Problem Facing Engineering Education in Africa:
The Role of African Engineering Education Association (AEEA)

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ABSTRACT

Engineering education is the process of training 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, non-availability of local codes and monitoring standards for the training of prospective engineers and an inadequate ICT environment.

African Engineering Education Association (AEEA) was established in 2006 in Pretoria, South Africa. It is to serve as the driving force for the African Regional Conference on Engineering Education, a biennial forum for all the stakeholders in Africa to identify and proffer solutions to the problems within the compass of engineering education in the region. AEEA aims at addressing all the issues of inadequacies in Engineering Education in Africa and fosters good relationship with both regional and international engineering organizations.

1.0 INTRODUCTION

Engineering is the application of scientific methods to technology and technology is the driving force for national/regional development. 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. The nations that have technological know-how are those nations that understand and have given scientific leaning its due. Engineers are by their education, training and experience, the disciples of technology and above all, modern technology must be seen for what it is, namely, the only key that controls the future.

Engineering contributions are widespread and visible ranging from chemical engineering, civil engineering, electrical and electronic engineering, 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 the 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 desires of the stakeholders to achieve these have been met by many 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 borders 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

2.1 FUNDING

In most African countries, universities are owned by Governments and they are funded by the governments. 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.

For example 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 and they 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.

Table 1: Average Age of Equipment

University	Engineering Sciences	Age of Sc. And Tech departments
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 engineers. 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 had 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 both local and foreign academic staff and retain them 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.

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 2 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.

The decline in engineering education is a global problem that affects developed and developing countries alike. The situation is more acute and poses serious challenge in the developing countries because they have limited sources of recruitment whereas the developed countries always have an alternative of recruiting from developing countries.

2.7 THE CURRICULUM

In Nigeria engineering curricula had been modified over time both in content and the system of assessing students. Initially, students were assessment annually at the end of the session, usually in June of each year ('Almighty June'). After a careful evaluation, the system was found to be too strenuous especially for the students. This necessitated the need to redevelop the existing curricula based on course unit system. Under the system, a student is supposed to register for a minimum of 12 units and maximum of 24 units per semester. The minimum duration for each of the engineering programmes is five (5) years while the maximum is seven years. During a semester, a candidate who has registered for a course is expected to attend lectures, tutorials, laboratories, workshop as the case maybe submit assignments and projects and at the end of the semester write an examination in the course. The total grade returned for a student comprises grades for the continuous assessment and grade in the final examination.

The maximum stipulated duration of Industrial attachment is 40 weeks comprising the following modules: (i) students' work experience programme scheme I- 8 weeks (long vacation at the end of 200 level), (ii) students' industrial work experience - 8 weeks (long vacation after 300 level) and (iii) students' industrial work experience scheme II – 24 weeks (2^{nd} semester of 400 level plus long vacation).

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.

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.

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.

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.

Jimngang (2004) Indicated that is 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 and 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 evan 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 for engineers in each African nation to get their acts together and develop relevant codes and standards for the training of engineers and for use 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

African nations have been and to a large extent they continue to be ruled by persons who are not committed to development and care less about addressing those factors that could lead to development. 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.

4.0 ROLE OF AFRICAN ENGINEERING EDUCATION ASSOCIATION (AEEA)

The discussion on the problems of engineering education in Africa formed the thrust of our deliberation during the African Regional Conference on Engineering Education and Sub-regional workshop on New Engineering Curriculum which was held at the University of Lagos in 2002. Further meetings took place in 2004 at University of Lagos and 2006 at University of Pretoria, South Africa. During the latter conference, a meeting took place on the 27th September, 2006, where it was agreed that the name "African Engineering Education Association" (AEEA) be adopted in order to give an identity to the African Regional Conference on Engineering Education (ARCEE).

The details of all areas of coverage of the work of the association have not been fully defined but based on the outcomes of our previous meetings the areas include:

1. Establishment of data base for Engineering Institutions in Africa.
2. Advocacy of the review of curricula in engineering and technology education in Africa by way of incorporating technology enhanced teaching and learning environment especially Information and Communication Technology (ICT) Systems, internet-based systems and technological entrepreneurship in an integrated way.
3. Formulation of strategies for strengthening Students' Industrial Work Experience Scheme and other hands-on experience programmes.
4. Promotion of exchange programmes and linkages between African universities as well as trans-national industrial placement plus removal of international fee barriers for students from other African countries.
5. Development of Mechanisms of quality assurance in the institutions of learning.
6. One of the greatest challenges facing engineering education in African countries is the level of funding of institutions by the governments which severely compromises the ability to deliver quality education to the students. AEEA shall link up with the member nations and sensitize them about the necessity to fund Education especially engineering.
7. Development of mechanisms for regional accreditation of engineering programmes as well as credit transfer.
8. Promotion and enhancement of regional cooperation and networks (chister) beyond national boundaries for hope of realizing economics of scale (by pooling resources together).
9. AEEA shall strengthen regional cooperation in engineering education with institutions like the African Network of Scientific and Technological Institutions (ANSTI), Directorate of Technical Cooperation in Africa (DTCA), New Partnership for Africa Development (NEPAD), African Union (AU), United Nations Educational Scientific and Cultural Organisation (UNESCO), International Federation of Engineering Education Societies (IFEES) and other International organisations.
10. The Association will also have a Council of reputable persons and Advisory Committee whose membership would be drawn across the Region.
11. Encouragement of women to enter engineering careers.
12. Ensure better participation of member states at ARCEE.

5.0 ACTION PLAN

In order to kick start the operation of AEEA, an action plan was drawn up:

1. The organization is to be registered in South Africa
2. Website is to be created with its associated e-mail addresses
3. Bank account is to be opened
4. The constitution is to be developed
5. Linkage with other regional and international organizations is to commence after all documents have been completed
6. Set guideline for membership
7. Provide data base for engineering Institutions in Africa
8. Ensure good participation at ARCEE 2008 in Tanzania

STRUCTURE OF AEEA

In order to effectively implement the AEEA programme, a structure was put in place to ensured good coordination of resources within the region. The Secretariat of the Association is situated at University of Cape Town which has an existing unit for Engineering Education and the office is to be run by a Secretary General. Five sub-regions were identified (Southern Africa, East Africa, Central Africa, West Africa and North Africa). It was agreed that the Association would be headed by a President and 4 Vice-Presidents (the region that produces the President would not have a Vice-president).

The principal officers for the take-off of the Association are:

a.	President	-	Prof. Funso Falade to coordinate West Africa
b.	Vice-president	-	Prof. Chris Pistorius to coordinate Southern Africa
c.	Vice-president	-	Prof. Mwamila to coordinate East and Central Africa
d.	Vice-president	-	Dr. Aisa Jadi to coordinate North Africa
e.	Secretary-General	-	Prof. Duncan Frazer
f.	Liaison Officer	-	Dr. Zola Mbaguta

The details of all areas of coverage of the work of the Association are being put together.

8.0 REFERENCE

1. Africa Human Development Department (2006) 'Nigeria Science and Technology Education at Post-Basic Level (STEP B) – Review of Science and Technology Education in Federally-Funded Institutions' Nigeria Country Office, Nigeria.

2. Akintunde Ife (1989), 'Brain Drain in Nigeria: Technological Development Through Self-Reliance, Selected Speeches – The Nigerian Society of Engineers. Vantage publishers (Int'l) Limited 1st Edition, Ibadan, Nigeria pp 185 – 198.
3. Bassi S. Y. (2004), 'The Role of the Directorate of Technical Cooperation in Africa (DTCA) in Technology Transfer and Acquisition in African Countries' proceeding 2nd African Regional Conference on Engineering Education, University of Lagos, Nigeria 20th -22nd September, 2004 pp35 - 42
4. Graham Y. Jimngang (2004), 'The Culture of Entrepreneurship 1st Edition, Treasure Books Co., Limited, Douda, Republic of Cameroon.
5. Hannington Oryem-Origa (2005), 'State of Research and Teaching Resources available for Basic Sciences in Schools and Universities in Uganda? 1st Africa Region Conference of Vice-Chancellors, Provosts and Dean of Science, Engineering and Technology (COVIDSET 2005) Ghana 2005 pp 46 -54.
6. Jennifer M. Case (2006), 'Issues facing engineering education in South Africa' proceedings, 3rd African Regional Conference on Engineering Education & 4th South African Conference on Engineering Education, University of Pretoria, South Africa 26th – 27th September, 2006 pp 13 -30
7. Massaquio (2004), 'Trends and Advances in Engineering Education in Africa' 2nd African Regional Conference on Engineering Education, University of Lagos, Nigeria 20th -22nd September, 2004 Reyes-Guerra ( )
8. Mshoro, I. B. and Mwamila, B.L.M. (2005), 'The Role of Science and Technology Training Institutions in the Fight Against Poverty: The Case of the College of Engineering and Technology' at the University of Dar es Salaam proceedings, 1st African Regional Conference of Vice-Chancellors, Provosts and Dean of Science, Engineering and Technology (COVIDSET 2005),Accra, Ghana, 2005 pp 164 -172.
9. Olunloyo V. O. S. (2002), 'The Challengers of Globalisation for the Design of Engineering Curriculum in Developing Countries' First Edition, University of Lagos Press pp 217 – 237.
10. Reyes-Guerra (1989), 'Where are we now? Proceedings, International symposium for Engineering, Deans and Industry Leader, pp 44-53.