

# Chemical Engineering Education in Nigeria: Challenges and Prospects.

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**Abstract**—Education in its broadest sense is any act or experience that has a formative effect on the mind, character, or physical ability of an individual. Such an experience should be dynamic to meet the demands of the constantly changing world. Chemical engineering with its interdisciplinary nature plays a vital role in a nation's development. This paper however reveals education in chemical engineering as it is applicable and obtainable in Nigeria, visions and mission including the essence of curriculum reform and personnel development to meet today and future challenges of Nigerian chemical engineers. Also, the paper aims at contributing to the nation's development and improving the welfare of the society through preparing professional chemical engineers and conducting applied research. The author also believes that sound education in engineering (chemical engineering inclusive) serves as artery for vision 20/2020 actualization in Nigeria.

**Index Terms**—Education, Chemical engineering, Curriculum, vision 20/2020

## I. INTRODUCTION

Nigeria is a developing nation situated in the west coast of Africa. It has a population of over 140 million and covers an area of about 1.5 times the size of the state of Texas in U.S.A. It became an independent country in 1960. On the 4th of July 1957, the first Nigerian chemical engineer graduated from the Victoria University of Manchester, UK. Today, there is considerable number of registered Nigerian graduate chemical engineers. More than 4,000 of these live and work in Nigeria [1]. In recent time, the study of engineering generally has received less attention. Various reasons for the declining interest in studying an engineering profession have been discussed elsewhere: A number of studies suggest that socio-political factors such as the level of technology acceptance are not solely responsible. However, it is nowadays less common for parents or other persons to whom they relate, to advise young people to study a natural science or a technical subject [2]. Disciplines such as business administration, accountancy, law, psychology, and medicine appear to be more attractive than engineering studies, which are regarded as more difficult and less lucrative [3]. Of great influence seems to be the actual situation in the job market for engineers (chemical engineers inclusive), which includes early retirements, and cautious recruiting practices by the employers. Chemical engineering education in Nigeria dates back to the early days of the modern day Obafemi Awolowo University, Ile-

Ife, Nigeria. Though, university of Ibadan was in existence long before its creation but no engineering discipline was considered important enough to be included in the programmes of the premier university (university of Ibadan). Students who wanted to study engineering were sent abroad after obtaining the requisite pre-engineering qualifications locally. Later, chemical engineering departments were set up in few other tertiary institutions. Today, over a hundred universities are present in Nigeria of which considerable percent of them offer chemical engineering. For the 2005/2006 academic session, the Joint Admissions and Matriculation Board, JAMB, (The board saddled with admission into Nigerian tertiary institution) conducted university entrance examinations to 16 federal universities, 3 federal universities of agriculture, 5 federal universities of technology, 15 state universities, 4 state universities of technology, 6 private universities, and 17 other degrees awarding institutions. During the same period, the board conducted entrance examinations to 18 federal polytechnics and 27 state polytechnics. Some of these institutions offer chemical engineering programme. Recently, in 2010 the board re-nomenclatured the yearly conducted examination from university matriculation examination (UME) to unified tertiary matriculation examination (UTME) [4-5]. Enormous growth in chemical engineering education was seen in the year licences were given to privately owned institutions. The local Chemical Engineering is faced with an environment in which employment is temporal, unstable, and scarce. The orientation of the chemical engineering education received must change to accommodate the highlighted problems. Nigerians must be fully educated to ensure that everyone is informed and is capable of contributing his/her own quota to the development of their country. Development of a nation can be made on the principle that the people are fully informed, educated and prepared to work very hard, be firm and stable both in planning and execution. Planned economy must put into consideration profitable utilization of the material resources and manpower of the country [6]. This is in fact where sound chemical engineering education plays a pivot role.

### A. Admission Requirements for Admission Into Chemical Engineering Degree Programme

Two criteria must be met by candidates who wish to be admitted to a university degree programme in any discipline in Nigeria, chemical engineering inclusive. One is obtaining passes at credit levels in a minimum of five subjects at one sitting or six at two sittings in the Senior Secondary School or the General Certificate examinations. For chemical engineering, these subjects include English language, mathematics, physics, chemistry and biology and another subject, preferably further mathematics. The second

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criterion is sitting and passing the unified tertiary matriculation examination and obtaining a grade higher than or equal to the cut-off mark for the programme during the year the examination is taken. This however does not include other respective university requirements.

Courses taken by students in tertiary institutions in Nigeria are grouped into three. These are the compulsories or core courses, the required and electives. Compulsory courses are those courses that are considered very important to the discipline which students must not only have knowledge of, but should have a minimum pass in them before they can be considered as well cultured products in their respective fields. Required courses are considered relevant and knowledge of such courses is considered adequate. Student must register for them and have the knowledge and also obtain a pass mark in the examination before they are graduated. There are a number of courses which would not put the students at a disadvantage if they do not register for them but because they could benefit from having the knowledge, they are recommended. Students may ignore the recommendations and would suffer no penalty. These are the electives.

### B. Graduation Requirements

Graduation requirements have undergone changes all over the years. At present, a number of Nigerian universities operate the cumulative grade point average system (CGPA) on a scale of 5 or 7. However, schools with chemical engineering programmes use the former. Under this system, all courses taken by a student are used in calculating his class of degree. That is of-course after meeting the other faculty and departmental criteria. Where a course is repeated, it is counted twice when computing the candidate's results. Although courses are still listed under the three headings of compulsory, required and electives, in practice, all the courses the student registered for become automatically compulsory to be passed before graduation. The classes of degree are as stated below:

TABLE 1: CLASSIFICATION OF DEGREE

<i>Class of Degree</i>	<b>Grade range</b>
First class	4.50-5.00
Second class upper	3.50-4.49
Second class lower	2.40-3.49
Third class	1.50-2.39
<b>Pass</b>	1.00-1.49

A minimum of second class lower division apart from other departmental fulfillments is a requirement for postgraduate studies in chemical engineering (M.Sc degree). For a third class division, a postgraduate diploma (PGD) in chemical engineering is a requirement for postgraduate studies (M.Sc). A grade point of 4.00 and above is registrable for a Ph.d degree while that from 3.50 - 3.99 is registrable for M.phil degree and subsequently Ph.d degree.

The chemical engineering curriculum is anchored on three points which are to ensure adequate theoretical instructions, adequate practical exposure and

entrepreneurability. The curriculum can be broadly divided into three parts. In the first two years, students are exposed to the basic engineering courses such as design of engineering drawing, fluid mechanics, strength of materials, principles of electricity, statistics, economics, advanced mathematics, material science, , workshop practice, management and certain aspect of law.

### C. Chemical Engineering Curriculum In Nigerian Tertiary Institutions And Needs For Curriculum Reforms

The Nigeria universities commission (NUC) accredits programmes of Nigerian universities in collaboration with council of regulation of engineering in Nigeria (COREN) when it comes to engineering disciplines. The Chemical Engineering Schools in Nigerian tertiary institutions operate on the same curriculum. The need for a curriculum reform is necessary on the recognition of changes taking place in the local and worldwide social environments and societies, scientific and technological wise. The traditional curriculum was successful for many years and was oriented towards a world of different conditions: mass, stable and well-paid employment; protected and buoyant economy. There is a need for curriculum reform to prepare a Chemical Engineer of all times[7]. One that is able to cope with both traditional and new frontiers of Chemical Engineering, because the young Chemical Engineers probably will find a closed traditional environment and an open challenge to build a new career as discipline and profession. Such a curriculum reform has to include at least subject contents, pedagogy, assessment, academic environment and rules. The core curriculum is responsible for the confidence with which chemical engineers integrate knowledge from many disciplines for the solution of complex problems. The chemical engineering curriculum is anchored on three points which are to ensure adequate theoretical instruction, adequate practical exposure and entrepreneurability.

The curriculum provides a background in some of the basic sciences including

- Mathematics (calculus, differential equations, linear algebra)
- Physics (atomic and molecular physics, electricity, magnetism, mechanics) Chemistry (inorganic and physical).

This background is essential for a rigorous study of topics central to chemical engineering.

- Multicomponent thermodynamics and kinetics
- Transport phenomenon
- Separation processes
- Process design and control
- Plant design and systems engineering for process safety
- Environmental protection and economic operation

The curriculum also refereed to as the minimum academic standard is designed by the National University Commission in collaboration with the Council for the Regulation of Engineering in Nigeria, both of which depend on the expertise of the academic staff of the various chemical engineering programmes for university programme, while in the polytechnics and other colleges, the responsibility is that of the National Board for Technical Education (NABTE). The objective of setting minimum

academic standards is to ensure that no matter which institution a student graduates from, he or she has the minimal capacity to provide the required chemical engineering services. The benefit of this becomes more appreciated when it is realized that an individual has the option of undertaking an undergraduate programme in one university and the postgraduate in another. It is only a minimum standard at the undergraduate level that can guarantee that such a student will be able to pursue a higher degree in another institution.

The chemical engineering curriculum is constantly being reviewed to accommodate new developments and to expand the entrepreneurial potentials of chemical engineering graduates.

The core of traditional Chemical Engineering has to be preserved as the basis for new developments as well as for traditional engineering; however it has to be expanded to new subjects, at least new in our environment, as are bio, nano, medical and computational engineering. More over, the formation for enterprise and for research and development based on new knowledge should be stressed. This new core of Chemical Engineering has to be supported on strong and modern formation in mathematics, chemistry, physics and biology.

The new directions of the curriculum should embrace new scope: from nano to macro scale; steady and unsteady states; traditional and new frontiers of Chemical Engineering science and technology, business vision and a universal perspective.

Periodically, NUC/NBTE and COREN send visitation panels to institutions offering chemical engineering programmes, the aim of which is to ensure that the minimum standards in terms of curriculum, number and calibre of teaching and technical staff and facilities including laboratories and classrooms, quality of examination questions, office accommodation for staff, library and information resources and other requirements specified by the Council for the training of potential engineers are met. Further, Supervised Industrial training Scheme For Intending Engineers (SITSIE) was put in place by COREN in the early 2000 to monitor and improve the industrial knowledge acquired by young engineering graduates.

#### *D. Challenges of Chemical Engineering Education In Nigeria.*

Here are few out of the numerous challenges facing chemical engineers and chemical engineering education in Nigeria.

- Actualization of vision 20/2020 in Nigeria.

Nigeria is a vast country with adequate manpower and resources. Nature has been very kind to us in that abundant resources buried and unburied can be found from the coastal zone to the arid zone of the country. However, we have not come to the realities with our potentials and have allowed neglect, lack of cohesion, planning to relegate the country to the state of being classified as a third world country. The case of developed countries is well understood, there are no other classification as first or second, somehow Nigeria is labeled third world country. Years by, America used to be called new world, on the same planet with Nigeria. The

country has witnessed many developmental plans but lack of understanding, patriotism, and dedication seem to have put these plans in pieces.

One of the major dreams of president Umaru Musa Yar'adua is to see Nigeria become one of the 20 largest economies by the year 2020. The vision in summary says that by 2020, Nigeria will be one of the 20 largest economies in the world, able to consolidate her leadership role in Africa and establish herself as significant player in the global economic and political arena. The Nigerian government hopes to achieve the vision 20/2020 through the seven point agenda of

- Critical Infrastructure
- Niger Delta Problem
- Food Security
- Human Capital Development
- Land Tenure and Home Ownership
- National Security
- Intelligence and Wealth Creation.

2020 is 11 years from now and according to Masayoshi Matsu-Shita, UNIDO country representative in Nigeria, in a paper titled "Non-oil sector as the key economy driver" said Nigeria needs an annual growth rate of 13% per annum in the next 11 years to meet the vision 20/2020 [8]. He said the current realities in Nigeria compared to developed countries and developing countries do not leave much to be desired. Non oil sector especially the manufacturing sub sector which is the basis for achieving development is almost dead in Nigeria. Once the manufacturing sub sector is not functioning, the multiplier effect it has on other sectors of the economy that can help awaken and generate all round development will be lacking. There is need for sound chemical engineering education to effect the actualization of the vision 20/2020..

#### *E. Funding*

In Nigeria, universities 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.

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. 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.

#### F. Facilities

In most Nigerian Universities, 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. [9] 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

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 chemical engineering graduates in Nigeria.[10] 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 [11].

#### G. 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 Nigeria as a region to other professional (including politics) calling. [13] 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 the present economic melt down 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. [13] reported that:

(i) About 40% of all African Professionals including Nigeria 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.

#### H. 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[14]. 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 Nigeria is meager, they migrate to other countries especially the United States of America, or local industry for better pay. Academics from within migrate to South Africa because of high wages that they pay to the academics and relatively better equipped laboratories. No wonder, Nigeria just recovered from a 4-month academic staff of Nigerian university strike action.

#### I. 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.

For progress to be made in chemical engineering

education in Nigeria, the challenges confronting engineering must be recognized and be allocated adequate resources to achieve positive outcomes.

## II. CONCLUSION

Chemical engineering is a discipline that continues to withstand the tests of time. Its neglect is a potential threat to the future industrialization of any country. Most of the countries who in recent times cried out for international aids are where the industrial system has failed. The profession has great potentials to actualize the vision 20/2020 of the federal republic of Nigeria. Stake-holders should recognize these and exploit them to the fullest.

It is obvious that there is his lack of professional commitment among members of the engineering profession. This is due to the fact that the leadership of professional bodies has not taken the welfare of the members seriously. For some years now, the proposed engineers' salary scale is still unactualised. If the various engineering societies must enjoy the fellowship of their members, there is urgent need to address the issue of members' welfare and conditions of service which must be enforced.

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