SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM) EDUCATION FOR ENTREPRENEURSHIP AND ECONOMIC GROWTH IN NIGERIA

Asma'u Itakure Suleiman & Haruna Isiaku

Department of Physics, F.C.T College of Education, Zuba, Abuja.
Email: suleimanasmau75@gmail.com **Phone:** +2348035055758.

Abstract
Science Technology Engineering and Mathematics Education (STEM) have become important tools to satisfactorily deal with the many challenges in the society worldwide. Recently, attention has been placed on STEM as a result of the employment gap in STEM-field and the need to meet the demand of technological development of this present time. Providing learners with the 21st century skills through entrepreneurship is the current pursuit of nations of the world who are willing to maintain economic competitiveness and national sustainability. STEM education is now seen by these nations as an option for equipping their up-coming generations with problem solving skills and potentials for becoming tomorrow's innovators and entrepreneurs. To succeed in this new information-based and highly technological society, students need to develop their capabilities in STEM to levels much beyond what was considered acceptable in the past. This paper looked into STEM education, entrepreneurship education and how to reposition STEM education for entrepreneurship and economic growth in Nigeria. It concludes that STEM education is necessary for the growth and development of the nation and if Nigeria will remain the giant of africa, then more emphasis must be placed on it. It also made suggestions of what Nigeria ought to do at this time to reposition STEM education to achieve economic recovery.
Keywords: *Science, Technology, Engineering, Mathematics Education, Innovation, Entrepreneurship and Economic Growth.*

Introduction

The economic attainment and development of any nation depends on the quality of science and technology education of that nation. Real development involves the creative capacity of people to transform effectively natural resources of the environment into goods and services through imaginative and practical application of their creative talents and productive labour force. As documented by Lewanika (2010), advances in science and technology contribute to the social and economic development of nations that result in improved standard of living manifested through good health, food security, adequate housing and sustainable use of natural resources, environmental protection and economic growth. Nigeria today faces a number of challenges which can only be met if it has innovative, well educated and entrepreneurial citizens who, whatever their walks of life, have the spirit and inquisitiveness to think in new ways and the courage to meet and adapt to the challenges facing them.

Uza (2013) opined that for many years, Africa and Nigeria in particular, are perceived as having been left behind, purely because of backwardness in technology. This can be seen in the bad roads, which leads to difficulties in transportation, education and infrastructure, among others that are poorly developed as compared to those of other developed and developing countries. Moreover, a dynamic economy, which is innovative and able to groom young people who will launch and successfully develop their own commercial or social ventures, or who will become innovators in the wider organizations in which they work, is definitely what Nigeria needs at this point in time to survive her challenges.

STEM Education was originally called Science, Mathematics, Engineering and Technology (SMET) (Sanders, 2009), and was an initiative created by the National Science Foundation (NSF). This educational initiative was to provide all students with critical thinking skills that would make them creative problem solvers and ultimately more marketable in the workforce. Historically, STEM implementation was profound in the business world ushering industrial revolution which saw Thomas Edison and several inventors alike evolve STEM education outside the classroom. STEM application

then was significant in the field of engineering leading to the manufacturing of light bulb, tools and other machines. Many of the people responsible for these innovations were only slightly educated and or were in some type of apprenticeship. For example, Thomas Edison did not attend college (Beals, 2012), nor did Henry Ford; although Ford did work for Thomas Edison for a number of years.

These “giants” of innovation used STEM principles to produce some of the most prolific technologies in history: however, STEM in education was virtually non-existent (Butz, Kelly, Adamson, Bloom, Fossum, & Gross 2004). The perception of researchers on STEM education is that student participants would benefit even when they refuse to pursue a post-secondary education and would benefit more if such students attend college, particularly in STEM related fields (Butz et al., 2004). Therefore, there is a vital need for STEM education in the 21st century because the job market requires a new set of skills and there is a need for intensification of efforts on technological skills (Voogt & Robin, 2012). Hence, it is imperative to teach STEM education in developing countries especially Nigeria.

Science Technology Engineering and Mathematics (STEM) Education

STEM Education is a global movement in educational practice that integrates science, technology, engineering and mathematics to develop 21st century skills (Bybee, 2013). Okoro (2013), stated that the inter-related nature of STEM is such that as a seamless robe, it is integrated into one entity "Science Education" whose principles and structure are anchored in mathematics. It removes the traditional barriers erected between the four disciplines by integrating them into one cohesive teaching and learning paradigm. The STEM education is vital for improved economic development manifested in international competitiveness and job creation (African American Institute, 2015). This might be attributable to the fact that it ensures a multidisciplinary approach to developmental issues pertinent to each economy coupled with real world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Southwest Regional STEM Network 2009).

Despite the increasingly common use of the term “STEM education,” there is still uncertainty as to what constitutes STEM education and what it means in terms of curriculum and student outcomes (Breiner et al. 2012; Lamberg & Trzynadlowski, 2015). STEM education can be considered a single or multi-disciplinary field, and in the case of the latter, no clear consensus exists on the nature of the content and pedagogic interplay among the STEM fields. While science and mathematics education are well-defined (though separate) entities across elementary and secondary schools worldwide, engineering education has largely been a function of higher education in the USA. And technology education has traditionally been delegated to vocational education, when included at all in secondary schooling.

Given that policymakers, parents, and business communities are calling for STEM education across grade levels and that STEM literacy is viewed as critical for the economic success and health of individuals and nations worldwide (National Science Board, 2015; STEM Education Coalition, 2014). It is important to consider the varied meanings that different groups may have for STEM and STEM education. While it may not be necessary, or even feasible, to coalesce around one common definition of STEM education, we argue that without some shared understandings across a system, it is difficult to design and implement curriculum and instruction to promote successful STEM learning for all students.

STEM is an approach that brings disciplines together, provides effective and high-quality learning, integrates knowledge into daily life and encompasses high-level thinking (Yıldırım & Altun, 2015). STEM refers to teaching and learning in the fields of science, technology, engineering and mathematics and includes activities at all grade levels, from preschool to doctoral education (Gonzalez & Kuenzi, 2012). In this context, STEM can be expressed as an interdisciplinary approach that can be applied at all levels of education.

STEM Fields

The four strands of Science, Technology, Engineering, and Mathematics, have been staple forms of all students' academic careers; particularly science and mathematics. They are defined as: **Science:** the systematic study of the nature and behavior of the material and physical universe, based on observation, experiment, and measurement, and the formulation of laws to describe these facts in general terms (Science, 2012).

Technology: the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science (Technology, 2012).

Engineering: the art or science of making practical application of the knowledge of pure sciences, as physics or chemistry, as in the construction of engines, bridges, buildings, mines, ships, and chemical plants (Engineering, 2012).

Mathematics: a group of related sciences, including algebra, geometry, and calculus, concerned with the study of number, quantity, shape, and space and their interrelationships by using a specialized notation (Mathematics, 2012).

Although these definitions are the well known usual and established descriptive terms for STEM fields, there is obviously more to them. Science and Mathematics are at the forefront of STEM Education mainly because these are the most recognizable fields that most people can relate to in terms of academia. Technology and Engineering are the fields that are not only the most underrepresented, but also the most underfunded in education, specifically in the k-12 arena (Miaoulis, 2011).

This is however far from the conception and practice of STEM education in Nigeria, where science, technology, engineering and mathematics are still been studied at all levels of education as single and separated disciplines without any form of integration or emphasis on connections across the disciplines. In other words, what we have in Nigeria is S.T.E.M. and not STEM. The difference is that while STEM presents a commonality of knowledge among the disciplines, S.T.E.M. presents single disciplines separately taught as the STEM subjects. In this approach, each of the four subjects are taught as single subjects with the view that the synthesis of disciplinary knowledge would later be applied. This is what Anderson (2016) has referred to as the 'Silos'. Owen (2017) remarks that just like the farmer uses silos for storing and separating grains, so do silos separate teachers, subjects and thought processes. Teaching STEM as silos makes students less proficient in the area of critical thinking, problem solving and acquisition of team building skills developed in integrating STEM as a discipline. In the integrated STEM (iSTEM) education, the subject barriers are removed thereby creating a new whole discipline.

The Science Teachers' Association of Nigeria is the largest science teachers' association in Nigeria and has put so much effort in popularizing STEM for over two decades now, but despite these noble efforts to popularize STEM, her usage of the term still remains at the level of mere acronym which makes one uncomfortable as to whether she actually understands STEM as an integrative multidisciplinary subject. In the earlier STAN conferences, the themes were limited to Science and Technology (S&T), later Science Technology and Mathematics (STM), with the 'E' excluded and more recently STEM with the 'E' added. It can therefore be concluded that the term STEM is yet to be understood in Nigeria, and its implementation is still very poor as well.

Importance of STEM Education

STEM skills are required to be competitive in today's global era. Knowledge in STEM fields is in higher demand than ever before. Because technological and scientific innovations affect our lives and provide Congress Joint economic benefits, students should be equipped with STEM knowledge, skills, and abilities (U.S. Committee, 2012). All the disciplines that make up STEM also plays an important role in the development of twenty-first century skills such as critical thinking, problem solving, co-operation, leadership ability, scientific thinking, adaptability, entrepreneurship, curiosity and

imagination, communication, access to information and use (Bybee, 2010). STEM, is a field of work that bridges the disciplines (Meng, Idris & Kwan, 2014). Technology and engineering design-based STEM foresees the integration of knowledge and skills related to these areas in teaching mathematics and science subjects (Bybee, 2010; Guzey, Harwell & Moore, 2014).

The STEM is one of the education approaches (Gonzalez & Kuzenzi, 2012). Although STEM education consists of an abbreviation, it actually has a much broader meaning in terms of the meaning and the content it contains. In other words, STEM education is an educational approach in which science, technology, engineering and mathematics are integrated, and these disciplines are linked to everyday life and supported by the 21st century skills. Today, many countries are implementing STEM education in formal and informal learning environments (Yildirim, 2017a).

The STEM is an educational approach aimed at providing students with the ability to communicate in an inter disciplinary way, to do team work, to think creatively, to research, to produce and to solve problems, focusing on the integration of knowledge and skills of science, technology, mathematics and engineering on an engineering design based teaching (Dugger, 2010).

The STEM education is important because it is a method by which students gain knowledge and skills by approaching problems from a multidisciplinary point of view and also provide opportunities for students to gain twenty-first century skills and opportunities for these four field of specializations. The area in which technology-based education is inevitable is waiting for the individuals to be producers and inventors which suggest that they can bring together the knowledge in the fields of STEM to enable individuals to demonstrate their productivity (Akgunduz, Ertepinar, Ger, Kaplan Sayi & Turk, 2015).

The STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Southwest Regional STEM Network 2009).

Innovation and discovery are important for driving the advancement of human society. As a result, there has been a large growth in STEM employment opportunities, which has surpassed other fields (Gonzalez & Kuenzi, 2012). STEM education is proposed as a response to depressed economies (Williams, 2011). There is a correlation between the promotion of technology education and economic depressions in the 1890s, 1930s and 1980s (Williams, 2011).

Manufacturing and services industries which are critical for industrialization require knowledge of mathematics and science. Mass secondary education is perceived as necessary for developing human capital to facilitate industrial development and modernization of the economy. Hence, mathematics and science were promoted in Tanzania and Senegal (Tikly et al., 2018). The Vision 2020 strategy in Nigeria has ambitious economic development targets which require a skilled workforce and STEM education can contribute to this especially in the manufacturing sector (Ohize, 2017). Most of the literature on STEM education mentions training for teachers which helps them to improve their teaching with the aid of ICT, or to enhance their teaching capacity in STEM subjects (Hooker, 2017). This results to improved professional development.

Entrepreneurship Education

Entrepreneurship involves innovation; bringing something new to a market that does not exist before. Even if the market already exists, there is no guarantee that the new product will survive the introduction stage of the product life cycle, Ntaking into consideration the teething competition. Some scholars are of the view that entrepreneurship is a service rendered by anyone who starts a new business (Ogundele, Sofoluwe & Kayode, 2012) A broader definition of entrepreneurship education was provided by Evans-Obinna (2014) as the process through which individuals acquire a broad set of competencies that can produce greater social and economic benefits to the individuals. According to

Enu (2012), Entrepreneurship education is a form of education that seeks to provide knowledge, skills, attitude and motivation to students for entrepreneurial success in any facet of human endeavors. Enu (2012), further argues that entrepreneurship education equips individuals with the ability to seek investment opportunities and maximize returns from those investments. Entrepreneurship Education is made of all kinds of experiences that give students the ability and vision of how to access and transform opportunities of different kinds. As such, it goes beyond business creation (Enu, 2012). It is about increasing student's ability to participate and respond to societal changes.

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The role of entrepreneurship towards economic and social development of a nation include: identification of business opportunities; selection of opportunities; decision on form of enterprise; allocation and distribution of resources; coordination of other factors of production such as land, labour and capital; planning and controlling organizational programmes activities; mobilization and utilization of locally produced raw materials; risk bearing; creating employment opportunities; marketing activities for customer satisfaction; promote balanced regional development, reduces concentration on economic power and innovation to meet the needs of local market (Danko, 2005; Kumar, 2011; Ogundele, Kayode, Oduleke & Alade, 2013). An environment where knowledge-based entrepreneurship transpire as a driving force toward job creation, economic growth as well as competitiveness is referred to as entrepreneurial society (Guerrero & Urbano, 2012).

Importance of Entrepreneurship Education

Entrepreneurship education has been found to be a vital tool in addressing unemployment where policies are designed appropriately and effectively implemented. For instance, entrepreneurship education was observed by scholars like Álvaro et al., (2008) and Iyiola & Azuh (2014) to assist in creating new businesses, resuscitating challenged businesses and as well as encouraging innovations, competency and improving the standard of living of the generality of the people.

Akhuemonkhan et al., (2013) examined the entrepreneurship education and employment stimulation in Nigeria. They discovered that entrepreneurship development could be an effective tool for poverty reduction, stimulating employment as well as fast-tracking the realization of universal primary education and promoting gender equality. In a similar vein, Olorundare & Kayode (2014), came up with a model of how public and private partnership can be enhanced through entrepreneurship education in Nigerian universities towards national transformation and stressed out that challenges of entrepreneurship education which include inadequate trainers or little knowledge of entrepreneurship

by the universities' lecturers, inadequate fund for the program by the universities administrators as well as challenges in the area of curriculum development and implementation.

Self-reliance, self-sufficiency, self-sustainability, self-support culture and self-employment are the end point or the main point of entrepreneurship education and entrepreneurship development to release the government's unfulfilled responsibility of creating and providing employment to its citizenry. It was because of this that Evans-Obinna (2014) examined the relationship among entrepreneurship, entrepreneurship education and self-reliance in the attainment of economic development and highlighted the challenges such as inadequate funding, lack of materials, entrepreneurship teachers among others facing entrepreneurship education in Nigeria. He recommended that the Nigeria government should not only embrace the policy of setting aside 26% of its annual budget for education as suggested by the United Nations Educational and Scientific Organization (UNESCO) but also try and mandate its implementation.

Adeoye (2015) and Adebayo and Kolawole (2013) discussed the evolution and current development of principles and practice of entrepreneurship in Nigeria. They found that entrepreneurship can enhance economic growth and development primarily by generating employment and foster the growth of Micro, Small and Medium Enterprises (MSMEs) in Nigeria. They further stressed that there should be proper policy coordination and policy stability; reforms in the educational curriculum to prepare students for self-reliance; and fixing the power sector-Nigeria's basic infrastructure because 95% of enterprises depend on constant supply of electricity, such that many vibrant Micro, Small and Medium Enterprises (MSMEs) that would aid gainful employment among the populace would be created leading further to wealth creation and poverty alleviation.

Enu (2012), argues that the ultimate goal of educational entrepreneurship is all about increasing the student's ability to anticipate and respond to societal changes. In other words, through educational entrepreneurship, students are equipped to deploy their creativity ability for their good and benefits of the larger society. They are also empowered to take initiatives, responsibilities and risks. The above views show that entrepreneurship education by its scope, nature and characteristics is a rebranding education culture meant to guarantee a comprehensive educational system re-engineering arising from the obvious deficiencies of the existing education system (Enu, 2012).

Relationship between STEM and Entrepreneurship Education

STEM education is an approach that requires the use of a large amount of interdisciplinary information. One of these approaches is entrepreneurship. In this context, it can be assumed that a relationship can be established between the two concepts. The scientific and technological developments in today's world require countries to raise entrepreneurial, productive, critical, problem-solving and entrepreneurial individuals. Therefore, STEM education has gained importance today. Innovative entrepreneurship contributes to the wealth of nations and their economic dynamism (Decker et al. 2014) through, for instance, job creation (Kuschel et al. 2018). Many of those innovative entrepreneurs and their businesses relate to the fields of science, technology, engineering, and mathematics fields.

STEM Education for Sustainable Entrepreneurial Work

The concept of sustainable work is proposed to challenge the perspective that work is mainly for financial gain (Likly et al., 2018). It recognizes that there are many forms of unpaid or informal work which contribute to society. According to Likly et al., (2018), STEM education can contribute to sustainable work as follows:

- The supply of skilled workers for social professions can be boosted through STEM education. For example, in sub-Saharan Africa there is a need for 5.7 million teachers and 3.8 million health workers;
- Secondary education should provide the skills for self-employment and entrepreneurship. Many artisan and trade occupations require STEM knowledge although there is more emphasis on technology. Hence, TVET is essential and it may be necessary to offer it earlier at secondary education level.

- Rapid urbanization and internet expansion creates job opportunities in the ICT sector, therefore it is critical to have training in ICT at secondary school level;
- Lower secondary education should provide adequate STEM knowledge of hygiene and health to enhance living standards. For example, knowledge on disease and infection are included in the biology curriculum at lower secondary level in Tanzania;
- Vocational subjects such as agriculture and domestic science include STEM content which may be useful for rural students who undertake cattle hoarding, small-holder agriculture or fishing; and Voluntary and creative work requires basic STEM knowledge such as ICT skills for audio visual editing or chemistry knowledge for mixing dyes.

Repositioning STEM Education for Entrepreneurship and Economic growth in Nigeria

The following are a number of things that is required in repositioning STEM education in Nigeria for economic recovery:

Curricular Reform in STEM Education

The government and educational authorities should introduce STEM curriculum and instructional materials as part of curricula reforms that addresses the current economic crises in the country. This curriculum must integrate innovation and entrepreneurship education into the STEM program and the emphasis should be to raise young generation of people with STEM skills that will be the future innovators and entrepreneurs of tomorrow. Case studies of innovators and entrepreneurs like Steve Jobs, Bill Gates, Dangote etc. should be part of the curriculum. Okpala (2014) has suggested that the following elements should be the integral part of the design of STEM curriculum that seeks to initiate innovation;

- To be trans disciplinary in approach;
- To be driven by standards that compliment trans disciplinary philosophy;
- To be problem- based and performance based;
- To be digital in format, coupled with digital technologies etc;
- To be linked to the real world challenges.

Increased funding for STEM education: To realize an effective STEM education, there is the need for increased funding. The Government should borrow a leaf from the response of the US to the Sputnik and see to it that sufficient fund required training teachers to use the right strategies that get more students interested in STEM and the provision of instructional gadgets and textbooks. The Government should also seek partnership with the private sector as the government cannot do it all alone. The US government under the Obama administration apart from spending $3m annually on STEM education announced in 2015 of over $350 million as a private sector commitment to inspire and prepare more boys and girls to excel in STEM (The White House, 2015). We need to see this quantum of funding coming from the government and the private sector in Nigeria.

Hands-on STEM Pedagogue should be encouraged: STEM education is about hands- on experience as the path to learning is open- ended as long as time and resources permit. Government should encourage the use of hands-on learning approaches which involves the process of developing ideas and experimenting to see what works the best as part of problem solving skills students should learn. STEM lessons should focus on the real life issues and problems which should be guided by engineering design process. Activities such as Robotics, building computer apps, web designs and three D printing, young engineering projects and Science fairs are a must for effective STEM education.

Create opportunities for students to participate in innovation and entrepreneurial contests: Another way of encouraging active engagement on hands-on is by allowing students participate in regular innovation, entrepreneurship and creativity contest. This can be a way to set our students in the path of creativity and innovation and business start- ups. The use of science clubs, junior engineers, science week for science fairs and exhibitions should be encouraged.

Changing students' mind-set from seeking employment after graduation to thinking ownership of companies through possibility thinking: It is very true that our students graduate from school thinking of working for different companies, and little do they think of becoming employers of labour themselves. Part of the work of educationist should be to motivate students to think big and see the sky as not just the limit but the beginning. Exposing students to career talks and motivational talks from successful entrepreneurs and innovators could serve as spring boards to catapulting them beyond the walls of mediocrity and poverty. We must remember that much of America's success stories of wealth creation and industrialization have come from the efforts of the positive and pragmatic thinkers like William James, Norman Vincent, Napoleon Hill etc. Through innovation, entrepreneurship and STEM education repositioning, we can have owners of industries and business like Bill Gates and Steve Jobs, etc, arising from our schools with sufficient motivation and encouragement.

Conclusion

The contribution of Science, Technology, Engineering and Mathematics Education to the economic development of any nation cannot be overemphasized. The economic situation of Nigeria needs re-engineering in order to strategically reposition it as the giant of Africa. For Nigeria to move forward economically, she must consciously agree to invest in STEM education by placing more emphasis on it. The oil sector has done a lot for the Nigerian economy but need to diversify into other areas such as agriculture, medicine among others.

Recommendations

The following recommendations were made in order to make STEM education contribute to the economic development of Nigeria:

1. Nigerian graduates lack employable skills which are synonymous with STEM skills. There ought to be some sought of synergy between the Colleges, Polytechnics, Universities and Private Sector in order to ensure the type of collaboration that will result in Research and Development because there seem to be some disconnect between what our institutions are teaching and what the industries are looking for.
2. The integrative approach is one method that is strongly recommended for an efficient STEM education.
3. A high level of integration and a holistic presentation of concepts, competencies and disposition of science, technology, engineering and mathematics which emphasizes the use of projects and other hands on activities.
4. Pupils should be encouraged to engage in designs of projects geared towards solving life problems by focusing on integrated STEM (iSTEM) in their K-12 educational system i.e. from kindergarten to 12 years.
5. Managers of higher institutions should ensure that the large volumes of thesis and projects undertaken by students in Colleges, Universities and Research Institutes should leave the library shelves to enable industries make use of them.
6. Graduates of science, technology, engineering and mathematics are expected to possess some set of skills which are required in today's workplace which include; Problem solving skills, Analytical skills, Mathematical skills, Communication and cooperative skills, Leadership skills, Technical skills and operating systems, and to stay abreast of new soft wares and equipment.

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