ENHANCING INDIGENOUS TECHNOLOGY THROUGH MATHEMATICS EDUCATION

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Abstract

With the abundance of natural resources in Nigeria, one would expect the country to rank among the richest and developed nations but the irony is, the country is hosting the third largest number of poor people in the world after China and India. Nigeria is endowed with a huge and vast array of natural resources such as petroleum and natural gas, solid minerals, agro materials, forest and wild life species and extensive water bodies. This is a clear indication that great nations are not made by the abundance of resources inherent in them, rather by the availability of the pool of knowledge adequately applied in delivering goods, processes and services. The country lacks the knowledge (human potential) that can translate its local natural resources to economic wealth. The country spends a huge amount of money importing finished products of its local resources that were exported, due to inability to process them for utility. If this trend is not checked, the future is not secured. It therefore becomes very necessary to develop/enhance the country's indigenous technology for proper harnessing of the local natural resources. This will reduce waste and ensure sustainable future of the country; because 'he that knows not diamond will certainly use it as a pebble to hunt birds'. It is the view of this paper that enhancing indigenous technology will create vast opportunities and potentials to adequately harness the local resource in a manner that will sustain the future. Also the paper is of the view that Mathematics education has the master key to unlock the door to indigenous technology.

According to the United Nation Document, despite the abundant natural resources in Africa, Africa contributes only 2% of the total industrial output of the world's market economies. Although this statistics may have changed, but does not disprove the fact that Africa contributes far bellow expectation in the world's industrial output. Of the total world mineral resources, Africa mines 90% of the diamond marketed, 81% of cobalt, 62% of platinum, 70% of gold, 50% of magnesium and chromium, and 30% of copper. Africa also produces 66% of world cocoa, 66% of sisal, 95% of groundnut and 25% of coffee, beans and cotton. There are rich reserves of coal, oil and iron ore (United Nation Document cited by Chukwujekwu, 2005). With the abundant resources, Africa countries should rank amongst the richest and most developed nations. Unfortunately, possession of abundant natural resources does not determine the greatness of a nation. In today's globalising knowledge economy, the major determinant of greatness is the available pool of knowledge, talents and creativity adequately applied in delivering goods, processes and services. Mogbo (2000) noted that there are potentially great nations endowed with abundant natural resources, but are underdeveloped, yet some nations like Japan and Israel are potentially poor in natural resource, but are developed. The potential great but underdeveloped countries are regular suppliers of raw materials to the poor but developed nations; who add values to the resources and resupply them at higher cost. Thus the economies of the underdeveloped countries are manipulated, controlled and determined by the developed nations. Nigeria can be counted as one of the countries richly endowed with natural raw materials. Nigeria's raw materials can be attested to be healthy, abundant and supporting multiple use. They are capable of providing an enviable quality of life for citizens and visitors if properly harnessed and utilized. They can attract and sustain business and tourism that translate into economic wealth.

No gainsaying Nigeria lack the productive human capital to tap its abundant resources and translate such to economic wealth. There is therefore great need to build up Nigeria's indigenous technology that will enhance healthy harnessing and utilization of the natural resources such that the future can be sustained. Thus, the paper examines available natural resources in Nigeria, how and why they should be harnessed with indigenous technology and the place of Mathematics education in developing indigenous technology.

Availability of Natural Resources in Nigeria

Nigeria is endowed with a huge and vast array of natural resources. The Nigerian economy is heavily dependent on the oil sector which according to International Monetary Fund (IMF), accounts for over 95% of exports earnings and about 40% of government revenue (Energy Information Administration – EIA, 2011). National Bureau of statistics also acknowledged that petroleum contributes as high as 78% of GDP and up to 90% of Nigeria's total annual revenue and foreign exchange earnings (Ehinomen & Adeleke, 2012). Nigeria has been estimated to produce about 2.9 million barrels of oil per day (EIA, 2011). There are abundance of natural gas, coal, and renewable energy resources that could be used for domestic electricity generation. The country holds the largest natural gas reserves in Africa and the ninth in the world (EIA, 2012). Nigeria has a total area of 923,768km 2, of which 910,768km2 is land and 13000km2is water. Approximately 33% (300,550km2) of the land is arable, 3.1% (28,235km2) is under permanent crop, 44% is under permanent pasture, 12% is under forest and woodland and 0.3% (2,820km2) is under irrigation (Osaghae, 2009, Obioh & Fagbenle, 2009). Biomass resources in the country include agricultural crops, wood, charcoal, grasses, and shrubs, residues and wastes (agricultural, forestry, municipal and industrial) and aquatic biomass (Agbro & Ogie, 2012). Research has revealed that bio energy reserve/potential of Nigeria stood at: fuel wood –13071,464 hectares, animal waste – 61 million tonnes per year, crop residue 83 million tonnes per year (Agba, Ushie, Abam, Agba & Okoro, 2010). Nigeria is the largest producer of cassava in the world and has the largest capacity for oil palm plantation, which serves as a great source of bio-diesel (Abiodun cited in Agbro & Ogie, 2012). There are numerous agro materials and solid minerals in Nigeria. Nigeria contributes significantly in the world's export of agro materials as cocoa, rubber, cashew nuts/kernels etc. Other agro materials in abundance are cereals, cassava, yam, tomatoes, onions, palm, ginger, gum Arabic, and sesame etc. Raw Material Research and Development Council –RMRDC (2000) reported that Nigeria is endowed with a variety of solid minerals much of which is yet to be exploited.

Great nations are not made by the abundant of raw materials deposited in them, rather by their ability to utilize the available materials and even those of other nations. These resources make no sense if the people have no capacity to identify them and convert them to economic wealth. It is obvious that if you do not know diamond, when you come across it, you will use it as a pebble to throw at birds. Nature abhors waste and so every material on earth is useful. Man can only say a material is useless when he has not found the means of converting it to something useful. Author Richard Dawkins rightly said: "Nature is a miserly accountant, grudging the pennies, watching the clock, punishing the smallest extravagance." For Nigeria to move forward, it needs its own indigenous technology, tailored to meet its peculiar needs just as Japan did (Orakpo, 2011).

Indigenous Technology

The word indigenous simply means native or local. It could be used to refer to something that originates within a locality and is unique to the locality. Technology on the other hand can be referred to the art and science of applying knowledge to meet man's needs. Putting the two words together, indigenous technology can be defined as locally developed art and science that is unique to a given culture or society, which is applied to meet man's need. (Okorafor, 2014). Eionet (2012) defined it as the technology employed by native inhabitants of a country and which constitutes an important part of its cultural heritage and should therefore be protected against exploitation by industrialized countries.

World Bank (2013) acknowledged that indigenous knowledge is the basis for local-level decision making in agriculture, health care, food preparation, education, natural-resource management and a host of other activities in rural communities. It is part of the lives of the rural poor; their livelihood depends almost entirely on specific skills and knowledge essential for survival.

Harnessing Local Natural Resource with Indigenous Technology: Benefits to Nigeria

Specialization in the production and export of raw material is detrimental to long-term growth prospects of the less developed nations. Specialization in export production leads to distortion or disarticulation of the domestic economy, thus preventing balance growth. A hyper-developed export sector is responsive to the demands of the world market, rather than to internal developmental needs. This seems to be particularly true of raw material production which has very limited up chain or down chain effects on the rest of the economy. Consequently exports revenue rise or fall in response to the world market but did not generate a long term growth process with the larger domestic economy. Contribution of the oil and gas sector to GDP growth (14%) is relatively low compare to investment in the sector (Arogie, 2013). A key reason for the huge difference between the contribution of the oil and gas sector to Government earnings and its contribution to GDP is the fact that most of the spending in that sector is on imported goods/services. The average direct cost of producing a barrel of crude oil in Africa stands at about $45.32 (Arogie, 2013). This is largely due to low Nigeria content in the industry. Nigerian content refers to the quantum of Nigerian human and material resources utilized in transforming Nigerian natural resources to economic wealth in a sustainable manner; and thereby developing indigenous capacity. Most of the work values in the sector are done abroad. Arogie (2013) noted that it has been estimated that about 90% of the expenditure in the oil and gas industry is paid to non-resident companies. In reality therefore, only a minute portion of the amount is available for the development of our economy. This has led to dearth of jobs, skill development, capacity building/utilization and lack of sustained national development. Mr. Harry Okolo, formal president Institute of Chartered Chemists of Nigeria, noted that Nigeria loses about a trillion naira annually to import between 80 –90 per cent industrial raw materials. Okolo maintained that the problem was not the non availability of raw materials locally, but the inability of Nigeria to transform available natural resources to utilizable forms (Business Day, 2013). Prof. Peter Onwualu, Director RMRDC, supported that Nigeria is expending foreign exchange to import raw materials and products that can be sourced locally, because of lack of awareness (SME, 2013). Domestication of a significant portion of the economy derivatives from oil and gas industry will transform the sector into the economic engine for job creation and national growth by developing in-country capacity and indigenous capabilities. Thus, a greater portion of the work will be done in Nigeria with active participation of all sectors of the economy. Ultimately, Nigeria will be positioned as the hub for service delivery within the West African Sub-region and beyond. It will also promote value addition in Nigeria through the utilization of local raw materials, products and services in order to stimulate growth of indigenous capacity.

Presently Nigeria is crowded with many educated unemployed; whereas there are enormous potential opportunities in harnessing the abundant natural resources. Approximately, 30% of recorded Nigerian raw cashew nuts (valued about $12 million USD) are exported to major processing countries, such as India, Brazil and Vietnam, for further value added processing (Chenomic, 2003). Prof. Peter Onwualu affirmed that within 25 years, the development of Nigeria's raw materials will save it over two trillion naira in foreign exchange, and create over two million jobs in the area of raw material production, processing, distribution and final procession of goods and services (News Agency of Nigeria, 2013; SME, 2013). For instance, crops like mango, guava, oranges, tomatoes, vegetables, onions, and cashew, etc. were available in plenty during harvest season. There is a good demand for processed finished food of these crops in the international market. If food processing units are established, which are labour intensive, it will argument employment opportunities. Likewise the abundant mineral resources all over Nigeria, if exploited locally, will transform into economic wealth. A popular quote by Falton Anderson said "the Glory of God is to conceal a thing; the glory of the king is to search it out".

Another quote by Philip Emeagwali said "those who create new knowledge are producing wealth while those who consume it are producing poverty" (Balogun & Aletor, 2008). It is obvious that knowledge is wealth. If Nigeria cannot create its technology and continue to consume the technological products of other developed countries, then it is bound to remain poor and underdeveloped; and the sustainability of its future will be endangered. EIA (2011) observed that in 2010, Nigeria consumed approximately 280,000 billion barrels of oil per day. The four refineries in the country with combined capacity of about 450,000 billion barrels per day could not meet the demand due to poor maintenance, theft and fire hazard. In fact the country imported about 85% of its fuel needs. Again, lack of oil field infrastructure to harness associated natural gas, cost Nigeria $2.5 billion USD per year in lost revenue for gas flaring (EIA, 2011). Rapid global change is putting many indigenous technologies to threat of extinction. Technologies that cannot adapt quickly to changes or meet new challenges adequately are often dropped. The common practice of going for foreign advance technologies, that promise short-term gains without being able to sustain them, often dismisses the potential of local experiences and practices. The tragedy of the loss of indigenous technology is most obvious to those who have developed it and make living through it (World Bank, 2013).This can explain why local groups seeking share of the oil wealth often attack oil infrastructure and staff; involving in oil bunkering and pipeline vandalism. This causes loss of production, pollution and shutdown of companies. The pollution further causes loss in arable land and decreasing fish stocks. These hoodlums as the government may call them, have developed local technologies to refine the crude oil. Instead of supporting them to enhance the technology, they are hunted as criminals. Being displaced of their source of livelihood by advanced technologies and no provision to get them employed in gainful acts, they continue to cause havoc.

Developing and Enhancing Indigenous Technology

Indigenization of technology is the adaptation of borrowed technological knowhow to suit your immediate local needs. Since education makes an individual person to realize his/her full potentials to contribute to the well being of the community/society and lead a personally fulfilling life, there is the need to advocate for a functional traditional education system which will transmit the local culture, ideas, knowledge and technology into the lives of the educated populace. A very good case in point is that of the Singaporean government which enacted a curriculum reform policy in addition to the marketing of education policy. This was designed in order to make sure that the curriculum in the school (STEM in particular) is so structured to provide local content both in materials and methodology. Technology is the product of creativity and innovation. Man in his ingenuity is in constant research to proffer solution to environmental challenges and lead a better life. The result of which culminates to technology through minor or incremental technical change. Indigenous technology development is enhanced through technology import and transfer. Onwualu (2008) observing the technological capacity development of India, identified three levels of indigenous technology development process: Basic level – ability to operate and maintain a new production plant base on imported technology. Intermediate level – ability to duplicate and adapt the design for an imported plant and techniques elsewhere in the country or abroad. Advance level – capability to undertake new designs and develop new production systems and components Technology transfer includes transplanting factory base production system; as was the case of the early industrialization of Japan in 1870s. The government established factories were equipped and employed foreign engineers and skilled workers at high salaries to instruct Japanese workers in the manufacturing technologies and techniques necessary for most up-to-date factory production (Masayuki, 2004). The trend of cotton industry in Japan is a good demonstration of technology transfer. The first government cotton spinning factory was equipped with only one British spinning machine with capacity of 2,000 spindles. Later, many cotton spinning companies with tens of thousands of spindles were established as a great boom of investment in cotton spinning. The result was that the English and Indian imported yarns were

driven out of the domestic market in Japan. Even Japan started exporting the stuff to foreign countries like Korea and China.

Technology import is good, because along it comes technology know-how and modernization that competition from abroad ensures. This is the classic justification for import liberalization. All countries import technology, but different modes of import have different impacts on local technological development. In a developing country, heavy reliance on foreign direct investment may become a substitute for domestic effort. Hence building a strong domestic technological base entails a selective curtailment of foreign direct investment entry. The complexity of technology should not be a justification for importing it, if the importing entity is not capable of adopting, adapting and diffusing the technology. In the early 1970s, the now defunct Eastern Regional Government of Nigeria established Premier cashew processing plant at Oghe Enugu. This factory was built to process roughly 350MT raw nuts. This plant utilized Japanese technology (fully automated with all equipment imported from Japan). This turnkey, project required reliable infrastructure (electricity), highly skilled labour and working capital; all of which were unavailable. The plant has been idle and up for sale since the early 1990s (Chemonics, 2003).However, the Jof Ideal Family cashew processing plant in Owo, Ondo State started exporting cashew kernel in late 1980s using labour intensive Indian technology. The owner hired an experienced Indian cashew production manager to start up the 2,500MT per year raw nut capacity plant. In less than two years, the Nigerian owned and managed Jof Ideal was fully operational, exporting cashew kernels to U.K. Since then, other processors have successfully copied Jof's strategy. Jof trained managers and employees are highly sought after by new processors (Chemonics, 2003).Technologies have to be developed through a gradual learning process, resulting from purposive effort to assimilate, adapt and modify the new technology. Thus they have to be developed in close collaboration with the prospective users through a process in which the user can take significant control over the direction of the project and equipment procedure. Technologies are rarely perfect when they come "off-the-shell" (Romijn, 2000). Several rounds of forwards and backward feedback of information between developers and users are needed to improve and adapt them in iterative fashion. Many of these efforts take the form of improvements on the shop floor rather than formal R&D. Making a mechanical lathe available to a woodworking shop or introducing an improved cooking stove model for low-income household to local metal workers who are to manufacture it, obviously constitute developmentally beneficial policy interventions in their own right. Rather than viewing the supply of these deliverables as final project objectives. The process of their introduction into a local business community should also be seen as a means through which small producers can master new technical and organizational skills and knowledge. This will strengthen their capacity to introduce other products and process innovations on their own initiative at a later stage. Innovation and technical change are sustained not within firm alone, but between networks of firms. The rate of technical change in an industry may well depend on dynamic linkages between firms. However, firms have more knowledge of their technology less about similar technologies of other firms and very little about dissimilar alternatives even in the same industry. Gaining mastery of new technology requires skills, efforts and investments by the receiving entity. The extent of mastery is uncertain and varies according to these inputs.

Nelson and Winter (1997) explained that technology accumulation strongly depends on the recipients ability to manipulate the given technology. Technology is tacit and the buyer can never hope to obtain all the required information form a blue print manual or training. The buyer must make certain effort to master the technology and adapts it to environmental conditions. This in turn brings about minor incremental technical change. It also confers idiosyncratic characteristic on individual plants and set firms on specific evolution trajectories. Foreign knowledge does not necessarily mean modern technology, it includes also indigenous technology developed and applied under similar condition elsewhere. These techniques are likely to be adopted faster and applied more successfully. To foster such a transfer, a sound understanding of indigenous knowledge is needed. This requires means for capture and validation, as well as the eventual exchange, transfer and dissemination of indigenous knowledge. (Okorafor 2014).

The Place of Mathematics Education in Technological Advancement

The standard of living of any nation today is dependent on the level of science and technology of that nation. Since Mathematics is the gate and key to the science, it can be concluded that, the level of Mathematics determines the level of science and technological component of any nation for sustainable development. The afore-mentioned statement further implies that children, should be encouraged to read Mathematics and Mathematics oriented courses/subjects to enhance their knowledge of science and technology. Mathematics is a science of the methods by which quantities sought are deducible from others known or supposed. Hence, any child, school or society who neglects the role of Mathematics may not be able to fare well in the sciences and technological advancement. The technological capability of a nation determines the efficiency at which the nation harnesses her natural resources or utilizes resources acquired from other nations. Abundance of natural resources means nothing if not transformed to generate wealth. Transforming them to optimum economic wealth requires knowledge and skills, particularly indigenous knowledge. Developing and adapting technology indigenously for harnessing local natural resources is more sustainable than importing finished products. Mathematics education plays a vital role in developing the required knowledge and skill (quality human capital) that stimulates growth. Mathematics reveals hidden patterns that help us to understand the world around us. The "functional" aspect of Mathematics stems from its importance as the language of Science, Technology and Engineering, and its role in their development. This involvement is as old as Mathematics itself and it can be argued that, without Mathematics, there can be neither science nor engineering.

Now, much more than arithmetic and geometry, Mathematics today is a diverse discipline that deals with data, measurements and observations from science, with inference, deduction, and proof; and with Mathematical models of natural phenomena, of human behaviour, and of social systems. Mathematics runs in the veins of natural sciences like Physics and Astronomy. This subject is inextricably incorporated with the world and the natural phenomena. Importance of Mathematics can be understood by the definition given by Galileo. He defined Mathematics as ‘a language in which God has written the world’. Although all careers require a foundation of Mathematical knowledge, some are Mathematics intensive. More students must pursue an educational path that will prepare them for lifelong work as Mathematicians, statisticians, engineers, and scientists. In this changing world, those who understand and can do Mathematics will have significantly enhanced opportunities and options for shaping their futures. Mathematical competence opens doors to productive futures. A lack of Mathematical competence keeps those doors closed. Generally it is an assumption that Mathematics is only for the select few. On the contrary, everyone needs to understand Mathematics. All students should have the opportunity and the support necessary to learn significant Mathematics with depth and understanding. There is no conflict between equity and excellence. Principles and Standards call for a common foundation of Mathematics to be learned by all students. This approach, however, does not imply that all students are alike. Students exhibit different talents, abilities, achievements, needs, and interests in Mathematics.

Nevertheless, all students must have access to the highest-quality Mathematics instructional programs. Students with a deep interest in pursuing Mathematical and scientific careers must have their talents and interests engaged. Likewise, students with special educational needs must have the opportunities and support they require to attain a substantial understanding of important Mathematics. Mathematics teaching is very important for intellectual development. There is no other subject in the curriculum likes Mathematics which make students brain active. Problem solving helps in the development of mental faculties. Mental work is needed to solve Mathematical problems. If a child, has a Mathematical problem her/his brain becomes active in solving that problem. Each problem of Mathematics posses such sequence which is necessary for constructive and creative process. In this way, all-mental abilities of child are developed through Mathematics. It, also develop the faculty of discovery and invention. The main aim of education is to help the children to earn their living and to make them self independent. To achieve this aim Mathematics is the most important subject than any other. It helps to prepare students for technical and other vocations where Mathematics is applied e.g.

engineering, architecture, accountancy, banking, business, even agriculture, tailoring, carpentry, surveying, and the office work which requires the knowledge of Mathematics.

In particular, Mathematics has contributed to progress in science and technology for thousands of years and still continues to do so. It finds useful applications in development of infrastructure i.e., industry, politics, medicine, agriculture, engineering, and the social and natural sciences. The physical appearance and development of infrastructure is crucial in a society. Thus, for the construction of roads, buildings, stadiums, flyovers, airports, dams, bridges, vehicles, airplanes etc. in mechanical engineering, civil engineering, electrical engineering etc

Mathematics has been successfully used in the development of science and technology in 20^{th} $–21^{st}$ century. Mathematics is used in almost every profession; it helps in improving the indigenous technology. The development in science and technology and indeed over-all development of society develops the standard of living. Thus, Mathematics plays an important role in making the living standards high. Although the ubiquitous use of information technology in all sectors has changed the nature of the Mathematical skills required, it has not reduced the need for Mathematics. Mathematics education constitutes the arteries that supply life sustaining blood to technological development. Therefore, the place of Mathematics in technological development cannot be overemphasized. It is very important to develop sustainable 21st century skill; to develop appropriate technology and inculcate adequate entrepreneurial skills in the youths.

Conclusion

Mathematics education should take care of the development of creative thinking and transformation of knowledge through technological and scientific processes into wealth and broader economic base. There should also be innovative technologically based training that promotes application of expertise to improving our society. Added to the above is the need to try and keep improving the creative process with fresh ideas. More scientific ways of sustaining the indigenous technology is through Information, Communication Technology (ICT) institutions, the school for oil and gas technology, Fashion institute of technology, the Construction and Engineering Institute and institute of Welding and Fabrication. Teachers of Mathematics should endeavour to teach and enlighten students about the relevance of Mathematics to science and technology in bringing about a change to issues being faced in the environment, society, nation and world at large for sustainable development.

Recommendations

Based on the scenario portrayed in the preceding sections of this study, the following recommendations were made:

1. The dynamic nature of Mathematics Education must be appreciated by the government at all levels. Teachers should therefore be exposed to regular training to keep abreast with current trends.
2. There should be a periodic review of the curriculum to suit evolving technologies. Training methods should also change.
3. Government should encourage the commercialisation of successful research in Mathematics in our institutions of higher learning. This will lead to innovations and inventions and create “technology incubation centres” near people.
4. Government should ban importation of certain goods or place high tariffs on them and encourage local production of goods. This will force the nation to look inwards just like the Asian countries had done in the past.

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