CHALLENGES IN ENGINEERING EDUCATION IN AFRICA

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ABSTRACT

Engineering education deals with the training of engineers for the purposes of initiating, facilitating and implementing the technological development of a nation. In Africa, the training of engineers has witnessed formidable challenges ranging from poor funding to inadequate facilities both quantitatively and qualitatively, non-availability of adequate human capacity, brain drain and poor staff training and retention profiles. Others include weak university/industry partnership, defective curricula, traditional approach to teaching, poorly equipped laboratories, and poorly developed local codes and monitoring standards for the training of prospective engineers and an inadequate ICT environment.

1.0 INTRODUCTION

Engineering education is the training of engineers who are supposed to be the initiators, facilitators and implementers of technological development of a nation. Engineering more than any other profession, has more direct impact on national welfare.

Engineering contributions are widespread and visible ranging from chemical engineering, civil engineering, electrical and electronic engineering, aeronautical etc. Consequently, engineers can serve as change agents not only for technical systems but also for many other societal changes. The technical nature of engineering education makes it unique in content and approach, thereby requiring special care and attention. The inputs of engineers are so visible to the extent that even an illiterate could see when 'failures' occur.

Engineers are supposed to solve societal problems in sustainable ways. For them to do so they need to be sufficiently informed in engineering concepts and application of engineering theoretical principles to practical problems. The desire of the stakeholders to achieve this has

been met by lots of challenges. Our inabilities to tackle the challenges appropriately in Africa have put us at a low level in technology. The difference between developed, developing and undeveloped countries rests on the ability of the developed countries to use engineering to convert scientific ideas to technology locally while the developing and underdeveloped countries are yet to effectively do so. The challenges mitigating the training of engineers are many but a few of the major ones are discussed below:

2.0 CHALLENGES IN ENGINEERING EDUCATION

The challenges of engineering education in Africa are many. The major ones are:

2.1 FUNDING

In most African countries universities are owned by Governments and they are funded by the governments. For example, Universities in Nigeria are owned by the Federal and State governments and recently Private individuals. The federal and state governments' universities rely predominantly on the governments for funding while the private universities obtain their incomes from the fees they charge the students. Other sources of revenue are endowments, investment income, grant and gifts. Over the years, governments' subventions to universities have never been adequate but at the same time governments maintain the policy that universities should not charge fees.

In Nigeria, the allocation to education as a share of GDP has tripled since the inception of a democratic government in 1999.In 1999, the Federal Ministry of Education's recurrent budget was 38.3 billion Naira (US$300 Million), in 2006, the Ministry was authorized to spend 129.2 billion Naira US$1.0 Billion).The real value of the 1999 budget expressed in 2006 Naira purchasing power was approximately 84.6 billion Naira (US$662 million). Therefore, the purchasing power of the Federal Ministry of Education increased by about 53 percent over eight years (African Human Development, 2006). However, because of the increase in the demand for engineering education and existing high decadence in the infrastructure, the effect of the increase in funding could not be noticed substantially. Private universities charge as much as 500,000 Naira ($3906) per student per annum.

Case (2006) indicated that engineering programmes in South Africa are costly for an institution to run, and that government subsidization of the programmes has sometimes driven some of the smaller departments into complicated arrangements with external funders. She further noted that Engineering Council of South Africa ECSA had earlier raised concerns about the quality of engineering programmes in some of those sub-critical departments.

2.2 FACILITIES

In most Universities in Africa, there is inadequate supply of laboratory space. The laboratories only have the items of equipment that were provided when the universities were established. The facilities are inadequate quantitatively and qualitatively and besides they are obsolete. Oryem-Origa (2005) indicated that only 45% of Institutions of Higher Education in Uganda have laboratory or workshop space. The others, 55% including most private universities did not have laboratory or workshop space and that this reflects the low number of science and technology programmes in higher institutions. He further noted that those universities that have laboratories experience acute shortage of laboratory equipment and supplies. He concluded that this made the teaching and research in science and technology difficult and therefore the country was producing insufficient and ill-prepared science graduates necessary for driving the technological and socio-economic development. Table1 shows the Average Age of equipment in some African universities. The biggest problem is the old age of the equipment. The average age of equipment is the universities considered is 15.8 years.

Table 1: Average Age of Equipment

University	**Engineering Sciences (years)**	**Age of Sc. And Tech departments (years)**
Addis Ababa University	10	52
Michael Okpara University of Agriculture, Umudike	-	8
University of Zimbabwe	-	45
Univesity of Malawi	23	35
Ahmadu Bello University	-	
University of Lagos	26	38
Kwame Nkrumah University of Science and Technology	12.6	51
University of Nigeria, Nsukka	30	42
JKUAT	9	12
University of Dar es Salaam	-	
University of Nairobi	14.5	43
University of Botswana	4	20
University of Ibadan	11	27
University of Cape Coast	-	40
Universite De Lome – Togo	18	30
Average	*15.8*	

Source: Massaquio (2004)

The situation is partly responsible for the reason why it has been increasingly difficult to run experiments effectively for students.

The inadequacy in teaching, laboratory and workshop facilities has contributed to the diminution of the quality of the engineering graduates in Africa. Reyes-Guerra (1989) categorized students into three, namely: Verbalizers, Visualizers and Doers. The Verbalizers are those who learn easily if information is in written or spoken form. They benefit from lectures, tutorials and hand –outs. Visualizers learn easily when information is presented in pictorial or diagrammatic form while the Doers learn more easily when information is presented by practical demonstration by the lecturers.

The inadequacy of facilities both qualitatively and quantitatively has put the visualizers and the doers at a disadvantage. The Verbalizers may also have problem in a class with large students' population. The implication of this scenario is that only a small proportion of the students benefit from the current pedagogical system.

There is dearth of ICT facilities for the training of students. The high cost of computer and teaching aids ownership is a major constraint to acquisition of the items. Access to affordable and reliable internet connectivity is only available in a few institutions even then power fluctuations have considerably reduced the reliability of the access and inadequate bandwidth also makes access difficult.

2.3 BRAIN DRAIN

In the context of this paper, brain drain can be defined as the movement from universities of highly trained professionals, Intellectuals, Talents and Specialists in engineering which is important for the socio-economic and technological advancement of African region to other professional (including politics) calling. Akintunde (1989) identified five different components of brain drain:

i). Experts in academics who moved to the industry where they get better pay for their services.

ii). Lecturers and students who left the region to acquire more knowledge and skill but later refused to return

iii). Experts who move from one country to the other within the region (limited number)

iv). Skill professionals who abandon the practice of engineering in favour of other more lucrative economic activities and political appointments which are not related to their training.

v). Skilled professionals, although in their field of training, who do not devote their full attention to their job because of their efforts to supplement their earnings through other unrelated economic activities.

In the 70s, Nigerian universities were able to attract experts from other countries e.g India because the economic conditions were favourable. But with down turn of the economy and consequences of the ineffective efforts of the government to resuscitate it, this resulted in the return of the foreigners to their countries and exodus of their Nigerian counterparts from the shores of Nigeria in order to earn a better living.

Bassi (2004) reported that: i) about 40% of all African Professionals have left the Continent shores over the decades since colonization ii) between 1985 and 1990 alone, Africa lost over 60,000 middle level and high-level managers to the western economies, iii) about 23,000 Lecturers from African universities continue to emigrate each year, particularly to Europe and America. Africans in Diaspora contribute 40 times more wealth to the American than African economy.

2.4 STAFF TRAINING AND RETENTION

The training of academic staff is ordinarily a continuous exercise to ensure consistent improvement in the quality of their outputs. The training is in two-fold: training to acquire minimum qualification (PhD) to teach and continued professional training. Both types of training can be acquired either locally or overseas. Usually, local training within each nation is cheaper than overseas training but more strenuous because of inadequate facilities, literature and distractions arising from the need to meet the necessary demands. Overseas training requires a lot of foreign exchange but the enabling environment exists to achieve success in a record time. However, over time it has always been difficult to get the trainees back to their respective countries after the completion of their study.

In the 70s the Nigerian universities were able to recruit foreigners and retain them and the indigenous academic staff because of the low exchange rate. Then, one US dollar ($1.00) was equivalent of seventy kobo (70k). But now that a dollar ($1.00) exchanges for one hundred and thirty naira (₦130.00) provides good attraction to move out. This is not to say that salary is the only issue, self fulfillment in terms of output via research efforts is also part of the driving force.

The salary and service benefits paid to engineering teachers in Africa especially in the West Africa sub-region is about the lowest in the world and because of this, they migrate to other countries especially the United States of America, or local industry for better pay. Academics from within and outside Africa migrate to Botswana and South Africa because of high wages that they pay to the academics and relatively better equipped laboratories.

2.5 STAFF SITUATION

Many universities across the region are inadequately staffed both qualitatively and quantitatively. In most departments the proportion of staff without PhD out numbers those with Ph.D.

Table 1 shows the result of a survey conducted by Massaquoi (2004). It is difficult to get people trained to the level of Ph.D because academic is not attractive whereas with first degree (B.Sc, B. Eng) graduates can function well in the industry and earn good money. Table 2 shows the relative percentage of academic Staff with PhD to those without it.

Table 2: Percentage of Staff with PhD

	UON	**Addis**	**UZ**	**JKUAT**	**Bots**	**Malawi**	**ABU**	**Unilag***
Subject								
Civil	28.00	18.75		27.27	56.25		36.36	70.59
Mechanical	52.17	20.00		30.43			20.00	27.27
Met &Mat								46.15
Systems								71.43
Electrical	46.67					77.78	41.67	43.48
Electronic		60.00	50.00			5.88		
Chem/Biochem		38.10				12.50	30.77	57.14
Comp Eng		60.00						
Mining			60.00					
Industrial		42.86	75.00		50.00			
Production				85.00	14.29			
Agricultural	44.44						40.00	
Survey	35.71						50.00	30.00

Source: Massaquio (2004)

* Author's input

In order to spur locally needed Science Technology activities, it is imperative that African governments should seriously consider proper retention schemes for their best talents by providing special working conditions including income supplements and adequate research supports.

2.6 STUDENTS' ENROLLMENT

In Nigeria where there is high population, one of the challenges is how to cope with high student enrollment and ensure that quality students are admitted into engineering programmes. In Tanzania and most other African countries the admission targets are not met. For example, Mshoro and Mwamila (2006) showed that the admission target was only met in University of Dar es Salaam in 1996 while between 1997 and 2005 the number of students admitted was less than the set targets. This was attributed to lack of adequate pool of applicants due to the fact that the number of Form 6 Leavers with relevant science combinations was still limited because of inadequate number of science secondary schools and inadequate science teachers and laboratory facilities in the few existing secondary schools as well as the observed erosion in mathematical skills among pupils. They further noted that the small pool of applicants to engineering programmes could also probably be attributed to the decreasing interests among youths to study engineering due to wrong perception that it is difficult to study engineering and/or prospects in engineering are poor.

2.7 THE CURRICULUM

The curriculum of a subject with practical content is generally organized into an average of 67% for the theoretical classes and 33% for laboratory. Students also use the laboratory to develop case examples on their own time.

Olunloyo (2002) noted that one of the issues confronting the design of appropriate curriculum for engineering is preparing students for the shift from the fordist to ICT paradigm in engineering production and practice.

The low pace of industrialization and technological growth in Africa can be attributed to the widening gap between science and technology as a result of inability of engineering to utilize adequately the scientific-ideas to promote technology. This suggests the need to overhaul engineering curricula in the region.

The overhauling of the curricula may not necessarily translate to the production of ready-made graduates for the industry which may result in rapid industrialization or growth in the economy of a nation unless solutions are proffered to some constraints that may militate against positive outcomes.

The problems associated with the current curricula are: i) they are based on a foreign model which has evolved under ideal conditions (staff, equipment, infrastructure, training

opportunities, etc) that are not easily duplicated in developing countries; ii) there is usually a shortage of highly competent indigenous teaching and support staff with sufficiently wide practical experience of engineering; iii) most of the available textbooks are often illustrated with examples from outside the local environment and which are irrelevant to the particular country; iv) the curricula are adjudged to be too academic and overloaded with intellectual content in pure science and mathematics at the expense of basic engineering and technology and v) inadequate provision for humanities, social sciences, business management concepts and entrepreneurship skills development. Because of the inadequate preparation of the students for the industry, some employers retrain the graduate to make them productive in their organizations.

The teaching approach follows the conventional method of transferring knowledge across through the lecturer reading out to students, who would then take down notes. The educational system continues to place considerable value on this transmit and receive model of teaching.

Jimngang (2004) indicated that in the Republic of Cameroon, there is need for a total overhauling of the educational system and that in many fields course work available only lead to rising unemployment, poverty and misery. He concluded that the situation could only be curbed if syllabuses were innovated, re-engineered or re-designed to include disciplines that build up the fighter-spirit needed for today's and even tomorrow's ineluctable battles of life.

2.8 CODES OF PRACTICE AND STANDARDS

These are documents, which set minimum requirements for properties of engineering materials, design, construction procedures and manufacturing techniques to ensure quality outputs. Training in engineering and its application are universal but its practice is localised to solve the problems in the society in the area where it is being practised. Generally, codes and standards are dependent on the environmental factors such as humidity, temperature, pressure and atmospheric particle density prevailing in the host environment.

In most African countries, we rely on Codes and Standards from developed countries for the training of our students and professional practice. For example, the First edition of National Building Codes was put together in Nigeria by the professionals in the building industry and approved by the National Executive Council in 2006. The major challenge is for engineers in each African nation to get their acts together and develop relevant codes and standards for the training of engineer and for you by the practising engineers for the design of facilities.

2.9 WEAK UNIVERSITY-INDUSTRY PARTNERSHIP

In African nations with the exception of Botswana and South Africa., the industry leaders are not involved in defining the research agenda neither do they participate in the development of engineering curricula to allow them integrate into the curricula the areas of needs of the industry consequently the two sectors operate at different levels. Also the multinationals usually locate their research units in their home countries.

3.0 POLITICAL SITUATION

Generally, education including engineering has been neglected. Engineering educators have the greatest challenge of convincing the law makers on why the law makers should give priority to engineering in allocating resources. Many options of getting positive results have been advocated at different fora, namely, lobbying, participation of engineers in governance, wooing, etc.

5.0 CONCLUSION

For progress to be made in Africa, the challenges confronting engineering must be recognized and be allocated adequate resources to achieve positive outcomes.

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