

KEYNOTE ADDRESS

Trends and Advances in Engineering Education in Africa

by

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1. INTRODUCTION

The theme to be addressed in this keynote speech is “*Trends and Advances in Engineering Tertiary Education in Africa*”. Let me hasten to add that this discussion is very timely because the financial stress which many institutions in the region had undergone over the last two decades, have resulted in many changes in the delivery of engineering education. Many institutions have witnessed decline of several of the resources that are required for quality education. While some have become innovative in adjusting to this reality and have maintained the quality of the education, some have witnessed the near total collapse of engineering programmes. It is instructive to examine these developments and analyse their effect on the quality of the engineering degrees in the region.

I note also that the main theme of the conference – “*retooling engineering and technology education for sustainable development*”, also requires that we take stock of the state of engineering institutions.

Therefore, this keynote address will address two issues: *The state of engineering institutions in Africa and the innovations in course programmes and delivery methods* that are emerging in the region.

2. STATE OF ENGINEERING INSTITUTIONS IN AFRICA

One of the topics of this conference is “*General issues in Engineering and Technology Education*”. Under this sub-title the conference is expected to discuss issues such as innovation in engineering education, new paradigms in engineering technology and many others. However before proceeding with the analysis of these obviously very important issues it may be worthwhile to just learn a little about where engineering education on this continent is heading. In particular, we need to make a frank

examination of the state of engineering training institutions in the region. Such an examination will enable us make a realistic assessment of our ability to avail ourselves of the opportunities of the fast-moving developments in the delivery of engineering education.

Over the last two years, the African Network of Scientific and Technological Institutions, has conducted a study of the trends in the state of African Science and Technology Training Institutions. The study covered both the faculties of science and engineering. The objective was to determine the quality of the physical and human resources available in the various institutions. The study surveyed, using a questionnaire, over twenty (20) institutions distributed among the four major geographic sub-regions (East, West, South, and Central). The questionnaire touched on all the important training resources including staff, library facilities, teaching/learning materials, laboratory facilities, ICT and teaching technology. It also enquired into relevance of existing courses.

2.1 Staff Situation

There are several ways of analyzing the staff situation. This can be through availability of staff (percentage of vacant posts), the quality of the staff, the effectiveness and efficiency of resource (staff) utilization.

The ANSTI survey mentioned earlier showed that most departments have only 60%-80% of the required staff at post. In some universities there are departments with only 30%-40% the staff required. Among the universities surveyed, only

University		Total Stud Population	Planned no of staff	Actual no of staff	% of filled positions
UZ	Eng	955	95	49	51.6
Malawi	Eng	474	69	56	81.2
Ahmadu	Eng	2287	161	86	53.4
Lagos	Eng	4063	142	88	62.0
JKUAT	Eng	794	149	90	60.4

Table 1: Percentage of staff at post

university of Botswana has several departments with a full compliment of staff. Table1 gives an indication of what prevails in a few selected institutions. There are several possible reasons for this large amount of vacancies in teaching departments. One is the obvious poor remuneration for academic staff in the region. In this connection it is instructive to note that the university of Botswana, which pays relatively high salaries to staff, has the lowest vacancy rate.

Other reasons for low staff levels include the absence of staff development programme (no training of new staff), brain drain (staff sent abroad do not return) and the inability of the institution themselves to train/develop their own staff. Table 2

summarizes reasons given for high staff vacancy. These factors clearly show that institutions have problems in training staff and retaining them. The problem has led to trends which have in some ways compromised the quality of staff. If one uses the percentage of staff with doctorate degrees as an indicator we find that staff quality is progressively getting weaker (see Table 3). Some universities have only 25% of their staff with PhD. On average, across the board, only about 50% of the staff have PhDs. Those institutions with very high number of PhDs (close to 95%) are older institutions and we find that the PhD holders are already close to retirement. What will happen in five (5) years time when most of these older staff retire? This is an alarming trend about staff quality which must be addressed.

REASON	UNIVERSITIES	FREQUENCY
Low Remuneration	Ahmadu,JKUAT,Dar es Salam,Ibadan,Lagos, Nairobi,Nsukka,Zimbabwe,Malawi	9
Poor Benefit Scheme	Addis Ababa,Malawi	2
More Gainful Employment Elsewhere	Michael Okpara,Dar es Salam,Nsukka,Malawi	4
Limited Prospects for Promotion	Nairobi	1
Recruitment Problem to Senior Level Staff	Botswana	1
Large Numbers of Students in Lower Level Degrees	Addis Ababa,Botswana	2
High Work Load	Nairobi	1
Slow and Bureaucratic Administration	Addis Ababa,Nairobi	2
Unbalanced Staff Distribution	Nairobi	1
No Training of new Staff Locally/Abroad	Addis Ababa,JKUAT,Dar es Salam	3
Weak Research and Postgraduate Training Program	JKUAT	1
Lack of Lecturing interest in Young Professionals	Kwame Nkrumah	1
Poor General Economic Situation	Addis Ababa	1
Staff sent for Further Studies Do Not Return	Nairobi,Malawi	2
Large Number of Employed Staff on Study Leave	Botswana	1
Lack of Qualified Personnel to Train Locally/Abroad	Addis Ababa,Michael Okpara,Dar es Salam	3

Table 2 : Frequency of reasons advanced for low staff levels

The short-term solution which some universities are already considering is dual degree programme (or Network degree programme). This programme enables staff of two neighbouring institutions to pool together their staff so as to complement each other. The institutions will offer separate degrees but the teaching in both programmes will be done by the single pool of lecturers. I understand this is already happening formally and informally in some Nigerian institutions. Last year the university of Zimbabwe and the university of Zambia made enquiries to ANSTI to support a similar programme in

Electrical Engineering, by which the staff at the two institutions, through a series of exchange visits from both sides, will mutually strengthen the two degree programmes.

	UON	Addis	UZ	JKUAT	Bots	Malawi	ABU
Subject							
Civil	28.00	18.75		27.27	56.25		36.36
Mechanical	52.17	20.00		30.43			20.00
Electrical	46.67					77.78	41.67
Electronic		60.00	50.00			5.88	
Chem/Biochem		38.10				12.50	30.77
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

Table 3: Percentage of staff with PhD at post (confirm this result)

2.2 Laboratory

With regard to the quality of the laboratory facilities two issues stand out: The level and quality of the stock of equipment and the availability of competent staff to facilitate the correct use and maintenance of the facilities. In the study by ANSTI/UNESCO several Departments in the faculties of engineering were invited to estimate the percentage of equipment in working order, the age of the equipment and the fraction of the laboratory experiments which are skipped for lack of equipment. The result of the survey showed that in some departments only about 20% are in working order. In strong departments such as Civil, Mining, Engineering, which attract funds from industry, about 80% of the equipment are in working order. This is not the case for say Metallurgy and Electrical/Electronic Engineering. The latter is due to the fact that electrical components change rapidly and replacement parts are difficult to get.

The biggest problem facing the laboratories is the very old age of the equipment. Most universities have laboratory where the average age of the equipment is more than 12 years (see Table 4). There are even those where most of the equipment date back to the establishment of the faculty/department. Laboratory technology has changed considerably in the last ten years with computer-controlled measuring instruments replacing manual measuring systems. Thus the average age of the laboratory equipment in African institutions may be too high. And this may even affect the ability to do certain experiments. The survey found out that the percentage of experiments skipped for lack of equipment range from 10-60% and most respondents classified the state of the laboratory equipment as just average or poor.

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
University 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
Ecole des Mines	-	-
<i>Average</i>	<i>15.8</i>	

Table 4 Average age of equipment

In the case where laboratory equipment are old there is need to have highly trained technical staff. Unfortunately a large fraction of the technical staff are fairly old and not very familiar with the emerging laboratory technologies. This is a trend that needs to be reversed.

2.3 ICT Facilities and Instructional Methods

The information and communication technology (ICT) is the technology that has brought excitement to teaching, learning and research. It has become a major educational technology. In its simplest form it can be used mainly to prepare and reproduce hand outs or make presentations of learning materials as slides in lecture rooms. At a higher level, ICT could be used in such instructional modes as e-learning. For African institutions the development in the use of ICT provide an opportunity to overcome the problem of non-availability of staff, books and even the lack of equipment in the laboratories. However, in order to make use of this opportunity, the institutions have to

be ready with the basic infrastructure. In connection with this, ANSTI/UNESCO surveyed the access of staff and students to computers. In particular, the survey enquired two into factors: staff/computer and student/computer ratios.

University	Engineering Sciences (%)	Average state of equipment
Addis Ababa University	14.8	Average
Michael Okpara University of Agriculture, Umudike	5.3	Poor
University of Zimbabwe	35.7	Average
University of Malawi	23.8	Average
University of Lagos	58.3	Poor
Kwame Nkrumah University of Science and Technology	16.4	Average
University of Nigeria, Nsukka	30	Avg – basic & poor for Eng.
JKUAT	10	Poor – Basic & Good - Eng
University of Nairobi	16.3	Average
University of Botswana	7.5	Good – Eng. & Avg- Eng.
University of Ibadan	29.3	Poor
University of Cape Coast	-	Good
Universite De Lome – Togo	80	Poor
<i>Average</i>	27.3	

Table 5 Percentage of Experiments not done

A total of 25 engineering departments were considered. The number of staff with computers in their offices in these departments is quite low with only 8 departments reporting at least 50% of staff with access to computers. Traditional engineering departments (such as mechanical, civil and electrical engineering) have an average of 42% of staff with computers in their offices. The ideal staff-computer ratio should be 1:1 which will enable staff to use ICT as a tool for delivery of engineering education. Sadly very few universities outside South Africa and Botswana have this ratio.

There are several computer laboratories now available in most universities in the region. However, the students' access to computers is still very limited. The ideal student computer ratio should be 5:1. The average in African engineering institutions is almost 26:1 which is too high and does not enable students to have frequent access to computers.

The use of other learning materials and instructional methods vary from university to another. The use of standard textbooks is not widespread because of their

high cost. However, several universities are producing and circulating bound lecture notes to students. Photocopying services are widely used to provide hand-outs. Students also use it to copy books that are not readily available. Use of projector (overhead) has become very common.

Percentage of Staff With Computers (Engineering Sciences)				
Subject	Number of Universities Analysed	Minimum Percentage Staff With Computers	Average Percentage Staff With Computers	Maximum Percentage Staff With Computers
Agricultural	8	2.00	50.45	100.00
Architecture	1	50.00	50.00	50.00
Building	1	50.00	50.00	50.00
Chem/Biochem	2	38.46	47.49	56.52
Civil	10	4.17	37.39	100.00
Design Tech	1	100.00	100.00	100.00
Electrical	9	9.09	50.41	100.00
Electronic	1	28.57	28.57	28.57
Environ	1	14.29	14.29	14.29
Geoinfo	1	8.33	8.33	8.33
Industrial	1	30.00	30.00	30.00
Mechanical	10	0.00	42.51	100.00
Metallurgical	2	20.00	32.22	44.44
Mining	1	100.00	100.00	100.00
Petroleum	1	80.00	80.00	80.00
Survey	1	0.00	0.00	0.00
Surveying	2	23.08	47.26	71.43
Wood	1	50.00	50.00	50.00

Table 6: Percentage of Staff with Computers in Engineering Sciences

2.4 Library

The availability of a well-stocked library is an important requirement of any engineering programme. Information on the state of the engineering collection at the various universities is not readily available. But the ANSTI/UNESCO survey examined the availability of current journals in the libraries. This itself is a reflection of the age of the stock in the library. Except for a few institutions the problem of scarcity of relevant and current journals continues to be of concern in most universities. The scarcity of current journals in engineering is more severe than that of the basic sciences. Some universities have one or two international journals. In effect, most universities no longer subscribe to international journals. The trend nowadays is that faculties publish their own journals. This is good in countries with several universities so that the journal can be

disseminated widely. However, in other countries where the population of scientists is small, the dissemination of scientific information through locally-produced journals will only mean that the scientist is sharing his knowledge and findings with himself.

2.5 *Other Observed Trends*

Other trends observed in most institutions include the increase in student population without a corresponding increase in the resource allocation. This large increase in student population has over stretched the teaching facilities and may already be affecting the quality of the degree programmes.

Another observable trend is the effort on the part of engineering institutions to be relevant to the solution of the national problem. This is evident both in research and teaching. In the case of the latter, the survey of the several faculties of engineering revealed that all of them regularly revise their curricula. The average age of syllabi is 6 years. The frequent revision assures relevance of the programmes to the developmental requirements of the country. Furthermore, there is evidence that several universities offer courses targeting niche areas.

3. ADVANCES IN THE DELIVERY OF ENGINEERING EDUCATION

Several things are happening in the field of engineering education in Africa. The problems highlighted above have forced university leaders to be innovative in the financing, management and delivery of engineering education. In the area of financing and management for instance, Deans of faculties/schools of engineering have, in response to the dwindling financial support from government, developed different sources of income. These include activities related to university-industry partnership, commercialization of inventions, imposition of user fees for certain facilities and cost-effective tuition fees. Some universities have even established companies to promote innovation and technologies developed in faculties of engineering as a means of generating income.

Some of the dramatic developments in the delivery and management of engineering education have however come from the use of ICT. This technology is now being used in some universities for management of student records and for teaching/learning. Several universities have invested a substantial amount of their limited financial resources into ICT infrastructure. And there is wisdom in using this infrastructure not only for e-mail communication and internet browsing for general information but also as a technology for teaching and research. The advantages of this are of course enormous. The technology will enable poorly resourced institutions to overcome two of their major problems: Staff scarcity, lack of textbooks and journals. With ICT it will be possible to save on the amount of physical contact between staff and student and hence enable the former to reach more students. This will enable institutions to efficiently and effectively utilize the existing staff. The use of ICT in learning will also provide access for students to training resources on the internet. But more importantly over a period of time, staff members may convert their lecture notes to e-

content and make them available to students. This will enable the institutions to overcome the problems of lack of textbooks. Various universities are now at different stages in the use of ICT for delivery of engineering education. Some may not have commenced but have the potential to at least be at the low end of the use of this technology.

There are several stages/formats for the use of ICT in teaching. At the lowest end one can use the computers to prepare and print lecture notes which are circulated to students. This can be done in MS Word format or MS Power point hand outs. At the higher level, staff are able to create and mount their own electronic content in any of the following formats:

(a) *Content on Media*

This is content organized into logical units and made available in portable media such as CDROMs. The content may have limited interactivity built into it. Graphics, animations, audio and video forms of content can be included.

(b) *Content on Intranet*

Any content on CD can be made available within an intranet as a shared resource. The presentation of such content is largely similar to the one above but limited asynchronous interaction can be enabled by e-mail. The university of Dar es Salaam and Addis Ababa University for instance have many engineering courses in their intranet.

(c) *Content on Web*

This kind of content is similar to the one in (b) above but is accessed using web browsers and therefore can be available on the internet. There is a constraint on this for most African institutions whose connection to the internet is very slow.

(d) *Content on ELE*

An Electronic Learning Environment (ELE) is an elaborate instructional platform that enables the development and delivery of content to learners. It also supports content development that follows sound pedagogic principles. Such content can be used for individualized learning within or off campus. Special tools are used for creating such ELEs and the content itself, that is the client to the system, requires people with specialized training to effectively create it.

There are other emerging ICT technologies that African institutions should try to adopt in order to overcome the problem of lack of laboratory equipment. In addition to computer simulation, there is also the Interactive Screen Experiment (ISE). The latter is a photographic display of the laboratory experiment on a computer screen. The student will then conduct the experiment by manipulating the various controls as if it were real life. This technique is useful for physics and those engineering experiments which normally involve only instrumentation (e.g. solid mechanics, strength of materials).

CONCLUSION

This address has given a review of the state of the institutions. In conclusion, let me say that the highlighted problems arising from resource limitation coupled with advances in methods for the delivery of engineering education provide us with an opportunity. In particular the proposed use of ICT will enable institutions to overcome the problem of learning materials, staff and equipment. This conference on engineering education must therefore examine strategies that could be adopted so that institutions in the region can have access to this vital resource. The deliberations of this meeting should be able to identify the obstacles to the widespread use of ICT in learning/teaching. More importantly you should determine measures and actions that should be employed to overcome those obstacles.