COMMUNICATION TECHNOLOGIES AND SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM) EDUCATION

Keynote Address

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- Goals of the STEM Education,
- Increasing the Number of Students and Professionals in STEM,
- Understanding the Components of STEM as an Education Programme,
- Implementing STEM Education, and
- Communication Technologies and STEME
- Conclusion

INTRODUCTION

- STEM is an acronym that refers to the academic disciplines of Science, Technology, Engineering and Mathematics collectively.
- Science, Technology, Engineering and Mathematics Education (STEME) is an educational programme generally developed to prepare students for college and graduate study in the fields of science, technology, engineering, and mathematics.
- STEME aims to foster inquiring minds, logical reasoning, and collaboration skills in the learners.

INTRODUCTION (Contd)

- The promotion of STEME aligns with the worldwide education trend of equipping students to meet the changes and challenges in our society and around the world with rapid economic, scientific and technological developments.
- In Nigeria and indeed in many African countries, promotion of STEM education is introduced as a key emphasis in the school curriculum, to nurture students to become effective lifelong learners equipped with appropriate knowledge, generic skills as well as values and attitudes necessary for facing challenges in the 21st century.

Concepts of Science, Technology, Engineering and Mathematics

- Science, technology, engineering and mathematics are distinct and complementary approaches to knowledge and practice.
- The scope of science in STEM will be limited to the enabling disciplines within the natural and physical sciences and this natural and physical sciences encompass astronomy and the earth sciences, physics, chemistry, the materials sciences, biology and biomedical science.
- These sciences rely on causal relationships, characterised by systematic observation, critical experimentation, hypothesis formation and falsification, but notwithstanding this focus, addressing the societal challenges fully requires the knowledge and skills of other science disciplines outside the natural and physical sciences.
- Thus, our conceptualization of science would include the human sciences which attempt to understand human and historical life, which involves theories and methods that are more diverse and contested than in natural and physical sciences research and what is also to be classified as science education here includes the design sciences such as architecture, urban planning and design studies.
- From the above classifications, three broad categories of sciences, namely; natural and physical sciences, human sciences, and the design sciences emerged.

Concepts of Science, Technology, Engineering and Mathematics (2).

- Technology on the other hand provides goods and services to satisfy real-world needs and with the growing importance of ICT, technology increasingly encompasses the cross-section of knowledge and skills that drive the advance of the business, government and non-government service sectors; that is, the so-called service sciences.
- Engineering is a profession which draws on the knowledge and methods of science, but science is far from sufficient for successful practice if there is no engineering.
- Thus, engineering and technology are critical factors in the long-term economic growth of modern industrial societies as they function within the larger social environment to sustain the innovation process.

Concepts of Science, Technology, Engineering and Mathematics (3)

- Technology essentially creates ideal learning and as such,Glickman (1991) notes that for long, it has been ignored or its past implementation has failed widely since it creates a learner-centred, learning environment with a belief that they learn more from what they do or think rather than the teacher's input.
- However, we must take care not to allow the dynamic nature of technology overshadow the enduring nature of learning and or the ever-increasing knowledge base about learning.
- Mathematics is a discipline which aims at understanding the world by performing symbolic reasoning and computation on abstract structures; combined with the disciplines within the natural and physical sciences, mathematics contributes broadly to all disciplines and practices used for the betterment of society as it unearths relationships among these structures, and captures certain features of the world through the processes of modelling, formal reasoning and computation and above all contributes to biology, medicine, social sciences, business, advanced design, climate, finance, advanced materials, and many more.
- Therefore, Mathematics education involves the integration of mathematics, statistics, and computation in the broadest sense and their interplay with areas of potential application.

Goals of STEM Education

STEME has three (3) basic goals and they include:

- To understand the components of STEM as an education programme.
- To expand the number of students prepared to study and pursue careers in the areas of science, technology, engineering, and mathematics.
- To boost the proficiency of all students in basic STEM knowledge.

Goals of STEM Education (2)

To understand the components of STEM as an education programme.

- In this regard as the first goal of STEM, STEM could be broken down into standards of practice (or skill sets) for studying science, technology, engineering, and mathematics in schools.
- In order to ensure successful implementation of STEME in Nigeria, the Federal Ministry of Education (FME), Abuja, and the agencies under the FME have adopted rigorous STEM standards and improved assessments, otherwise known as benchmarks and schools implementing this are therefore expected to ensure that the implementations of the benchmarks at all levels should meet the internationally benchmarked science.

Goals of STEM Education (3)

- In implementing curriculums of STEM in Nigeria, implementers must ensure a steady flow of new ideas and knowledge as Innovations in STEME must turn knowledge into new and better ways of doing things for the benefit of all learners and for humanity at large using the global connections that are intrinsic to quality STEM.
- (AITSL, 2011) states that the levels of STEM literacy will only improve tremendously through better engagement of all stakeholders as well as increased engagement of the community with the STEM enterprise and in this respect, the Science Teachers' Association of Nigeria (STAN) led efforts in propagating and promoting STEME is desirable and needed as it would ultimately boost the STEM education and support the achievement and maintenance of the set STEM standards.
- As regards the above, the efforts being made by STAN are in tandem with the recommendation that to reverse the trend for decreasing STEM participation in schools, governments at all levels, individuals and associations will need to cooperate to drive the school education system away from educating students as we used to, and towards preparing students for a future increasingly bound to STEM.

Goals of STEM Education (4)

Expanding the number of students prepared to study and pursue careers in the areas of science, technology, engineering, and mathematics.

- This second goal is designed to boost the innovative capacity of our workforce, which is falling behind in comparison with some other nations in Africa that churn out higher numbers of STEM trained individuals each year.

Goals of STEM Education (5)

To boost the proficiency of all students in basic STEM knowledge

- This third goal is designed to improve the ability of students and teachers to assess problems, deploy STEM concepts and apply creative solutions in their daily lives and this goal requires that all high school graduates be ready with the basic skills to pursue work or study in both STEM and non-STEM fields and meets the demands of most jobs today.
- These goals are intended to enhance the global competitiveness of the economy and help individuals achieve economic security in their careers

Increasing the Number of Students and Professionals in STEM

- A major goal of the STEM agenda according to Thomasian (2011), is to increase the number of individuals pursuing STEM careers as the major pathway to STEM career is through postsecondary study, boosting the number of individuals in STEM jobs implies that more individuals will be graduating from college with STEM degrees or certificates. This can only be possible if there is increased emphasis in the popularisation of STEM at the pre-tertiary education levels.
- When promoting STEM education, reference has to be made to the local and international experiences in the educational trends of equipping students with appropriate knowledge and skills to meet the changes and challenges in society and around the world.

Increasing the Number of Students and Professionals in STEM (2)

Guiding principles for promoting STEM education

- *Learner-centred approaches:* They help facilitate students to learn STEM through STEM-related learning activities. Here, the diversified learning, teaching and assessment strategies are used to suit the needs and interests of students.
- *Essential learning experiences:* This principle posits that all learners have the ability to learn, and they should be provided with STEM-related learning opportunities which form part of the essential learning experiences that include learning opportunities beyond the classroom.
- *Balance among different purposes, views and interests:* In promoting STEM education, a balance has to be struck with considerations of learners' interests and needs, teachers' views and partnerships with community key stakeholders.
- *Building on strengths:* This principle suggests that promoting of STEM education should be built on school experiences and some factors, such as the flexible use of learning time and life-wide learning experiences. In doing so, teaching time devoted to STEM could be increased depending on the level of the learners.
- *Continuous development process:* Promoting STEM education at school level is a continuous and dynamic improvement process.

Understanding the Components of STEM as an Education Programme

- STEM education stresses a multidisciplinary approach for preparing all learners in STEM subjects for STEM occupations.
- Ojugo, Aghware and Okonta (2005) listed STEM goals in Nigeria to include

(a) provides preparation for training in science and mathematics.

(b) provides basic mathematics and science literacy for everyday living.

(c)provides basic skills, attitude to prepare us for technological developments and

(d) helps to stimulate and enhance creativity.

Understanding the Components of STEM as an Education Programme (2)

- A labour force without a rich supply of STEM skilled individuals will face stagnant or even declining wealth by failing to compete in the global economy.
- Thus, the ability to understand and use STEM facts, principles, and techniques are highly transferable skills that enhance an individual's ability to succeed in school and beyond across a wide array of disciplines; some of these skills include:
  - Using critical thinking to recognize a problem;
  - Using science, technology, engineering and mathematics concepts to evaluate a problem; and
  - Correctly identifying the steps needed to solve a problem (even if not all the knowledge to complete all steps is present).

Understanding the Components of STEM as an Education Programme (3)

Achieving greater STEM proficiency begins early in learners' life and STEME in Nigeria starts from pre-primary education when children are made to explore their environments, play with toys and sing songs and rhythms.

Implementing STEM Education, and Suggestions for the way forward

The promotion of STEM education aims at strengthening the Science, Technology and Mathematics Education with a view to nurturing diversified talents in the science and technology fields for enhancing the international competitiveness could be achieved through:

- developing among students a solid knowledge base as well as enhancing their interests in Science, Technology and Mathematics for further studies and careers in meeting the changes and challenges in the contemporary world;
- strengthening students' ability to integrate and apply knowledge and skills, and nurturing students' creativity, collaboration and problem solving skills, as well as fostering their innovation and entrepreneurial spirit as required in the 21st century;
- strengthening the professional capacity of and collaborating among teachers in schools and partnering with community stakeholders; and
- nurturing talents and developing experts in STEM areas so as to contribute to the development of our nation's strategic position in Africa.

Implementing STEM Education, and Suggestions for the way forward (2)

Curriculum Development Council, 2015 features a holistic approach using different strategies focusing on strengthening students' ability to integrate and apply knowledge and skills of different disciplines in school education have been adopted to unleash learners' potential in innovation. The holistic approach ensures that all stakeholders in STEM are involved in activities such as:

- development and review of the curriculums of Science, Technology and Mathematics Education;
- enrichment and provision of learning and teaching resources and activities for students;
- enhancement of professional development of schools and teachers; and
- strengthening of partnerships in the dissemination good practices with community key stakeholders.

Implementing STEM Education, and Suggestions for the way forward (3)

The Place of STAN in Promoting STEME

The Science Teachers Association of Nigeria (STAN) has done a lot so far but should among other things strive to do the following:

- Continue its role as a torch-bearer for science, technology and innovation and to provide high-level advice to the Government at all levels on relevant science, technology, engineering and innovation issues.
- Help articulate the important role of information and communication technologies and science, technology, innovation and engineering in the our national development agenda by acting as a forum for horizon scanning and strategic planning, providing foresight about critical trends in science, technology and innovation in various areas.
- Raise awareness among policymakers about the process of innovation and to identify particular opportunities for institutions to benefit from such innovation, with special attention being placed on new trends in innovation that can offer novel possibilities'

Implementing STEM Education, and Suggestions for the way forward (4)

The Place of STAN in Promoting STEME (Cont'd)

- Discuss and explore innovative financing models as a means to attract new sources of investment capital for science, technology, engineering and innovation-based solutions, in particular smaller scale, off-grid renewable energy technologies, to address pressing challenges and needs for sustainable development, in collaboration with other organizations where appropriate.
- Provide a forum for sharing best practices, successful local innovation models, case studies and experiences on the use of science, technology and engineering for innovation, in symbiotic relationship with information and communications technologies, for inclusive and sustainable development.
- Play an active role in creating awareness of the potential contribution of science, technology and innovation to the post-2015 development agenda through substantive inputs to relevant processes and bodies of the United Nations and to share findings and good practices on science, technology and innovation among member States and beyond;

Implementing STEM Education, and Suggestions for the way forward (5)

The Place of STAN in Promoting STEME (Cont'd)

- Provide a forum for sharing good practices and experiences to identify and recommend ways and appropriate measures to promote innovation, research and development, creation of new knowledge and transfer of technology, as well as information and communications technologies for capacity-building in science, technology and engineering education, research and entrepreneurship for the benefit of developing countries and, in this context, to explore ways to expand cooperation among all countries, with particular attention to addressing pollution problems.

COMMUNICATION TECHNOLOGIES AND STEME

- Meaning of Communication Technologies
- Characteristics of Communication Technologies
- Roles of Communication Technologies in STEM Classrooms
- Types of Communication Technologies in STEM Classrooms
- Communication Technologies in Stem Classrooms – Digital Divides
- Conclusion

Meaning of Communication Technologies

- Communication Technology is a composite of two (2) concepts, 'communication' and technology'.
- Communication is the act of conveying intended meanings from one entity or group to another through the use of mutually understood signs and semiotic (meaning-making) rules.
- It involves sharing information among partners or parties. Communication is social interaction where at least two interacting agents share a common set of signs and a common set of semiotic rules.

Basic Steps of Communication

- the forming of communicative intent
- message composition
- message encoding
- transmission of the encoded message as a sequence of signals using a specific channel or medium
- reception of signals
- reconstruction of the original message
- interpretation and making sense of the reconstructed message.

There are different types of communication, depending on the context that is at focus.

Meaning of Technology

- ‘Technology’, on the other hand, is the practical application of science to industry or commerce.
- It is the application of knowledge to the practical aims of human life or to changing and manipulating the human environment.
- Technology includes the use of materials, tools, techniques, and sources of power to make life easier or more pleasant and work more productive.
- Whereas science is concerned with how and why things happen, technology focuses on making things happen.

Meaning of Communication Technology

- Communication Technology, then, is the act or activity of designing and constructing and maintaining communication systems.
- It is the utilization of technology to carry out or enhance communication process or activity.
- Information and communications technology (ICT) refers to all the technology used to handle telecommunications, broadcast media, intelligent building management systems, audiovisual processing and transmission systems, and network-based control and monitoring functions.
- Although ICT is often considered an extended synonym for information technology (IT), its scope is broader.
- ICT has more recently been used to describe the convergence of several technologies and the use of common transmission lines carrying very diverse data and communication types and formats.
- (Communication technology, information technology and ICT are used interchangeably)

Meaning of Communication Technology contd

- Information and communication technologies refers to a diverse set of technological tools and resources used to communicate, and to create, disseminate, store, and manage information.
- ICT implies the technology which consists of electronic devices and associated human interactive materials that enable the user to employ them for a wide range of teaching - learning processes in addition to personal use.
- Information technology (IT) is the acquisition, processing, storage and dissemination of vocal, pictorial, textual and numerical information by a micro-electronics-based combination of computing and telecommunication.
- It refers to anything that renders data, information or perceived knowledge in any visual format whatsoever, via any multimedia distribution mechanism.

Characteristics of Communication Technology

- Acquisition
- Storage
- Manipulation
- Management
- Transmission or reception of data or information.
- Real time access to information
- Easy availability of updated data
- Connecting Geographically dispersed regions
- Wider range of communication media.

Unique Characteristics of Communication Technology

- ICT is pervasive and cross-cutting
- From personal use to business and Govt
- Can be tailored to meet personal, local, diverse needs.
- ICT creates networks
- Those connected benefit from the network
- The Network externalities increases as it grows.
- ICT disseminates information and knowledge
- Separates content from its physical location
- Makes knowledge available to remote communities
- ICT allows for zero or declining marginal costs

Unique Characteristics of Communication Technology contd

- Replication of content is free
- Distribution of marginal cost is near zero
- ICT reduces transaction costs
- ICT enhances efficiency
- Has power to store, retrieve, sorts, filter and distribute information
- Makes processes and transactions leaner and more effective
- ICT reduces the need for intermediaries
- Links consumers directly to producers
- Allows users to acquire products and services directly
- ICT is global
- Transcends cultural and linguistic barriers
- Allows local communities to be part of the global network

Communication Technology in the Classroom

- Communication technologies have the potential to transform the educational process.
- They also have the power to change the roles of teachers in our schools, even to the point of threatening to reduce the number and status of teachers.
- Since the early 1980s, advances in computer technology have transformed how we communicate, entertain ourselves, work and even learn.
- The rapid pace of technological change has been felt in elementary, secondary and tertiary education classrooms.
- Over the years, technology has advanced to become not only an instructional tool but also a medium of education itself.
- The growth of the Internet in the 1990s fueled the push for expanded classroom technology.

Communication Technology in the Classroom contd

- Information and communication technologies are of paramount importance to the future of education.
- ICT in education initiatives that focus on the following areas are most likely to successfully contribute to meeting the Education for all (EFA) and Sustainable Development Goals (SDGs):
- • **Increasing access through distance learning** – ICTs can provide new and innovative means to bring educational opportunities to greater numbers of people of all ages, and across all populations.
- • **Enabling a knowledge network for students** – Knowledge is Power: Effective use of ICTs can contribute to the timely transmission of information and knowledge, thereby helping education systems contribute to national economy.
- • **Training teachers** – Large numbers of school teachers will be needed to meet the EFA and SDGs for education. The use of ICTs can help in meeting teacher training targets.
- • **Broadening the availability of quality education materials** – Network technologies have the potential to increase the availability of quality educational materials. Their interactivity and global reach allow for customized sharing of knowledge, materials, and databases.

Communication Technology in the Classroom contd

- Technology in the classroom is doing just that – keeping learners stimulated by using the latest and greatest inventions in computers and digital media.
- **The slogan in vogue is *Digital Learning*.**
- According to Steinberg (2013), five reasons why Digital Learning is important are:
- **Personalization**: Digital learning offers an unprecedented ability to provide educational experiences that are tailor-made for each student.
- **Accessibility**: By embracing digital devices and connected learning, classrooms around the globe can connect to one another to share insights and boost learning, experience and communications skills.
- **Cultural Relevance**: Nearly every aspect of the real world has gone digital. Digital learning experiences in school involve the use of a dizzying array of technological devices and connections to prepare learners for the reality of higher education and world of work offers.
- **Efficiency**: Digital learning solutions also bring to bear a number of key efficiencies, both real and virtual, that can't be matched by traditional learning techniques.
- **Performance**: Studies have shown that students using technology as an education tool become more engaged in the process and more interested in growing their knowledge base, and ultimately perform significantly better

Types of Communication Technologies in STEM Classrooms

- **Personal web sites**: Sites that anyone can make/design to post material, including writings, drawings, and pictures. They may allow users to post comments on them.
- **Blogs (weblogs)**: Interactive personal online diaries or journals.
- **Email**: Communication sent to individual(s) or a discussion list.
- **Discussion groups or bulletin boards**: group communications around a topic.
- **Chat**: Real time group communication programs or websites, with ability to establish private chats as well.
- **Instant Messaging (IM)**: instant, text based 'chat' programs through which users on a private contact or "buddy list" can communicate.
- **SMS text/digital image messaging**: Messages or images sent via mobile-phones.
- **Social networking communities**: Web sites like MySpace that combine the features of profiles, personal web sites, blogs, discussion groups/boards, chat, gaming, and messaging.

Types of Communication Technologies in STEM Classrooms

Also, according to Schaffhauser (2013), the following twelve (12) technologies will flood the STEM classrooms in few years from now:

- **Learning analytics**, the use of data to improve student retention and provide more personalized instruction;
- **Mobile learning**, facilitating education through mobile devices;
- **Online learning**, which is undergoing massive experimentation to uncover solutions for assessment and learning at scale that are completely fresh and new;
- **Virtual and remote laboratories**, web applications that emulate the operation of real laboratories to allow learners to "practice" experiments without the use of physical components;
- **3D printing**, for modelling and prototyping;
- **Games and gamification**, to motivate and train students;

Types of Communication Technologies in STEM Classrooms

Also, according to Schaffhauser (2013), the following twelve (12) technologies will flood the STEM classrooms in few years from now:

- **Immersive learning environments**, to mimic realistic situations in training students and providing new ways for them to practise their skills;
- **Wearable technology**, such as goggle glass, to generate new kinds of data that can be integrated into learning experiences;
- **Flexible displays**, such as screens that are pliable and can be folded or wrapped around curved surfaces;
- **The Internet of things**, in which objects can communicate information about themselves through a network;
- **Machine learning**, computers that can act and react without being explicitly programmed to do so; and
- **Virtual assistants**, new ways of interacting with computing devices.

Types of Communication Technologies in STEM Classrooms

These various technologies, and many more emerging ones, can be grouped into two (2) main categories, namely:

- ***Teacher-Centered Technologies***
- ***Student-Centered Technologies***

Communication Technologies in STEME – Challenges (Digital Divides)

- Rapid changes in the technologies versus a conservative population, particularly in the third world;
- Some States (nations) have the resources to support technologies, and others do not;
- Some parents/guardians have the resources to provide necessary or required gadgets, while other parents do not;
- Some parents/guardians have the skill, interest and time to supervise their wards in the use of the technologies, while others do not have any or all of these;
- Teachers' knowledge: those who know, and those who are ignorant;

Communication Technologies in STEME – Challenges (Digital Divides) (contd)

- Teachers' willingness to learn, to be relevant in the class, and those who are not;
- ICT experts versus Educational Technology experts. Technologies in education require more than having ICT experts in the school environment. School staff that know how to deploy these expertise and available gadgets to foster the educational needs of the learners are the additional, but more important, requirement.
- Relevance of the technologies, and the abuse of them;
- The interaction between the *digital natives* (the children/youth/learners) and *digital immigrants* (the adults/parents/teachers. Who is really in charge in the teaching-learning process? Who needs help more than the other?

CONCLUSION

The STEM classroom of today, and of the 21st Century, requires intelligent and resourceful application and adaptation of available and emerging technologies to impart 21st Century skills, and produce appropriate and requisite manpower for our nation, and for our present and future generations. The characteristics and roles of communication technologies in the classroom have been explored; and the different technologies in the STEM classroom have been highlighted. The challenges that tend to confront massive and successful application of technologies in the classroom have also been highlighted. If the paper has aroused the interest, and whetted the appetite of the listeners in the direction of ICT in STEME, the desire of the presenter would have been met, and perhaps, the dream of the conference organizers would have been realised.

Thank you For Listening