WWJMRD 2017; 3(10): 48-53
www.wwjmrd.com
International Journal
Peer Reviewed Journal
Refereed Journal
Indexed Journal
UGC Approved Journal
Impact Factor MJIF: 4.25
e-ISSN: 2454-6615

France O. Akpojedje
Ag.Dean, School of Engineering Technology, National Institute of Construction Technology (NICT), Uromi, Nigeria

Emmanuel C. Mormah
Lecturer, Department of Electrical/ Electronic Engineering, Delta State Polytechnic, Ogwashi Uku, Nigeria

Correspondence:
France O. Akpojedje
Ag.Dean, School of Engineering Technology, National Institute of Construction Technology (NICT), Uromi, Nigeria

Appropriate Engineering and Technology (AET): A Stimulant for African Economic Transformation and Sustainability

France O. Akpojedje, Emmanuel C. Mormah

Abstract
This paper aims at x-raying appropriate engineering and technological evolution as a stimulant for economic transformation and its sustainability in Africa. The issues associated with economic setback in Africa and factors militating against its appropriate engineering and technological revolution were critically reviewed to see how "Appropriate Engineering and Technology (AET)" can play a key role in transforming the current economic ulcer looming in Africa and its sustainability. Consequently, the paper suggested a building model for economic transformation and ways to enhance and sustain it in Africa.

Keywords: Africa, appropriate engineering and technology, economic transformation, evolution, fusion, sustainability

Introduction
Engineering and technology are considered to be the key factors for stimulating a nation's economic development [1]. They (engineering and technology) can be referred to as catalyst for driving a nation's economy and its sustainability. Hence, there is a need for transformation of indigenous engineering and technology to form appropriate engineering and technology for a better productivity of goods and services. Akpojedje and Abu [2], stated that "the concept of indigenous technology and engineering transformation in Nigeria and her counterpart nations in Sub-Saharan Africa is inevitable, if the fortune of the region must change for its nations' economy building, development [2] and its sustainability. Also, Onipede [3], stated that "appropriate engineering and technological development are generally regarded as catalyst for national development because they offer among other things: the necessary support for change in all the major sectors of the economy, most especially in agricultural and industrial sectors." Therefore, appropriate engineering and technology are unarguably the prime source of change, that is, of innovations and improving production methods needed to propel growth and development of any nation's economy [3]. "The use of indigenous engineering and technologically based economy are viable alternatives to transform key sectors for wealth creation and development in the third world. Developing component, resourceful and skillful man power that can add value to the engineering and technological development cannot be overemphasized" [4] in a any nation's economic building and sustainability. Consequently the concept of modern indigenous engineering and technological inventions if prudently exploited will minimize waste, poverty and maximize value in critical sectors [4] of the economy for the African economic drive and sustainability. As a result, there is a need to critically review the terms "appropriate engineering and technology and its importance to stimulate the economic transformation and its sustainability.

Engineering
"Engineering is one of the oldest professions along with divinity, medicine and law [5]. While the linear model has led to the perception of engineers as an applied science [5],

engineering is distinct from but related to science, and in fact predates science in the use of the scientific method - engineers were the first scientists" [5]. "Science is the pursuit of knowledge in its purest sense without any concern to the needs (or interpreted needs) of society, whereas engineering is the combination of both. Engineering connects pure science to society unlike science" [6]. According to Oxford Advanced Learner's English Dictionary, "science is knowledge about the structure and behaviour of the natural and physical world, based on facts you can prove while engineering is the activity of applying scientific knowledge to the design, building and control of machines, roads, bridges, electrical equipment etc." Also, according to Akpojedje, Abu and Onogbotsere [1], "engineering can be accepted as the application of scientific knowledge to meet man's needs."

The term "engineering is derived from the word "engineer" used in the 1300s for a person who operated a military engine or machine-such as catapult or, later, canon etc. [5]. So, who is an Engineer? According to Oxford Advanced Learner's English Dictionary, "an Engineer is a person whose job involves designing and building engines, machines, roads, bridges, etc. or a person who is trained to repair and controls engines." "Science and engineering are essentially part of the same spectrum of activity and need to be recognized as such; while engineers use both scientific knowledge and mathematics to create technologies and infrastructure to address human social and economic issues, and challenges. Engineers connect social needs with innovation and commercial application" [5] for national development [1]. "The engineering profession plays a major role not only in the growth and development of a country's economy but improving the quality of life for its citizens [5]. The linkage between a country's indigenous engineering capacity and its economic development [5] is inevitable and cannot be overemphasized if the country fortune must change in terms of economy and infrastructural development [1].

Technology

"Technological development and management are considered to be key driving force in the development of any economy" [6]. The economic growth of both developed and developing countries depends on it [6]. Hence, according to Akpojedje et al. [1], "the concept of technology as a transformer for national development is jaded if not considered as a critical factor or element to be tackled by stakeholders in any nation. Consequently, what is technology? According to Oxford Advanced Learner's English Dictionary, technology is defined as "scientific knowledge used in practical ways in industry, for example in designing new machine." But the term technology has different representations and meanings to different people and their culture. Hence, according to Abdulkaream, technology is defined as the "art and science of applying man's knowledge in human endeavours so as to satisfy man's needs [7].

The International Technology Education Association defined technology as the "use of knowledge, skills and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environmental factor into consideration" [8]. Furthermore, Ibeau and Okonkwo [9], defined technology as the "systematic knowledge and actions usually of industrial process but applicable to any current activity". They went further to say that by application; technology utilizes knowledge acquired and experience gained to satisfy man's needs. Therefore, technology is a scientific knowledge aimed at satisfying the basic man's needs [9]. It is classified into three broad categories [9]:

1. The human embodied technology such as skills, knowledge and experience,
2. The capital-embodied technology such as machines, equipment and tools, and
3. The disembodied technology, which includes blue-prints, product and product satisfaction.

In totality, according to Akpojedje and Abu [2], "technology can be accepted as putting human knowledge, acquired skills, experience, philosophy and recourses to meet people or communities' needs and wants."

Appropriate Engineering and Technology (Aet)

The importance of appropriate engineering and technology (AET) to national development and socioeconomic well-being cannot be overemphasize [1] for nations growth.

According to Akpojedje and Abu [1], "Engineering and Technology" is the major key player for transformation of any nation development. The fusion of the relevant of both indigenous and foreign technologies is what is popularly referred to as "appropriate technology" [10]. Hence, we can say the fusion of relevant indigenous and foreign engineering and technology is what is called "Appropriate Engineering and Technology". According to Essien [10], "appropriate engineering" stresses the socio-cultural and environmental importance of both indigenous and foreign technologies. Consequently, "appropriate engineering and technology is the application of engineering and technology at the simplest level that can effectively achieve the intended purpose in a given locality or nation" [1]. The development of any nation's economy is always linked with the application of appropriate engineering and technology [1].

"Appropriate engineering and technology development" can be generally regarded as a catalyst for nation's economic and national development, because it offers among other things the necessary support for change in all the major sectors of the economy, most especially in agricultural and industrial sectors [3].

Therefore "Appropriate Engineering Technology Development" is unarguably the prime source of change; that is, of innovations and adaptations required for improving production methods needed to propel growth and development [3] of African economy. It is a well-known fact that technological advancement divorced from this cultural context, is destined to grow without a soul [10]. Then, we can say, "Appropriate Engineering and Technology Development" divorced from it cultural context, is destined to advance without soul and spirit. And any living body without a soul and spirit is dead alive. In fact, the best appropriate engineering and technology is the combination of indigenous and imported (foreign) engineering and technology knowledge to build human capacity for progressive [1] economic growth and sustainability.

"There is an apparent dearth of engineering and technology entrepreneurship and capital in Africa; a situation that has led to the near non –existent productive capacity of the

continent, with very minimal potentials for value addition" [4]. "The result of the foregoing scenario is low capacity for wealth creation and increasing level of employment" [4]; since knowledge and innovation are the two key drivers for sustaining economic growth in the 21st century [4]. Then, African countries should be keyed into harnessing its strong appropriate engineering and technology for foundational ecosystem to industrialize relevant research with a strong focus on commercialization, and to extend the ecosystem to facilitate innovation and enterprise" [4] for nations economic growth.

Present State of Appropriate Engineering and Technology (Aet) In Africa.

It is both bothersome and worrisome that in Africa today, there is no mode of operandi to come up with a model of appropriate engineering and technology that will transform into meaningful economic development. As it is today, all manner of technologies are been dumped in Africa without proper harnessing them with Africa cultural context to form appropriate technology that will impact meaningfully for economic transformation that will lead to wealth creation and development of the Africa nations. According to Akpojedje et al. [1]. "Nigeria as at today is a consuming nation and not a producing nation. Nigeria has been turned to a dumping site where all manner of engineering and technological productions are been dumped for usage."

Appropriate engineering and technology is a veritable tool because it harnesses the transformation of natural resources (endowment) into goods and services that will cause economic revolution in the system. There is no gain saying that over decades of existence of Africa nations that they still largely depend on foreign technological service to sustain their technological needs that will drive the economy.

The present state of appropriate engineering and technology in Africa is regrettable because over decades of existence of African nations, they still largely depend on foreign (borrowed) or imported machines, goods and technological needs [1]. "Technologically wise, African countries can be said to be technological backward and in bad shape [2]. "Consequently, we can say as at today, despite the enormous availability of natural resources and indigenous knowledge, the appropriate engineering and technological development of Africa is grossly low and inadequate in terms of her technological development, advancement and productivity [2].

Factors Militating against "Appropriate Engineering and Tecnology (Aet)" In Africa.

The factors militating against "Appropriate Engineering and Technology (AET) advancement in Africa are enormous. "It is important to recap here that appropriate engineering and technology (AET), is the stimulant for economic transformation and sustainability [1]. The following are some factors militating against appropriate engineering and technology in Africa.

i. **Infrastructural Decadence [1]:** The rate of infrastructural decay in Nigeria public infrastructure and her counterpart nations in Sub - Saharan Africa posed a prime frustration to the local (indigenous) technological development and advancement in the region. The pace at which public infrastructure decay in the region is bothersome. A state where there are no good public facilities such as good roads, pipe borne water, good schools, good library of world class standard, healthcare etc. since they are in a state of decadence, they have led to struggle and frustration of the development of local technology and engineering in the region.

ii. **Inadequate Synergy [1]:** The synergy between the industries and academic institutions in the region (Africa) is inadequate to foster technological development. A case study of Nigeria today, there is no proper or serious synergy between the industries and research institutions as it stands now. This lack of synergy has led many good types of research and inventions in the institutions to end up in the office shelves of the researchers in the research Institutes. This is because most governments in the region have not created the enabling environment for the bilateral relationship.

iii. **Over-Reliance on Foreign (Imported) Technology:** The over-dependent on imported technologies constitutes a serious threat and setback to the development of indigenous technology [11]. Consequently, most of the technology in the markets of developing countries in Sub - Saharan Africa is imported (foreign) [11]. In other words, many Nigerians and people of her counterparts in Africa are just like the people of India having a penchant for foreign technologies [11].

iv. **Non-Commercialization of Academic Research [1]:** The non - commercialization of academic researchers from institutions is a prime challenge. Today, academic research papers and publications are obtained mainly for the purpose of routine academic promotions and recognitions. But the producer/user synergy and bilateral relationship determine the commercial values of these research papers. The commercial values of most research papers and publications are very low and less market value in relation to the industries.

v. **Operations of Research Institutes [1]:** Almost all the research institutions and other higher research institutes operate and conduct researches outside the relevance of industries today; perhaps is one of the prime reasons industry/academic synergy remains very weak today in the Sub - Saharan Africa and Africa at large.

vi. **Inadequate Funding:** The inadequate funding of engineering and technological institutions and other research institutes is a major setbacks factor to technological development in the region. The funding of technological sector in Sub - Saharan Africa and Africa is grossly poor. In the case of Nigeria for instance, between 1985 and 2000, research funds averaged only 0.08% of the Gross National Product (GNP) and this is a far cry from the UNESCO recommended target of 1.0% [12 &13].

vii. **Low Human Capacity Building [1]:** The failure of the government to recognize potential local technology within the region and encourage it by adequately supporting the local intellectuals has led to the low human capacity building in the region. This has exacerbated the backwardness of local technological development and drive in the region of Sub - Saharan Africa and Africa today.

viii. **Policy Instability [1]:** The instability of government system in policy making and keeping (continuity) has jeopardized the development of local technology in the region due to lack of continuity in the governmental system in the region. One government will make policy today and another will step - it down tomorrow. This impediment factor has grossly hindered local technological advancement in the Sub - Saharan Africa and Africa at large.

ix. **Poor Patronage of Local Technology [1]:** The goods manufactured using traditional (local) technologies have been jettisoned by individuals and government from the region. There is low patronage from locally made goods from the region and this has led to low morale of local intellectuals and also, hindered the advancement of local technology. Although, recently in Nigeria, the government and individuals have started campaigning for locally made goods patronage which is a welcome development for the region.

x. **The Attitude of Government [1]:** The attitude of government towards potential local knowledge and technology in Sub - Saharan Africa and Africa is worrisome today. They failed to recognize potential local technology and knowledge, like the case of Boko Haram and the Niger Delta activities in the North - East and South - South respectively of Nigeria where mini industries were setup to produce "Improvised Explosive Device (IED)" in the North - East, and illegitimate oil bunkering and mini-refineries in the South - South of Nigeria. These negative activities can be a blessing in disguise if the government of the day can properly transform and channel these local knowledge's appropriately.

xi. **Corruption:** Corruption is like a cancerous plague that has eaten deep into the Sub - Saharan Africa nations and Africa at large. It is generally known that African government measures progress and achievements in terms of funds allotment [3], but what they do with these funds allocated or shared are not accounted for. This has led to serious corruption in the governmental system of the region which has grossly hindered the advancement of local technology in the region.

Economic Transformation and Sustainability

Appropriate engineering and technology are considered to be the key factors for stimulating economic transformation and its sustainability. According to Akpojedje et al. [1] "Engineering and technology" is the transformer through which the fortune of a nation can be transformed for socioeconomic well-being with the application of appropriate engineering and technology. Consequently, appropriate engineering and technology are economic enhancer which drives a nation's economy if it is appropriately harnessed and developed. Most underdeveloped countries failed to have developed their own engineering and technology capabilities through transformation of appropriate engineering and technology to create wealth and socioeconomic well-being for their citizens [1]. This is the case of many Africa countries where low human capacity building, absence of good and safe infrastructure and epileptic power supply amongst other [4] are prevalent today. "The shortage in manpower technologically has remained a major setback to African countries technological breakthrough. This shortage is linked with the imperial educational system that gives little or no consideration to the technological needs of a rapidly changing industrial economy; that Africa today has to rely heavily on foreign assistance and expertise at the expense of local industrial research and developmental institutions" [4].

Appropriate engineering and technological evolution is seen as the panacea to the economic ulcer that has held the economy by the jugulars in the continent, while the narratives seem to have shifted to economic diversification of the economy to a technological driven sector, the list seems in-exhaustive. We believe that no meaningful economic impact will be achieved if they are not technologically driven. Consequently, the impact of appropriate engineering and technological evolution as the way or pathfinder to economic transformation and sustainability in Africa cannot be underestimated.

The building model of appropriate engineering and technology for economic transformation and sustainability in Figure 1; if religiously harnessed, it will facilitates economic transformation and its sustainability in Africa. Appropriate engineering and technology must be given the right priority and the appropriate place it deserves in the course of economic development in the region.

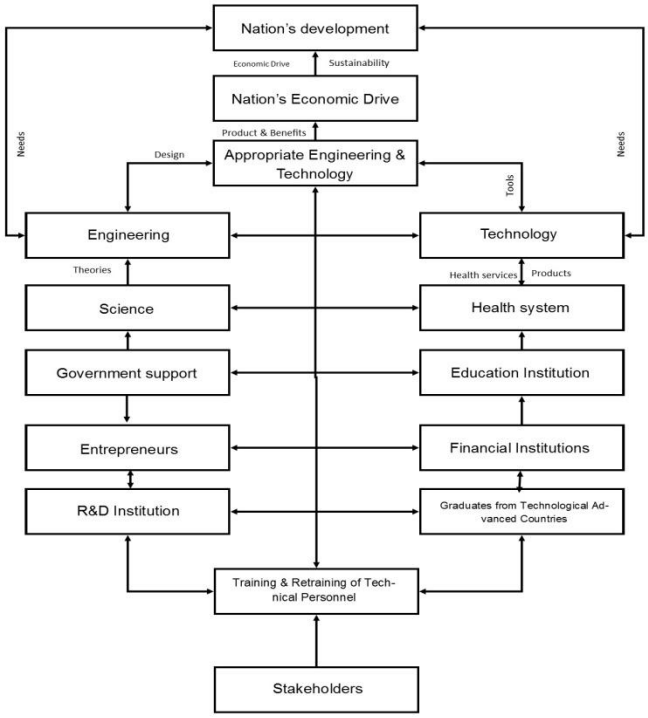

Fig. 1: Building Model of Appropriate Engineering and Technology for Economic Transformation and Sustainability in Africa

Enhancing Appropriate Engineering and Technology in Africa

In dealing with the enhancer (appropriate engineering and technology) all hands must be on deck. According to Akpojedje et al. [1], "Government is business and all businesses that will strive must be taken seriously." The fusion of indigenous engineering and technology with foreign engineering and technology to form appropriate engineering and technology is something every stakeholders should have a key role to play, especially the government. The government should support appropriate

engineering and technology by formulating a favourable technical policies and giving financial support to research institutions. Also, the government should revamp the imperial educational system that currently practices to suit the local needs and wants.

In enhancing appropriate engineering and technology in Africa that will transform meaningful economic transformation, the following should be put into considerations:

i. **Government Support for Commercial Technologies should be provided**: Government has a compelling rationale for directly enhancing development [14] through adoption and stimulation of appropriate engineering and technology. National "Research and Development" (R&D) funding and procurement contributes substantially to the development of high-technology products [14].The government has the role for supporting the development of commercial technologies and also facilitating the development of "path-breaking technologies"- those with the potentials to create major new industries or transform existing industries and thereby yield high returns to society as a whole but such development poses risks too high to attract sufficient private - sector investment [14].

ii. **Adequate Funding of "Research and Development" (R & D) [1]:** The present state of leaving researches to waste away in institutions' library shelves is bad and is a drawback to the technology advancement in the region. The governments of the region should adequately fund and encourage a bilateral relationship between the industries and the research institutions in the Continent.

iii. **Commercialization of Research and Development (R&D) [1]:** The results of R & D should not be allowed to rot away in the institution's library shelves. The governments of the region should promote meaningful R&D in the educational sector and see how to cement the relationship between industries and institutions in the region by making policies that will enhance the bilateral relationship and giving incentives and research scholarship.

iv. **Synergy and Sustenance of "Public Private Partnership" (PPP) [1]:** The governments of the region most see how to revamp the PPP sector and encourage it by adequate funding, promotion and sustain the strong synergy between the two sectors. The strong domestic researches are facilitated by the PPP in acquiring, absorbing and adapting new technologies that evolved.

v. **Educational System:** One of the major setbacks to national development can be attributed to the kind of educational system African countries runs today. The curriculum of most tertiary institutions in Africa is obsolete and inadequate to address current trends in engineering and technology. The schools' curriculum today is theoretically based but practically weak. Consequently, most graduates from the tertiary institutions have little or no practical orientation to match the current technological needs and trends in the industries. According to Onipede [3], "The imperial educational system that gave little or no consideration to technological needs, the cumulative effect is the graduation of half-baked graduate engineers, technologists, and technicians that know little or nothing as regards the practical application of the knowledge." This is an exception of some African countries such as Egypt, Ghana, South Africa etc. whose educational system are generally regarded to be standardized.

vi. **Strengthening Capacity Building [1]:** The government should strengthen the capacity building of science, technology, and innovations in the region, as well as basic technical skills for both men and women which are also a prerequisite for the future development of local technology in the region.

vii. **Technical Policy [1]:** Policies that are technically inclined should be promulgated by policy makers in the region. Stakeholders should make policies that will drive the technological sector and jettison any policy that will hinder local technological development.

viii. **Science and Technology:** Is one of the major pivotal for national development in enhancing and strengthening national development. The roles of the educational institutions, technology managers/technical skilled people, science, R&D institutions, financial institutions and government support are inevitable at this stage [15] as shown in Figure 1 above. The African government should invest heavily on science and technology and support research institutes. Technological institutions will go a long way in enhancing research and development of technological abilities of engineering workforce thereby leading to transformation of natural resources for wealth creation and national development for socioeconomic well-being of their citizens. "Science and Technology" is the bedrock for national development. Development at any phase is always linked with technology and technology happens when there is advancement in science [16]. Hence, science, technology and development are all proportional to one another [16]. For any meaningful development to happen, particularly in today's quest for knowledge based economy; science, technology and engineering are the basic requisites [16].

Conclusion

Having x-rayed the impacts of appropriate engineering and technology on the economic transformation and its sustainability in Africa, we can say that appropriate engineering and technology is the stimulant that enhances economic transformation and its sustainability. You will agree with us that the recent economic down turn in the world is having negative effects on employment levels, especially the Africa continent and this is something every serious government should be worried about. If economic drive is the only solution to every economic downturn; then appropriate engineering and technology should be the key object that every stakeholder should be concerned with. Economic transformation and its sustainability in Africa needs appropriate engineering and technological evolution that will enhance productivity and quality of goods and services, thereby creating jobs and economic boom and viability in the region.

References

1. Akpojede, F.O., Abu, Y.O. and Onogbotsere, M.E., "Engineering and Technology: A stimulating transformer for National development," COMPUSOFT, An international journal of advance computer technology, volume 6, issue 1, January,

2017. Pg. 2260 - 2268.
2. Akpojedje, F.O. and Abu, Y.O., “Transforming Local Technology is Sub-Saharan Africa through Appropriate Engineering and Technological Development to Meet Global Standards,” Journal of Multidisciplinary Science and Technology (JMEST), Vol.3, Issue 7, July 2016. Pg 5324-5330
3. Onipede, K.J., “Technology Development in Nigeria: The Nigerian Machine Tools Industry Experience,” J economics, 1 (2): 85-90, 2010.
4. Adeolu, A., Daniyan, I., Omohimoria, C. and Afolabi, S., “Development of Indigenous Engineering and Technology in Nigeria for Sustainable Development through Promotion of Smes (Case of Design of Manually Operated Paper Recycling Plant)," International Journal of science, technology and society, vol.3, No 4, June 3, 2015. Pg. 124-131.doi:10. 1168/j.ijsts. 20150304.15
5. UNESCO REPORT, “Engineering: Issues, challenges and opportunities for development,” Published in 2010 by the united nations educational scientific and cultural organization, 7, place de Fontenoy, 75352 Paris 07 sp, France. Retrieved on the 30th of November, 2016. Time: 3:21 am
6. K. Park, M. Ali and F. Chevalier, “A Spiral Process Model of Technological innovation in Developing Country: The case of Samsung,” Africa Journal of Business Management, Vol. 5 (13), Pg.5162-5178, July 4, 2011. Http://www.academicjournals.org/AJBM.
7. Y. A. Abdulkareem, "Indigenous Technology: Past, Present, and Future," Paper Presented at the Raw Materials Research and Development Council Workshop for the Processing of Raw Materials, Kwara State Library Complex, October 6, Retrieved on March 31, 2013, from htt://www.unilorin.edu.ng/publications/PAST - PRESENT - AND - FUTURE
8. International Technology Education Association, “Standard for Technological Literacy: Content for the Study of Technology," Reston: ITEA, 2002.
9. A.M. Ibeanu and E.E Okonkwo, "Indigenous Technology and Cultural Practices in Umudu, Nigeria," Chapter. June 2014. Retrieved on the 1st December, 2016. Time: 6:45am. www.reserachgate.net|....|ication|280603460
10. [C.F Essien, “Empowering Indigenous Industries for National Development: A review," JORIND (19)1, June, 2011. ISSN: 1596-8308. www.transcampus.org/journals, www.ajol.info/journals/jorind
11. S. S. Manabete and Professor Bobboi Umar, "Indigenous Technology for Sustainable Development in West Africa," Journal of Education and Practice, Vol. 5, No. 37, 2014.
12. J. S. Oke, "An Evaluation of the Nigerian Innovation System and Technological Capability Building in the Manufacturing Sector," A Ph.D. Thesis submitted to Obafemi Awolowo University (O.A.U) Ile - Ife, 2005.
13. A. I. Oduola, J.B. Akarakiri, and M.O. Ilori, "Financial Management Practices in Public R & D Organizations in Nigeria," International Journal of Engineering Management, 2005.
14. Preparing for the 21st Century, "Technology and the Nation's Future," Accessed on the 3rd December, 2016. Time: 5:40pm. www.nas.edu/21st/technology/technology.html
15. K. Park, M. Ali and F. Chevalier, "Strengthening Indigenous Technological Innovation Capabilities in Developing Countries," Journal of US - China Public Administration, Vol. 8, No. 3, March 2011, Pg. 340 - 354.
16. Article shared by S. Samiksha, "Importance of Science and Technology in National Development-Essay," Accessed on the 3rd December, 2016. Time: 5:40pm. www.yourarticlelibrary.com/technology/importance-of-science-and-technology-in-natural-development - essay/8563