QUALITY OF PHYSICAL FACILITIES AND HUMAN RESOURCES FOR ENGINEERING EDUCATION IN AFRICA

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ABSTRACT

This paper assesses the quality of the facilities and resources for the training of engineers in some countries in Africa. The facilities are classified into internal and external. The internal facilities and resources are those within the training institutions while the external ones are those in the industry for use by the engineering students during the industrial attachment and after graduation for professional development training *that is* usually organized by professional body in each country.

The internal facilities include classroom and laboratory spaces, teaching and research equipment, information communication technologies, library and periodicals while the external facilities includes office equipment and design software as well as projects to work on. In the training institutions and *industry,* highly skilled and experienced academics and practicing engineers are needed for proper transfer of skill to the prospective engineering graduates but to a large extent they are lacking. The basic infrastructure (energy and water) is in a poor state especially in the laboratories for the basic sciences as well as in the laboratories and workshops for engineering and technology; the situation is similar in the industry.Each country sets minimum standards (human and non-human resources) comparable to International Standards for engineering education but in general the minimum standards are hardly met quantitatively and qualitatively in most African Universities. The inadequacies in teaching, laboratory and workshop facilities as well as manpower for capacity building contribute to the diminution of the quality of engineering graduates in Africa. In order to improve the quality of facilities, the skills and abilities of the engineering personnel in the training institutions and industry, there is need for adequate funding. Partnership between universities and industry *needs to* be strengthened with the universities providing the platform for the creation of knowledge and the development of human resources while the industry provides platform for the commercialization of the research outputs.

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Keywords

Equipment, Space, Poor Infrastructure, Quality Assurance, Funding, Multimedia, Human Capacity.

1. INTRODUCTION

Engineering education is the process of training engineers for the purposes of initiating, facilitating and implementing the technological development in the society. Engineers are to solve societal problems in a sustainable way using appropriate engineering tools to proffer the required solutions. Prospective engineers and technologists are trained in the universities and polytechnics respectively. However, some products of polytechnics who have earned good grades in their examinations can become engineers either by entering universities after the Ordinary or Higher National Diploma at the appropriate level or undertake professional development training organized by the professional body in each country.

Usually in the Universities, the training is in two fold: (i) training in basic science courses often based in Faculty of Science and (ii) training in core engineering and elective courses are either Departmental or Faculty-based. The training of engineers has been undermined by many challenges including inadequate physical facilities and human resources. This has resulted in poor performance of the engineering graduates in the industry after graduation. The curricula of engineering disciplines have been widely criticized by the industry leaders, insinuating, misalignment or a disconnect between the industry needs and what the prospective engineers are being taught in the universities.

The route to become an engineer starts from the primary through secondary school to the university.

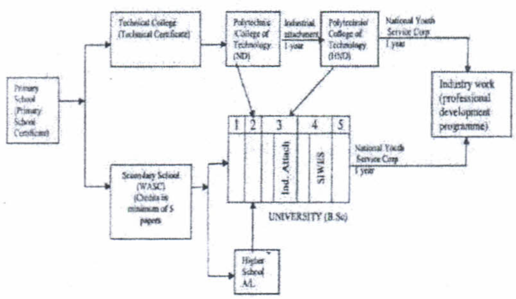

Fig 1: Knowledge Acquisition Processes for Prospective Engineers

At the primary school level, there is an acute shortage of personnel to lay solid foundation for the acquisition of knowledge in engineering. In some secondary schools, students are poorly exposed to laboratory facilities. Alternative to practicals' are done in lieu of real practicals in the relevant science courses.

At the tertiary level both the physical facilities and human resources are inadequate both in quality and quantity, culminating in poor preparation of prospective engineers to take up challenges in their different disciplines after graduation. 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 applications of engineering theoretical principles to practical problems. Unfortunately, the conditions under which the students study and available the physical and human resources are not complementary to achieve greater success. The physical and human resources can be categorized into Internal and External. The Internal ones are those within the training institutions while the external ones are those in the industry where the students are expected to undergo industrial training attachment as an extension of their learning process as well as after graduation for further training to acquire professional certification.

2.0 INTERNAL PHYSICAL FACILITIES

The internal physical facilities are considered under the following headings:

2.1 Space and Equipment

The facilities for the training of engineers include workshop facilities, classrooms, laboratories, staff offices and equipment.

2.1.1 Space

In 1985, the Federal government of Nigeria approved the submission of the National Universities Commission (NUC, 1989) for minimum academic standards for all disciplines (including engineering) in the Nigerian Universities. The minimum standards specify the requirements (human and non-human) for each programme. The document provides for minimum floor space for laboratory, library and other facilities per student. Table 1 provides NUC minimum Standards for space requirements for difference purposes.

Table I: Space Requirements

Professor's Office	18.50m^2
Head of Department's Office	18.50m^2
Tutorial Teaching Staff Space	13.50m^2
Other Teaching Staff Space	7.00m^2
Technical Staff Space	7.00m^2
Secretarial Space	7.00m^2
Science Staff Research Laboratory	16.50m^2
Engineering Staff Research Lab.	14.00m^2
Drawing Office Space (A.O. Board)	1.85m^2
(per Student)	4.60m^2
Drawing Office Space (A.I. Board)	
(Per Student	3.70m^2
Laboratory Space	7.50m^2

Source: NUC, 1989

Most of the time, at the take-off of institutions, some of the requirements are met but with growth in students' enrolment and increase in the number of staff (academic, technical and administrative), without commensurate increase in the facilities, the facilities become inadequate; with staff members sharing offices, as well as overcrowding in the classrooms and laboratories.

The curriculum of subject with practical contents is generally organized into average of 67% for the theoretical classes and 33% for laboratory. Besides the 33%, students use the laboratory to develop case example on their own. Laboratory works are designed to inculcate in the engineering students the ability to experiment and learn to confirm theories by experiment. They teach students that situations are never ideal and that results may be affected by a myriad of factors over which the experimentalist may or may not have control. A student who misses the opportunity to experiment is deprived of a most important component of his engineering education. The laboratories can not take all students in a class at a time because of inadequate space, this result in arranging the students into groups for laboratory experiments. In a large group, some students may be deprived of carrying out experiment on their own. Thus, the objective of the practical has been defeated by this singular act. Most universities lack-up-to-date items of equipment. This results in the research efforts of both the staff and students being directed at fact-finding, survey-type, non-innovative research rather than mission-oriented research.

Oryem-Origa (2005) indicated that only 45% of institutions of Higher Education in Uganda have laboratory or workshop spaces. The others, 55% including most private universities do not have laboratory or workshop space and that this reflects the low number of science and technology programmes in higher institutions.

2.1.2 Equipment

There is shortage of laboratory equipment and supplies. Some of the available equipment are obsolete. The poor stage of the laboratory equipment has made teaching and research in engineering and technology difficult.

Table 2, provides the average age of teaching equipment in some African universities (Massaquoi,2004).

Table 2: Average Age of Equipment

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

Source: Massaquio (2004)

The table indicates that as at 2004, the average age of equipment in faculties of engineering in some selected African universities is 15.8 years. The newest being 4 years and the oldest 30 years. Generally, the items of equipment are inadequate.

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 lectures. The poor state of the facilities 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.

2.1.3 Library and Periodicals

Accessibility to on-line electronic journals in various fields, electronic library and electronic bookshops that can enhance intellectual development and capacity building in research in engineering and technology is of utmost importance in development but seriously lacking in most African Universities. The development of virtual library is an important facility to expose engineering students to advances in relevant engineering disciplines.

2.1.4 ICT Facilities

The use of multimedia applications offer potential for reduction in time needed for formal instruction. They provide better lectures delivery environment. These enable trainees' access to technological innovation taking place around the world but they are not available in some universities while in some, they are partially in existence. Only in few cases e.g. South Africa and Botwana can we say that the facilities are available in a good proportion.

2.2 Human Resources

Many universities across the African region are inadequately staffed both qualitatively and quantitatively. For example, in Nigeria, the NUC minimum academic standards stipulate a staff - student ratio of 1:15 for engineering programs for effective teaching and learning but the ratio hovers between 1:24 and 1:35. In extreme cases it can be as high as 1:90. In most departments the proportion of staff without PhD is higher than those with Ph.D. The low level of experts has reduced capacity building in various engineering disciplines. Njunwa (2008) noted that the goal of human resource is to promote industrialization in a country in order to gain economic growth and development. He further noted that brain drain has contributed to inadequate capacity building efforts in Africa.

Table 3, shows the results of a survey conducted by Massaquoi (2004).

Table 3: 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.

The table above shows the results of a survey that was conducted by Massaquoi (2004) on the percentage of staff with Ph.D in different engineering disciplines in some universities in Africa. The survey indicates that the lowest percentage of 5.88 was recorded in the department of electronics in University of Malawi and a maximum of 85% in production engineering Department in Jomo Keyatta University, Kenya. It is difficult to get people trained to the level of PhD because academics is not attractive to young graduates whereas with first degree (B.Sc, B.eng.) graduates can function well in the industry and earn good money.

Members of academic staff are poorly remunerated. The aftermath of this is the exodus of teaching staff from the universities to greener pastures where they get adequate financial reward and self satisfaction.

In some African countries, for example, Nigeria adequate policies are formulated that focus on human capacity building but without political will to drive the policies. In South Africa, the role of the training institutions are made effective by the government through linkages between training institutions and industry and encouraging them to apply indigenous technology and develop their capability (Sobongile, 2005). The government of South Africa also funds R & D, insists on intellectual property protection, and where necessary procure advanced and new technologies and advanced in cluster formation. It was further noted that to increase the skills and abilities of people, partnership between universities and industry was strengthened with Universities providing the platform for the creation of knowledge and the development of human resources and with industry providing the platform for commercialization of the received outputs. Companies are endeavouring to foster industrial technologist by providing in-house training, such as through basic skills training programmes for new employees and by providing on-the-job training directly tied to product development and manufacture

3.0 EXTERNAL PHYSICAL FACILITIES AND HUMAN RESOURCE

In general, curricula for engineering disciplines are designed to include maximum stipulated duration of 40 weeks of industrial attachment comprising the following modules (i) students' work experience programme I-8 weeks (long vacation after 200 level), (ii) Students' industrial Work experience – 8 week (at the end of 300 level and (iii) Students Industrial work experience scheme II-24 weeks (2nd Semester of 400 level plus long vacation). The aims of the programmes are. (i) to provide the students with the needed on-the-job experience by applying the theories learnt in the classrooms to practical problems (ii) to motivate students and improve their academic performance by demonstrating the relevance of course consent in industrial practice (iii) to promote the personal development of student by increasing their maturity through interacting with colleagues and mentors in industry and acceptance of professional responsibilities. Falade (2002) showed that in 1997 in the Department of Civil Engineering out of 37 students only 26 could be placed on SIWES, in Mechanical Engineering 46 out of 59, chemical engineering 38 out of 43. The situation is worse today with its attendant problem of quality placement because of the declining situation the industrial sector.

In the sixties, seventies and early part of the eighties, the aim and objectives of the programme were achieved, the students' population per class ranged between 25 and 30 and the industries were growing in quality and size. Students were adequately placed with enough exposure to practical problems. Beginning from late eighties with increase in students' enrolment, devaluation of Nigerian currency and its resultant high cost of equipment and running costs, the industry started to downsize, some closed down to operations. In the process of downsizing, the experienced workers were laid off. While the enrolment increase; the placement of students became more difficult with the result that many of the students undertake their attachment in companies that have little or nothing to offer because there were no projects that would provide necessary challenges for the students.

The enabling environment is hardly in place, only in few cases there
exist both physical facilities and human resources to take the students through the application of the theories that they have learnt to practical problems. In some cases where physical facilities exist Human resources are not and vice versa.

4.0 EXPERIENTIAL LEARNING

Experiential learning technique is important in the universities and industries. Kolb (1984) linked the theoretical knowledge gained with experience through reflection and planning. He indicated that the interest of students in learning can be motivated when the teaching staff adopts a method of teaching which displays ability of a facilitator rather than an instructor. The personal experience of the author in his professional development indicate that in civil engineering education, for instance, as well as engineering education in general, experiential learning through the use of real-life engineering projects either in design or construction proves very useful in understanding engineering better.

5.0 POOR INFRASTRUCTURE

The number of science, engineering and technology training institutions in Africa is rather few. In most of the existing Universities and many of the research institutes, basic infrastructure (energy and water) is in a poor state especially in the laboratories for the basic sciences as well as within the laboratories and workshop for engineering and technology. Apart from the fact that the salaries of staff in teaching and research institutions are extremely low in Africa, as compared with other regions of the world, the working environment of these same researchers in terms of access to financial resources, instruments and other capital equipment and research facilities like computers, is very poor

6.0 QUALITY ASSURANCE

In order to ensure that the physical facilities and human resources for engineering education comply with the minimum academic standards, accreditation panels comprising senior academics and captains of industry are usually set up to accredit all programs in Nigerian Universities including engineering. Quality assurance for engineering programs is carried out at three different levels.

i) On semester basis, quality assurance of programs is carried out via (a) institutional culture of quality mechanism and self analysis using in-house experienced senior academic staff for continuous evaluation of the performance of their academic programs against predetermined academic standard as moderation benchmarks and (ii) External Examiner system in which senior academic staff is invited from another university to vet the question papers, the marking scheme and final year students projects. Atimes the external examiner is enjoined to sit in during the final year students' projects defense. The examiner sends his report directly to the Vice-Chancellor for the consideration of his suggestions and recommendations for implementation.

The National Universities Commission (NUC) on regular basis conducts accreditation exercise for all disciplines in the universities using experienced senior academic staff. Under the scheme, programmes that fail to meet the minimum standards will not be accredited while those that meet the requirements at different levels may receive partial or full accreditation.

Apart from the NUC accreditation exercises statutory professional bodies e.g. Council for the Regulation of Engineering in Nigeria (COREN) also ensure maintenance of standards in tertiary institutions through a system of visitation, accreditation and re-accreditation of programmes in various disciplines and inspection of human resources. The graduates of unaccredited programmes by COREN will not be registered to practise engineering.

7.0 KEY FACTOR IN PROVISION OF QUALITY FACILITIES AND HUMAN RESOURCES

The major challenge to the provision of quality facilities and appropriate human capacity building for engineering education is paucity of funds. UNESCO recommends 26% of annual budget for education but most countries in Africa do not near this figure in their annual allocations to education. Under-funding manifests in poorly equipped laboratories, inadequate library stock, poor salaries with attendant low staff morale and braindrain. Falade

(2007) formulated an interactive funding model and performance feedback for engineering education (Fig. 1)

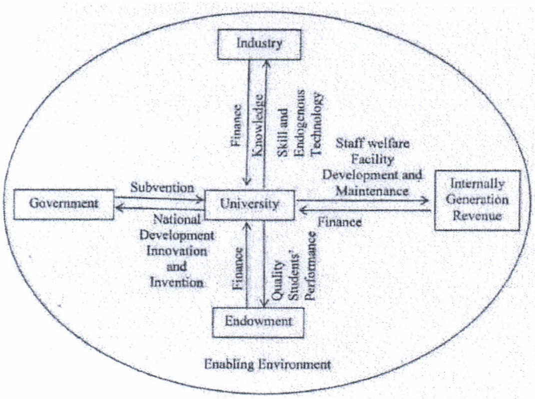

Fig 1. Interactive Funding Model and Performance Feedback (Falade, 2007)

Figure 1 shows the interactive funding model of the universities by the stakeholders and performance feedback that they expect from the universities. The Government would expect the output from the university to result in industrialization, growth in the economy and national development. Industry expects its production line to be driven by endogenous technology developed from the university. The university community expects the quality of students' output to be better with the award of scholarship from endowment fund while staff welfare for development and maintenance of facilities is to be top priority from the internally generated revenue.

CONCLUSIONS

(1) The facilities and human resources for engineering education are inadequate both within the university and industry.

(2) The inadequacy in the facilities and human resources, in part, contributes to inadequate preparation of graduates for the challenges in the industry.

(3) Poor funding is the major challenge to provision of quality facilities and appropriate human resources for engineering education.

(4) A tripalite funding system will enhance quality facilities and human resources needed for engineering education.

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