-Basic Education, and
4. Tertiary Education

The goals of Quality Assurance Agencies according to (Federal Republic of Nigeria, 2014) shall be to:

- a. Set, maintain and improve standards in all aspects of school system;
- b. Ensure Minimum Standards and quality assurance of instructional activities in schools through regular inspection and continuous supervision;
- c. Disseminate on regular basis, information on problems and difficulties of teachers and institutions and offer practical solutions to them; and
- d. Encourage dissemination of information on innovative and progressive educational principles and practice in school system through publications, workshops, meetings, seminars, conferences, etc

Accordingly, there are established quality assurance agencies at the various level of education at Federal, States/FCT and Local Government level for monitoring and maintaining set standards at all the level of education below the tertiary level. While quality assurance activities at the Early Child Care and Development Education; Basic Education and Post-Basic Education levels is been conducted by the various Local Education Authorities and States Ministries of Education and other related agencies, at the tertiary and University levels the activities are carried out by established Regulatory Agencies.

These agencies are:

1. National Universities Commission (NUC) for the Universities;
2. National Board for Technical Education (NBTE) for the Polytechnics, Monotechnics and Vocational Entrepreneurship Institutes and Technical Colleges; and
3. The National Commission for Colleges of Education (NCCE) for the Colleges of Education and the National Teachers Institute (NTI).

National Universities Commission (NUC)

The National Universities Commission is empowered by law to lay down Minimum Academic Standards (MAS) for universities in the Federation and to accredit their degrees programmes. This led to the preparation, with the use of experts, of the Minimum Academic Standards for the 13 disciplines taught in Nigerian Universities in 1989. The disciplines are; Administration, Agriculture, Arts, Basic Medical Sciences, Education, Engineering and Technology, Environmental Sciences, Law, Medicine and Dentistry, Pharmaceutical Sciences, Sciences, Social Sciences and Veterinary Medicine (National Universities Commission, 2015).

Following the development of the MAS, the following documents were also produced;

1. Manual for accreditation procedures for academic programmes in Nigerian universities;
2. Self-Study form (NUC/SSF)
3. Programme Evaluation Form (NUC/PEF)
4. Accreditation Panel Report Form (NUC/APRF)
5. Accreditation Re-visitation Form (NUC/ARVF)

The MAS served as a reference document for programme accreditation until 2004, when the Commission employed the services of distinguished professors to review the MAS and the Benchmark Minimum Academic Standards (BMAS) was produced. In 2022 the Core Curriculum Minimum Academic Standard (CCMAS) was introduced. The CCMAS documents are uniquely structured to provide for 70% of core

courses for each programme, while allowing universities to utilise the remaining 30% for other innovative courses in their peculiar areas of focus. In addition to the overall Learning Outcomes for each discipline, there are also Learning Outcomes for each programme and course. In general, programmes are typically structured such that a student does not carry less than 30 credit units or more than 48 credit units per session.

Accreditation of degree programmes by the NUC is a system of evaluating academic programmes in Nigerian universities to ensure that they meet the provisions of the MAS documents.

The objectives of accreditation of academic programmes are to;

1. Ensure that the provisions of the MAS are attained, maintained and enhanced
2. Assure employers and other members of the community that Nigerian graduates of all academic programmes have attained an acceptable level of competency in their areas of specialization
3. Certify to the international community that the programmes offered in Nigerian Universities are of high standards and their graduates are adequate for employment and further studies.

The NUC, therefore conducts quality assurance activities through accreditation exercises which is carried out by the accreditation unit of the Commission. The functions of the Department are as follows:

1. Coordination of accreditation visits to academic programmes at undergraduate and postgraduate levels in all Nigerian Universities and degree awarding institutions.
2. Coordination of institutional accreditation in the Nigerian University System;
3. Coordination of the development of new instruments used for accreditation exercises;
4. Periodic review of the instruments used for programme and institutional accreditation in Nigerian universities and degree-awarding institutions;
5. Promotion of institutional culture of quality assurance and self-analysis by encouraging universities to develop strong internal quality assurance mechanism and conduct internal mock accreditation exercises;
6. Responding to inquiries and advising the National Universities Commission on all issues that relate to accreditation of academic programmes in Nigerian universities;
7. Obtaining annually, the list of approved Full-Time/Part-Time Undergraduate, Postgraduate and Distance Learning academic programmes from the Department of Academic Standards to determine programmes that are mature for accreditation;
8. Maintaining a database of professors in Nigerian universities and update same annually;

Quality Assurance activities carried out by the NUC, therefore involved:

Pre-Accreditation Activities:

1. Drawing up list of academic programmes to be accredited
2. Compilation of list of Panel Chairmen/Members, time-tabling and budgeting
3. Organizing the accreditation coordination meeting for panel chairmen and members in a simulation workshop

Post Accreditation Activities:

1. Analyzing Accreditation Reports (Technical and Administrative).
2. Ranking of programmes and universities, based on their accreditation status.
3. Publishing of accreditation status of programmes.
4. Issuance of certificates to programmes that earned Full and Interim accreditation results

National Board for Technical Education (NBTE)

The NBTE used a Technology-Enabled Quality Assurance instrument for quality assurance in institutions under its mandate. In response to the demands of the Fourth Industrial Revolution (4IR) and the Federal Government's strategic emphasis on a digitally-driven economy, the National Board for Technical Education has spearheaded the development of a digital platform for seamless communication with all institutions within their regulatory ambit. The Board has unveiled a paradigm-shifting approach—Technology-Driven Quality Assurance for TVET Institutions. This pioneering initiative seeks to significantly curtail the need for on-site visits, thereby relieving financial pressures on institutions nationwide. Notably, it fosters sustainability by obviating the requirement for the traditional submission of Self-Study Questionnaires (SSQ), hitherto presented in hardbound copies.

A key facet of this initiative is the deliberate reduction in personnel deployment, achieved through the comprehensive digitization of the entire quality assurance process. Formerly manual procedures,

conducted during physical visits, are now seamlessly executed through state-of-the-art technology, enhancing overall efficiency and efficacy.

Institutional Guidelines for Technology-Enabled Quality Assurance

To ensure a smooth transition into the era of Technology-Enabled Quality Assurance (QA), the NBTE has implemented new measures and develop the following guidelines for Institutions:

1. **Website Updates:**
Update institutional websites to encompass all accredited departments, including details of both teaching and non-teaching staff.
2. **Staff Documentation:**
Upload passport-size photos of staff recruited for each program.
Include abridged Curriculum Vitae (CV) or a synopsis, specifying educational qualifications, professional memberships, and years of experience.
3. **Student Project Management:**
Establish a database in the library for storing final-year approved student projects in PDF format, readily available for upload during the quality assurance process.
4. **Logbook Digitization:**
Scan and save existing practical logbooks in PDF format on a google drive.
Adopt digital logbooks for subsequent records, utilizing platforms such as Google Forms.
5. **Practical Recordings:**
Video record practical sessions using mobile devices for subsequent upload to a dedicated YouTube channel.
Create a Gmail account for each class to facilitate the creation and sharing of the YouTube channel.
6. **Software-Related Practicals:**
Screen record software-related practicals for enhanced verification and improved student comprehension.
7. **Admission Lists and Academic Records:**
Ensure the availability of approved admission lists for both ND and HND programs in Excel format.
Include detailed candidate information on O-Level scores and National Diploma (ND) results where applicable.
8. **Architectural Drawings:**
Save soft copies of architectural drawings (floor plans) for classrooms, offices, workshops, laboratories, etc., in PDF format for uploading to the eSSQ.
9. **Learning Management System (LMS):**
Develop a Learning Management System (LMS) for traditional students, complementing conventional teaching and facilitating the gradual integration of technology-enabled learning. Note that LMS is already mandatory for Distance Learning Students.
10. **Document Scanning:**
Convert scanned copies of all relevant documents often requested during quality assurance visits to PDF format. This includes student result sheets, soft copies of student projects, lists of core teaching staff, service staff, and examination question papers and marking schemes, lists of books, and lists of available equipment.
11. **Equipment Identification:**
Engrave the name of the institution on all equipment in laboratories and workshops to indicate ownership.
12. **Digital Photographs with GPS Data:**
Capture digital photographs of equipment in laboratories, workshops, classrooms, and offices using GPS cameras available on the Play Store. Include location coordinates for upload on the eSSQ.
13. **Remote e-Library Access:**
Establish a remote-accessible e-Library containing collections of both free and subscribed books and journals.
14. **Infrastructure Master Plan:**
Maintain an up-to-date master plan showcasing current infrastructures and proposed developments, available in PDF format.
15. **Virtual Meetings:**

Be prepared for virtual meetings scheduled by the NBTE with staff and students for the purpose of interviews.

The National Commission for Colleges of Education (NCCE)

The NCCE adopted a Quality Assurance strategy, in line with current best practices. The Quality Assurance strategy has the unique features of addressing comprehensively, the various factors that may affect the “school life” of an institution and especially those factors that may have a bearing on quality output from the system. Quality Assurance addresses the input and transaction variables in an educational setting in a fairly objective manner, as details of what to look for (as evidence) and the grading system are made public. The Quality Assurance strategy provides an opportunity for the would-be-visited for accreditation institutions to undertake their own self-evaluation, using essentially the same instrument (tool), criteria and standard that the external assessors would use for their accreditation (Federal Republic of Nigeria, 2012).

The institution’s self-evaluation may be undertaken as many times as the institution can afford and well before the external accreditation visit. It thereby allows the institutions not only the opportunity to assess and rate themselves before others but indeed, an opportunity to amend, make up their shortcomings and improve on their observed weak areas long before external assessors visit their institutions.

This NCCE Accreditation Toolkit for NCE awarding institutions is a compendium of the tools the NCCE will use to assess the quality of NCE-programmes in the teacher training institutions in Nigeria henceforth. It is the regulatory body’s insurance that Colleges of Education and similar institutions offering teacher education for the Basic Education sub-sector, are keeping faith (at the desired standard) with their mandate.

The NCCE accreditation toolkit consist of four documents, thus:

Document I: Introduction and Guidelines

This document provides the General Introduction to the Toolkit as well as the Guidelines to various aspects of the kit and the accreditation exercise. It includes:

1. Guidelines for the operations of the Internal Quality Assurance Units in each institution,
2. Criteria for Appointment as Head of QA unit,
3. The Role of the Chairman/Team Leader of an Accreditation Team,
4. Guidelines for the Accreditation Visit.

Document II: Quality Indicators and Grading Process

It contains the Quality Indicators, Grading Process and Grading Grid that are used in the course of accreditation of an NCE awarding institution.

There are five key areas for identification and determination of Quality. They are:

1. Leadership, management and organization.
2. Curriculum organization and implementation.
3. Infrastructure and learning resources.
4. Assessment and evaluation.
5. Students support and progression.

Each of the key areas comprises a range of quality indicators against which institutions will be assessed. Some of the quality indicators have been broken down into sub-indicators and suggestions have been made on where to source for evidence.

Grading is generally based on a 4-point Likert Scale from “Fail” through “Need to improve” to “satisfactory” and “Good”, with Fail = 0 and Good = 3. The only exception to this general grading procedure is with the two compulsory key areas of Leadership, management and organization and Curriculum organization and implementation. The grading scale in these two areas has been modified to a 3-point scale i.e. Good, Satisfactory and Fail.

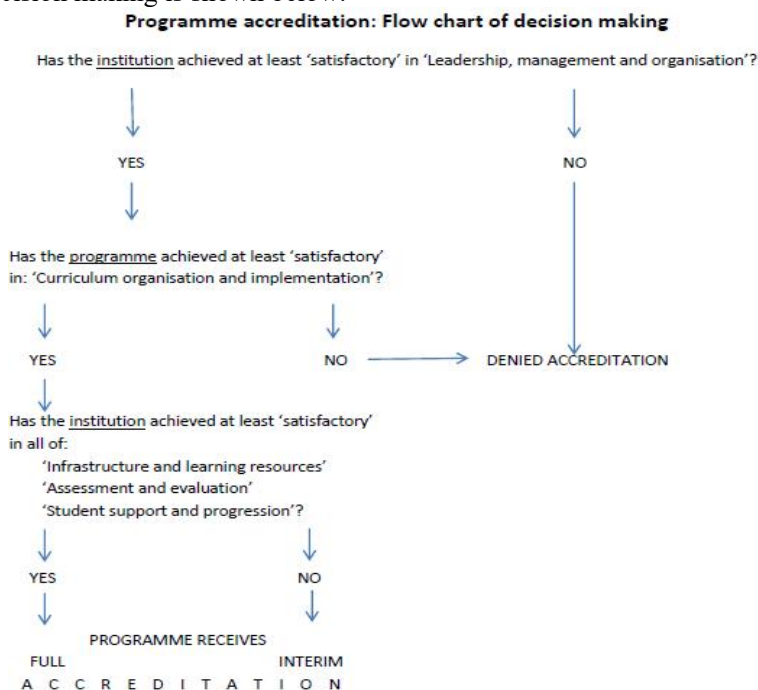
Document III: Institutional Self-Assessment and the Statement of Facts forms

Consists of the Institutional Self-Assessment form and the Statement of Facts form. These two forms are to be completed and submitted to NCCE by institutions before each accreditation exercise. While the self-assessment is the main instrument used to describe the situation on the ground in the key areas of QA, the Statement of Facts form is used to capture some factual (statistical) information about the institution and its programmes.

Both of these documents should be used by institutions to develop and enhance their own internal quality assurance procedure and status. The documents should be used and updated on an ongoing basis rather than being used/completed immediately before an accreditation exercise.

For those institutions that offer more than one programme (i.e. ECCE, Primary, Junior Secondary, Adult and Non-Formal and Special Education) there will be a separate assessment for each programme for the key area of Curriculum organization and implementation. Thus, an institution may receive, for example, “Full Accreditation” for some programmes and “Denied Accreditation” for other programmes. NOTE: this means that there could be multiple assessments for the key area of “Curriculum organization and implementation”, but there will be only one assessment for each of the other four key areas.

A flow chart of decision making is shown below.



(Federal Republic of Nigeria, 2012)

Document IV: External Assessors Documents

This consists of:

1. Role of the Chairman/Team Leader of an Accreditation Team.
2. Code of Conduct for the members of the Accreditation Team.
3. Agenda for the 1st meeting of the Accreditation Team.
4. Lists of Documents to be made available to NCCE Accreditation Team.
5. Guidelines/Criteria for Appointment as Head of QA unit.
6. External Assessment form for NCE awarding institutions.
7. Statement of Fact form.
8. Final Report Form.

IV. CHALLENGES AND BENEFITS OF EFFECTIVE QUALITY ASSURANCE IN STEM

Looking back into the presentation, the main focus of Quality Assurance especially by the N.C.C.E. is on:

1. Leadership, management and organization.
2. Curriculum organization and implementation.
3. Infrastructure and learning resources.
4. Assessment and evaluation.
5. Students support and progression.

Accordingly, the challenges to Quality Assurance in the institutions can be viewed in the following:

1. Leadership, management and organization.

Although there laid down procedures for selections and appointment of the various levels of leadership in the institutions, sometimes these procedures are derailed for one reason or the other. In many instances, the

lead to poor management and bad organization which resulted in the institutions not being able to meet the minimum requirement on this area.

2. Curriculum organization and implementation.

For all levels of education, there is a minimum benchmark set for the programmes to attain before they obtain Accreditation Status. Institutions failed to secure Accreditation because of their failure to meet these minimum benchmarks.

3. Infrastructure and learning resources.

Despite huge interventions on infrastructure and learning resources, the culture of poor maintenance is posing serious challenges to full utilizations and hence bastardizing the efforts. There is also the issue of misplacement of priority.

4. Assessment and evaluation.

Assessment and evaluation are major components of any education sector. They are the bedrock for admission, progression and certifications. These important components are grossly marred by issues of malpractices and misconducts, sharp practices, and so on.

5. Students support and progression.

As a result of challenges associated with conducts of Assessment and evaluation, students support and progression are highly affected and this affect the overall institutional performance.

The way forward

For effective production of quality teachers of science, technology, engineering and mathematics, therefore, the following measures are highly recommended:

1. Adequate funding of Quality Assurance activities to enable effective process without recourse to the heavy expenditure involved and without comparison to financial profits as in other economic endeavour.
2. Ensure objectivity, transparency and prudence in the conduct of Quality Assurance by ensuring the use of the right human and material resources.
3. Effective use of Quality Assurance instruments at all levels without compromising the set standards.
4. Implementation of the outcomes of Quality Assurance activities by all concerned with immediate effect.

Equally, (Akor, Enefu, Okolo, & Okaforcha, 2016; Ekpo & Asuquo, 2020; Usman, 2020; Ogunode & Adanna, 2022; Ogunode et al., 2021 and Aluede et al., 2020 in Imhangbe, O., Oviawe, J., Aluede, O., Obinyan, G. & Oke, T., 2023) recommended that Quality Assurance in teacher education should encompass the following:

1. Quality Admission
Steps must be taken to ensure the admission of high-quality candidates to teacher education programmes and to give them the necessary information to assure them of a rewarding career so that they turn out a willing and quality teacher. It is through the selection of intelligent, qualified, and interested prospective teachers into teacher education programmes that can lead the production of sound teachers with the competence to handle advancement in instructional technology and the dynamic of suitable methodologies for a complex world.
2. Regular and Continuous Review of the Curriculum
Schooling in the era of the new knowledge economy must embrace the need for learners to learn as they go, solve problems, collaborate, and be flexible and creative. The curriculum must reflect the notion of this new learning. It calls for intensive application of global visions of preparing students for the world of work. Therefore, the curriculum review should be geared towards modernisation, including the incorporation of information and communication technology, not only as a subject or course of study but as an application tool in order to meet the needs of the society.
3. Providing Information Communication Technology Training Programme for Teacher Educators
For the teacher to function properly, the teacher education process must adequately integrate Information Communication Technologies (ICT). ICT are major tools for advancing teaching, learning, and research. It can help broaden access to education and improve learning outcomes. Therefore, there is a need for professional development of teacher educators in the area of ICT integration. For example, the internet can assist teacher educators through extensive research in getting quality information and making them more confident to speak out in their subject area. Exposure to ICT will definitely change their teaching style in a tremendous and positive way.

Therefore, teachers should be encouraged to develop strategies to adapt their teaching to information-rich environments.

4. Teaching Methods

Education is meant to prepare learners for effective life in the society. Poor instructional methods hinder such preparations. No teaching is useful until the learner learns and practices the skills required. Steps should be taken for continuous teaching method review/improvement to make the teaching method current and relevant to contemporary needs.

5. Improving Supervision

Supervisors must have adequate time to devote to their work, consult and plan together, hold conferences with the students, observe the students' teaching, and become acquainted with the students' strengths, weaknesses, and concerns. They should be ready to collaborate with the students in mutually beneficial educational tasks.

6. Provision of Required Manpower

There is a need to constantly prepare a sufficient number of teachers to teach at all levels of the educational system and to replace those retiring to meet the needs of expanding enrolment. This is because the lack of teachers affects students' performance.

7. Career Development and In-service Training for Teachers

Teachers are made more effective and productive through re-training in order to entrench new but useful methods, practices, and concepts. It is essential to employ all avenues to educate subject teachers who will be competent in their field of specialisation. Assessments of teacher performance may regularly be conducted to identify teachers' needs for additional training or development. In other words, capacity-building programmes should be organised at regular intervals for effective and efficient performance.

8. Establishment and Maintaining Linkages

Teacher education institutions should establish linkages with some top-ranking foreign universities and teacher training institutions for staff exchange in order to ensure conformity with international best practices (standards and developments).

9. Staff Motivation

There is a need to improve remuneration and conditions of service for teachers in order to get the best from them. Special allowances should be paid to teachers on a regular basis. The teacher salary structure should be upgraded and made attractive so that they can live comfortably and be motivated to put in their best.

10. Accreditation of Academic Programme

The periodic accreditation of programmes in universities by the National University Commission should be strengthened for quality control and assurance. Institutions should also endeavour to limit the admission of students to what their facilities can support.

11. Research-based Teaching

Students should be introduced to research in their areas of specialisation in order to bring together recent research information about theories and methods as well as best practices in students' area of specialisation. This will strengthen the link between theory and practice in order to foster the growth and development of students into experts in teaching and education. It will also be important for teacher education to provide teaching qualifications to be based on the combination of scientific and constructive critical thinking and practical skills.

Specifically, the paper strongly recommends the following internal Quality Assurance measures:

1. Active Quality Assurance Committees at Faculty/School and Departments/Units.
2. Full utilization of all Quality Assurance Instruments, such as:
 - i. The SSF
 - ii. The four NCCE Documents
 - iii. The instruments for lecture monitoring and assessment
 - iv. Instrument for Analysis of Examination Question Papers
 - v. Mentoring Observation Instrument
 - vi. Instrument for Students Evaluation of Lecturers
 - vii. Lectures attendance monitoring Instrument, etc
3. Innovating additional Quality Assurance measures/instruments
4. Adequate funding of the Quality Assurance process.

Conclusion

The paper traces the development of western education in Nigeria from pre-colonial to colonial era, through independence and post-independence. It discussed the post-independence development of the education sector, the various attempts in the development of the Nigerian education system. It pinpointed the place of STEM in the Nigerian education from early childhood care education up to the University level. The paper also identified the various agencies responsible for Quality Assurance at all levels. It concluded that for the successful implementation of STEM programs, an effective Quality Assurance mechanism is imperative.

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