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THEME:

ENGINEERING TRAINING RESEARCH AND DEVELOPMENT: A catalyst for the attainment of the transformation Agenda.

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Topic:

Engineering Education and Training in Nigeria for Sustainable National Development.

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1. INTRODUCTION

When the history of human development is considered, Engineering becomes the prominent word that persists throughout. From the food we eat, where we leave to our modes of transport, communication, medicine, our lifestyles, etc, it can easily be concluded that the world is all about Engineering. The evolution of human development can be categorized into four stages:

Stage one: Neolithic Revolution, during this time, people moved from social systems based on hunting and gathering to much more complex communities that depended on agriculture and the domestication of animals. This led to the rise of permanent settlements and, eventually, urban civilizations.

Stage two: Agricultural Revolution (First wave technology): It was ruled by living batteries – replaceable "energy slaves" and characterized by large extended families.

Stage three: Industrial revolution (Second wave technology): It was ruled by fossil fuels or irreplaceable energy base. It started with the invention of the steam engine by Thomas Savery in 1698. It was characterized by small nuclear families because of the shift from homes to factories. During the Industrial Revolution, there was widespread replacement of manual labour by machines that began in Britain in the 18th century and are still continuing in some parts of the world. The Industrial Revolution was the result of many fundamental, interrelated changes that transformed agricultural economies into industrial ones. It changed society both significantly and rapidly. The most immediate changes were in the nature of production: what was produced, as well as where and how.

Stage four: Microelectronics Revolution (Third wave technology): Third wave technologies started with the innovation of the Integrated Circuits (IC) in 1959 and the microprocessor in 1971. They have not yet been fully deployed on grand scale; nevertheless, we can already glimpse the dangers of electronic smog, information pollution, and combat in outer space, genetic leakage, climatic intervention and what might be called "ecological warfare" – the deliberate induction of earth quakes e.g. triggering off vibrations from a distance. Beyond these lies a host of other perils associated with the advance to new technological base.

Modern nations show great concern for education, especially education in science, engineering and technology for obvious reasons. It provides the great needs of the nation through the development of the social and economic infrastructure necessary for the growth of enterprise (Gemade, 2009), an antidote to poverty and leveler in the knowledge emerging society (Ajimotokan et al., 2009). Today, education has evolved as the primary agent of transformation towards sustainable development, increasing human's capacities to transform their visions for society into reality (Oloyede, 2008; UNESCO, 2005).

The literature is replete with numerous definitions of education based on philosophy of life, disciplines, past experiences, circumstances, environment among others. ***Education is the aggregate of all***

process by which an individual develops values, attitudes, abilities and other forms of behavior that is of positive value to the society (Fafunwa, 1974). Education provides the theoretical knowledge in both basic and applied sciences, acquired through formal method designed for human capital development meant to serve national interest (Ibidapo-Obe, 2009). It implies that ***engineering education can be defined as education in science, engineering and technology for capacity building in engineering towards sustainable development***. Thus, the aim of **engineering education** should be the integration of knowledge, skills, understanding and experience (Padmanabhan, 2000).

The Nigerian government has made frantic efforts to encourage engineering education. From the mid 1980s, the first remedy introduced was diversification and specialization of the universities with a view to increasing their scientific, technological and agricultural contribution to the transformation of the country (Ajimotokan et al., 2009; Ekeh, 2009). The development of a viable **engineering education** is an indispensable tool in the various sectors of the economy if the nation hopes to develop and sustain development to attain its national vision and goals, be it Millennium Development Goals (MDGs), National Economic Empowerment and Development Strategy (NEEDS) and Vision 20:2020 (Ekeh, 2009).

2.0 HIGHER EDUCATION FOR SUSTAINABLE DEVELOPMENT

The quest for continuing investment in higher education stems from the mandate of higher education globally. Considering the mandate of higher education for sustainable development, one cannot but note that the roles and functions of university in enhancing sustainable development are anchored on such issues as:

(i) Increasing the relevance of teaching and research for the societal processes leading to more sustainable and discouraging unsustainable patterns of life;
(ii) Improving the quality and efficiency of teaching and research;
(iii) Bridging the gap between science and education, and traditional knowledge and education;
(iv) Strengthening interactions with actors outside the university, in particular with local communities and businesses; and
(v) Introducing decentralized and flexible management concepts in higher education.

It is within this context that the factors of access, resources, quality assurance and relevance, reassessment of academic degrees and globalization of higher education teaching, training and research predict the economies of scale of sustainable development.

Education may contribute to development, but it does not mean that the expansion of school attainment necessarily guarantees the improvement of economic and social conditions (Lee, 2008). The important thing is the quality of education and schooling – that is, whether students are really learning what truly matters in the context of sustainable development. In this sense, the mandate of higher education research can never be overemphasized as exemplified in **three major areas** below (Peter and Jonathan, 2010):

First, higher education institutions, especially universities, are responsible for research on sustainable development. Therefore, the demand for access must be equated with the crucial role of higher education as the higher advanced and comprehensive knowledge provided. This becomes the best means to bring about harmony and synthesis among the three pillars of sustainable development, namely, economic, environmental, and social task and issues, which are often in conflict with each other.

Second, higher education incorporates institutions that train and produce teachers for the lower level of learning. Quality education therefore completely depends on qualified teachers, and education for sustainable development can be practiced only through teachers who have been trained and "conscientized" on the values and perspective of sustainability. Higher education is only relevant to the extent that research and innovation arising therefore are able to provide learners with skills, perspectives, values and knowledge to live sustainable in their communities. It is in that context that the economies of scale are measured.

Third, higher education also produces leaders and elites of the country who manage governmental bureaucracies, political parties, economic agencies and private sector industries who all constitute the stakeholders of sustainable development. So, it is crucial to educate and build a vanguard group of leaders in each sector of society, public or private who will take a leading role in promoting the values of sustainable development (Lee, 2008). The extent to which higher education research is able to guarantee these areas justifies the demand for access and not just expansion of institutions without a corresponding added values.

3.0 OBJECTIVES AND VALUES OF ENGINEERING EDUCATION

One's success in engineering largely depends on one's attitude, self improvement and skills developed on factual knowledge. An engineering education is designed to make a major contribution to one's development in these areas. Each field of specialization requires some knowledge of other fields. As a result, all Engineers are required to work hand in hand, not only with other Engineers and other engineering fields but much beyond this. It is therefore very important to stress that the main objectives of an engineering education among others are:

(i) To impart factual knowledge required. This subdivided into:

a) Basic physical sciences such as chemistry, physics, mathematics, etc.

b) Applied physical sciences such as basic electrical circuits, mechanics of soils, thermodynamics, etc.

c) Codified empirical knowledge.

d) Other knowledge, which I refer to 'external knowledge' such as sociology, literature, history, law, psychology, humanities, etc.

(ii) To give a reasonable start in development of engineering skills such as: Design, inventiveness, judgment, experimentation, reaching reasonable conclusions, optimisation, thought, communication and most of all working with others.

(iii) To help shape one's attitude in his ability to inquire, able to accept or reject proposals and be open-minded.

(iv) To equip and motivate for a continuing self-improvement.

These qualities distinguish engineering from other profession such that the Engineer is often referred to as a problem-solver. One's success in acquiring these characteristics determines his effectiveness as an Engineer.

4.0 ENGINEERING EDUCATION FOR SUSTAINABLE DEVELOPMENT

'Sustainable development' has been defined best by the Brundtland Commission as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Arshad and Garegin).

Education is critical to promoting sustainable development (UN, 1992). The United Nations defines **Education for Sustainable Development** as education that encourages changes in behavior that will create a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations (UN, 2002); increasing the capacity of individuals, groups or organizations to contribute to sustainable development, through content and skills acquisition (Byrne *et al.*, 2010). It was to this end that the organization declared the **2005 – 2014 period the UN Decade for Education for Sustainable Development** (UN, 2002; Ahlberg, 2004). According to Clark (2003), the people and countries which will succeed fifteen (15) years from now are those which are most - based on a sustainable vision of the world; that is the attitude we should be training people to imbibe if want any of our visions to succeed.

The engineer of 2020 will need to learn much new technical information and techniques and be conversant with and embrace a whole realm of new technologies, but some old problems will still need to be tackled. They will demand new attention and perhaps, new technologies (National Academy of Engineering, 2005). We are most certainly going to witness a situation where some of the present preoccupations of the engineer cadre must have to be passed on to the technologist cadre. This trend has been peculiar with the development and evolutions of the engineering profession over time, and the reason has always been to enable the engineer focus on the more challenging issues of the job. This of course has implications for the trainings of technologists and technicians which have to be updated to comply with the trend.

The UK Forum for the Future Higher Education Partnership for Sustainability has stressed that sustainable development is a crucial aspect of engineering education to understand the impact of an engineer's professional activity on economy, environment and society (BEST, 2006). Long term goal of the 21st century engineering education must include enabling practicing engineers to incorporate tenets of sustainability into all phases of their practice.

Engineering accreditation bodies need to think critically about what should or should not be included in a curriculum into which sustainable engineering has been incorporated (Allen *et al.*, 2008). It has been observed that the accreditation process for university engineering courses should be proactive in driving the development and updating of course content, rather than being a passive auditing exercise.

In a consultative forum involving about 30 academic staff from universities in the UK, there was no consensus reached on the form in which sustainable development should be introduced into the engineering curricula. Opinions were however spread between embedding (that is, making the concept an element in all courses, to which many were not agreed), making the concept to occupy 10% of the curriculum (representing median opinion), and making it a compulsory component of all engineering programmes (to which many were agreed) (Wara, 2012). Certain countries (Byrne *et al.*, 2010) include the following criteria as accreditation requirements with regard to engineering education for sustainable development:

(i) Sustainability/sustainable development
(ii) Environmental or social issues
(iii) Ethical issues, but only in the context of (1) and (2) above
(iv) Multi-disciplinarity and
(v) Complexity or complex systems, and related (open ended) problems

Some fora have made recommendations on how sustainable engineering content should be incorporated in the engineering education programme (BEST, 2006). Some of the suggestions are to:

a) Incorporate an introductory course on sustainable development at beginnings of studies or programmes
b) Introduce applied courses on sustainable development at ends of studies or programmes
c) Make sustainable development part of the technical courses already existing in engineering curricula
d) Adopt discussions approach, examples, case studies, projects, internships, etc. as learning methods
e) Involve the professional world in the teaching of sustainable development
f) Teachers of sustainable development need to have up-to-date knowledge about the available technologies

In order to address the challenges of the 21st century, it is essential that our undergraduate programmes be reformed.

Nigerian universities have been tasked with developing high level manpower required for the country's development (Federal Government of Nigeria, 2004; Obadara, 2010). The country achieves middle level manpower trainings at Technical Colleges, Monotechnics and Polytechnics (Olumodeji, 2010). The Federal Government of Nigeria in various National Development Plans placed emphasis on engineering manpower training (Badekale, 2003). It was not until the 3rd national development plan that specific demand was made with regard to enrolment into engineering programmes, and this was helped with the establishment of more universities. The establishment of Universities of Technology during the 4th national development plan reflected government interest and concerted effort at generating sufficient technical manpower to drive industrialization.

Long term brain drain, combined with insufficient output from national postgraduate programmes, in the face of rising student enrolments has left the Federal Universities system with a little less than 50% of its staffing need filled. Staffing scarcity is most acute in engineering, science and business disciplines.

Enrolment alone cannot be the main index for manpower generation in engineering. Other indices include 'wastages' in the course of the engineering programmes (i.e., dropout rates). Absorption of graduate engineers into non-engineering jobs with associated subsequent loss of interest in the profession, and non-availability of jobs for the graduate engineers.

As at June 2012, the Council for the Regulation of Engineering in Nigeria (COREN) had on its registers (online) 1,027 engineering craftsmen, 327 engineering technicians, 1,646 engineering technologists, 20,085 engineers, 687 expatriate engineers, and 987 consulting firms. Whereas these cannot be said to be true figures of available engineering manpower in the country, it does reflect the state of professionalism and the practice of engineering in the country and buttresses the point for urgent and concerted efforts on manpower generation and capacity development.

5. CAPACITY BUILDING AND NATIONAL DEVELOPMENT

Capacity building is a functional approach to making people useful to themselves and to society as a whole (Sodangi, 2007). ***Sodangi advocated a capacity building drive anchored on the practice of engineering.*** Most productive activities in the national economy involve manufacturing and distribution of goods and services. In each of these activities, engineering is crucial. The facilities required for manufacturing and distributing the goods and services are designed, fabricated, installed and maintained by engineers, or technical personnel. In all these activities, manpower is required. The more facilities that are set, the more would be the manpower requirement, since the establishment of these facilities result in very high value addition, with equally very high multiplier effects. This should set a platform to drive skilled manpower trainings and attendant job creation.

There is however more to our capacity building needs. Major deficiencies in our industrialization policies and economic development are the absence of capacity to produce a better trained population and strong institutional framework within which development can take place (World Bank, 1989; Bamiro, 2007; Alaibe, 2007; Ilaboya and Wara, 2008). Our technological base is weak. Wara and Ngubi (2008) opined that competitive advantage is essential to growth of 21^{st} century industries. Presently, the world is on the threshold of a new technological age – driven by rapid advances; new products will emerge that may quickly make conventional processes and products in Africa obsolete (Bamiro, 2007).

The world is knowledge intensive and increasingly dominated by emerging technologies. Mere possession of capital or natural resources is no longer pre-condition for national development; future developments will be more and more technologically based. Science is man's attempt at comprehending the workings of our systems. ***Scientific capability or "know-why"*** is acquired through research and its acquisition can take place meaningfully only if there exists a critical mass of scientific manpower in the country – within our firms and in our national R&D institutions. ***Technology or "know-how"*** however refers to ways of doing things and technological capability has always existed in any human society. ***Technology*** affects human development through innovation, by increasing functionality of existing means and increasing human capabilities, and through enhanced productivity, as seen in increased outputs, heightened efficiency of services and higher incomes. However, ***Engineering*** is the package of actions we take to put technology to work in the production of goods and services. Engineering capability is utilized for the translation of new technologies or processes into plants and process machineries.

Innovation refers to the application of knowledge in production, knowledge acquired through learning, research, training or experience is not innovation until it is applied in the production of goods and services. A Scientific, Engineering and Technological capacity underlies innovation and technical change, which are the drivers of economic development (Bamiro, 2007). Creating and sustaining a knowledge-based economy requires an innovative system of policy making which is different from our traditional centralized and rigidly regulated economic decision making. The key to this is partnership between Science, Engineering, Technology, Economics, and Public Policy and between Tertiary Institutions, the Private Sector and Government. The institutions for capacity building in Science, Engineering, Technology and Innovation as including the

Education, Training and Research and Development System. The emphasis areas are (Bamiro, 2007):

(i) Entrepreneurship Development
(ii) Management for production
(iii) Professional and skilled manpower development'
(iv) Basic and Applied Science
(v) Engineering for Production
(vi) Technology (including ICT)

Key stakeholders that should constitute a national innovation system for SETI capacity buildup should include: Firms/Enterprises (particularly the manufacturing sector), Government, Research and Development institutions, Educational and Training institutions, Engineering Consultancy Firms, Financial Institutions, Foreign firms, and International Agencies.

6. CURRENT STATE OF ENGINEERING FACULTIES IN NIGERIA

There are currently in Nigeria, thirty eight (38) Federal Universities, thirty seven (37) State Universities and fifty (50) Private Universities (NUC, 2012). Table 1 presents data from COREN and the analyses of the results obtained. There are thirty four universities running the B. Eng or B. Sc in 182 Engineering disciplines. Of these, 77.8% are fully accredited, 16.7% have interim accreditation, 5.6% were denied accreditation. Accreditation of twenty engineering programmes is being awaited. As at 2011, there are seventy eight (78) engineering programmes, which is 46.3% of the total, whose status had lapsed.

There are thirteen universities running forty eight postgraduate diploma courses in Engineering. Of these, 77% are fully accredited and 23% have interim accreditation. There are fourteen engineering programmes whose status had lapsed as at 2011 (Ref. Table 2)

This figure is disturbing and hence not apt for a nation's thirst for development to surmount its present technological and scientific dependence. However, engineering education in Nigeria has great promises; it also has a lot of challenges. Some of these challenges and thus the dismal state of engineering education can be traced to the following:

(i) Ill equipped laboratories and workshops,
(ii) Poor funding and thus poor educational infrastructures,
(iii) Deficiency in teaching and research equipment,
(iv) Paucity of quality teachers and poor learning environment,
(v) Paucity of ideas, scarcity and prohibitive cost of books,
(vi) Challenges of relating the curricula to national manpower needs.
(vii) Incessant interruptions of academic calendar,
(viii) Epileptic power supply, deficiency in ICT,
(ix) Very low industrial base,
(x) Little or no industrial universities collaborations,
(xi) Existing monolithic training programmes, etc. (Bako, 2005; Oloyede, 2008; Ekeh, 2008; Adetokunbo, 2009; Ekeh, 2009).

Table 1: COREN 2011 Accreditation Status of Existing Bachelor of Engineering Programmes in Nigerian Universities

S. No.	Engineering Disciplines	Number of Universities	Accreditation Status			
			Full	Interim	Denied	Awaiting
1	Agricultural Engineering	18	16	2	-	3
2	Chemical Engineering	18	13	5	-	1
3	Civil Engineering	28	22	4	2	3
4	Computer Engineering	10	6	3	1	1
5	Electrical / Electronics Engineering	23	18	4	1	4
6	Electrical Engineering	6	5	1	-	-
7	Electronics Engineering	1	1	-	-	-
8	Food Engineering	3	2	1	-	-
9	Industrial Engineering	1	1	-	-	-
10	Information/Communication Engineering	1	1	-	-	-
11	Marine Engineering	1	1	-	-	1
12	Mechanical Engineering	29	23	4	2	5
13	Metallurgical /Material Engineering	6	6	-	-	-
14	Mining Engineering	1	1	-	-	-
15	Petroleum Engineering	9	4	3	2	1
16	Polymer and Textile Engineering	1	1	-	-	-
17	Production Engineering	2	2	-	-	-
18	System Engineering	1	-	-	1	-
19	Water Resources Engineering	2	2	-	-	-
20	Wood Products Engineering	1	1	-	-	1
	Total	162 100%	126 77.8%	27 16.7%	9 5.6%	20

Table 2: COREN 2011 Accreditation Status of Existing **PGD** Engineering Programmes in Nigerian Universities

S. No.	Engineering Disciplines	Number of Universities	Accreditation Status			
			Full	Interim	Denied	Awaiting
1	Agricultural Engineering	4	2	2	-	-
2	Chemical Engineering	6	4	2	-	-
3	Civil Engineering	8	8	-	-	-
4	Computer Engineering	2	2	-	-	-
5	Electrical / Electronics Engineering	8	6	2	-	-
6	Electronics Engineering	1	1	-	-	-
7	Food Engineering	1	1	-	-	-
8	Marine Engineering	1	1	-	-	-
9	Mechanical Engineering	11	9	2	-	-
10	Metallurgical /Material Engineering	3	3	-	-	-
11	Petroleum Engineering	2	1	1	-	-
12	Production Engineering	1	-	1	-	-
	Total	48 100%	37 77%	11 23%	-	-

7. CONCLUDING REMARKS

- Engineering education is so momentous and should be spiritedly pursued, to fully exploit the available possibilities for promoting sound engineering education and sustain development.

- The challenges to guarantee quality engineering education seem overwhelming, however, they are attainable. Undoubtedly, the major obstacle to sustainable development is the lack of viable engineering education and training. Thus, the quest for the sustainable national development and growth as envisaged is dependent on the extent to which engineering education is revamped and transformed to compete globally.

- Concerted efforts are needed for harnessing available scientific, engineering, and technological capability, within right policy frame works to guarantee our vision for development through innovativeness.

- Our society must transit to a knowledge – based society, capable of meeting the challenges of the 21st century with regard to rapidly changing needs subject to increasingly complex constraints.

- Specific reforms are needed to achieve manpower/capacity development, deployment and coordination of technological, industrial and R & D capabilities, as well as Education and Training.

8.0 RECOMMENDATIONS

- The National Universities Commission and the Council for the Regulation of Engineering in Nigeria, as well as the National Board for Technical Education, should work at refocusing our engineering curricula in higher institutions to meet the challenges posed by sustainability and world technology development trends.

- There is need for a complete overhaul of our perceptional system with regard to engineering and our expectations from the engineer. For the nation to benefit substantially from the contributions of the engineering family in translating our nation from a consumer to productive economy there is need for a complete overhaul of our perceptional system with regard to engineering and our expectations from the engineer.

- Professionalism in practice must be emphasized. The roles of the engineer, engineering societies and COREN with regard to ensuring strict compliance to requisite details cannot be overemphasized.

- Engineering societies and COREN should work at updating our codes of ethics and practice guidelines for conformity with requirements for sustainability.

- Appropriate policy framework must be established for human and institutional capacity building in Science, Engineering, Technology, and Innovativeness for National Development through society.

- Research and Development must be a top priority and commitment of governments at all levels to ensure growth in a competitive knowledge based society.

- Engineers must be involved as **stakeholders** at the planning and implementation stages of all projects in order to ensure that crucial decisions with regard to the project are not neglected.

- Government and private concerns must encourage and drive indigenous practice of engineering in Nigeria which in turn promotes job creation. Requirements for this from the government are; opportunities, enabling environment, support for acquisition of technical facilities, special tax waivers on productive engineering activities, etc.

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S/No	Engineering Disciplines	No. of Universities	Accreditation Status		
			Full	Interim	Denied
1	Agricultural Engineering	13	1	10	2
2	Chemical Engineering	12	3	7	2
3	Civil Engineering	22	2	14	6
4	Computer Engineering	6	Nil	1	5
5	Electrical & Electronics Engineering	14	3	5	6
6	Electrical Engineering	8	1	5	2
7	Electronics Engineering	1	Nil	1	Nil
8	Food Science Technology	13	2	7	4
9	Industrial Engineering	1	Nil	1	Nil
10	Marine Engineering	1	Nil	1	Nil
11	Mechanical Engineering	24	8	7	9
12	Metallurgical & Material Engineering	6	Nil	6	Nil
13	Metallurgical Engineering	1	Nil	Nil	1
14	Petroleum Engineering	4	1	2	1
15	Polymer & Textile Engineering	1	Nil	1	Nil
16	Production Engineering	1	Nil	Nil	1
17	Water & Environmental Engineering	1	Nil	1	Nil
Total (%)		129 (100)	21 (16.28)	69 (53.49)	39 (30.23)

Source: Extract of NUC (2002)