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The State Of Engineering Sciences In Nigeria

ABSTRACT

Engineering Sciences include engineering fundamentals that have roots in mathematical and natural sciences with knowledge extended to develop models and methods to solve practical problems. The types of knowledge used by engineers in their work are wide ranging and knowledge of engineering sciences is just one of the knowledge types. An engineer uses his knowledge of engineering sciences to develop a model to analyse each candidate solution proffered for a problem. Most of the courses taken by undergraduate engineering students are engineering science courses. The postgraduate courses and research are even more preponderantly in engineering sciences than undergraduate courses. The laboratory, computational facilities, manpower and funding are inadequate for teaching and research in engineering sciences in Nigerian Universities at undergraduate and postgraduate levels. To accelerate the production of enough manpower to teach engineering sciences in Nigerian Universities, it is strongly recommended that funding be provided by Nigerian government for Ph.D. students in Nigerian Universities and post-doctoral fellows who did their Ph.D. work in Nigeria to go for 3 to 6 months research visits to Universities in developed countries.

Keywords: Engineering sciences, knowledge, courses, Nigerian universities.

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1. INTRODUCTION

Engineering provide the link between scientific research and commercial applications by applying the principles of mathematics and science to develop economical solutions to technical problems (Hamilton, 2015). Thus engineering practice involves use of systematic processes to define and resolve problems making use of specialized knowledge. Therefore engineers receive professional education through which they acquire a body of specialized knowledge, problem-solving skills and good judgment to serve the society. The specialized knowledge that an engineer needs to practice needs to be updated regularly through continuing professional education.

Sheppard et al (2006) made the following observations about engineering knowledge:

- Engineering knowledge grows out of the engineers being occupied with practical problems;
- Engineering knowledge is dynamic and engineers need to stay informed of new and emerging technologies through continuing professional education to carry out their work successfully;
- The types of knowledge used by engineers in their work are wide ranging and science-based knowledge is just one of the knowledge types.

The science-based knowledge are generally called “engineering sciences.” Engineering sciences provide mathematically based and conceptual theoretical tools for the engineer and they consist of “specific combination of mathematics and science around particular engineering domains” (Sheppard et al, 2006)

The International Engineering Alliance (2009) defines engineering sciences as “engineering fundamentals that have roots in the mathematical and physical sciences, and where applicable, in other natural sciences, but extend knowledge and develop models and methods in order to lead to applications and solve problems, providing the knowledge base for engineering specializations”

Thus engineering sciences vary by engineering discipline. Based on his knowledge of engineering sciences, an engineering analyst uses models to analyse candidate solutions proffered for an engineering problem to predict performance so that the best candidate solution can be selected. An engineer also uses

his knowledge of engineering sciences to carry out detailed design calculations of components of an engineering system.

It was reported by Hoppmann et al (1980) that Polanyi distinguished engineering from physical sciences by observing that physical and chemical investigations cannot help somebody to understand the operational principle of a machine, structure or an engineering system. Relevant engineering sciences will help one understand a machine as expressed by its operational principle. Sheppard et al (2006) also reported that Vincenti said that a distinguishing characteristic of engineering is the inseparability of knowledge from practical application. This means that knowledge from mathematical and natural sciences may not necessarily lead to practical application, whereas knowledge from engineering sciences will always lead to practical applications.

The aim of this paper is to present the current state of engineering sciences in Nigeria and to highlight the problems with teaching and research in engineering sciences and make recommendations on improving on the current state of engineering sciences in Nigeria.

2. ENGINEERING SCIENCES IN UNDERGRADUATE CURRICULUM

There are currently forty-six Universities in Nigeria given approval by Council for the Regulation of Engineering in Nigeria (COREN) to run engineering programmes. See Table I.

One of the qualifications for admission into an engineering degree programme is a good score in Unified Tertiary Matriculation Examination (UTME) in which a student is expected to write examination in Use of English, Mathematics, Physics and Chemistry. The other entry requirement is having at least 5 credits at O' level at not more than 2 sittings in Mathematics, Physics, Chemistry, English Language and any other subject. Only University of Lagos requires that a student has a credit in Further Mathematics among the 5 credits at one sitting for admission into all engineering programmes. Twenty-one other Universities require O' level credit in Further Mathematics for only Computer Engineering (JAMB, 2015). See Table II

Many students now enter Faculties of Engineering in Nigerian Universities without taking Further Mathematics at O' level because the subject was not taught in the secondary schools they attended or they did not know the importance of the subject due to poor counselling. Unless good effort is made to make up for this deficiency in their background, the students' weak mathematical background makes it difficult for some of them to cope with engineering science courses in engineering programmes.

The five general areas of study for any engineering discipline at undergraduate level are (Shanahan, 1982):

- i. The broad area of communications, social studies and humanities;
- ii. Mathematics and basic sciences;
- iii. The engineering sciences;
- iv. Design-systems synthesis and engineering specialization; and
- v. Development of the capacity to solve complex technological problems through creative design and research.

TABLE 1 LIST OF NIGERIAN UNIVERSITIES RUNNING ENGINEERING PROGRAMMES WITH YEARS OF ESTABLISHMENT AND OWNERSHIP

S/No	UNIVERSITIES	YEAR ESTABLISHED	OWNERSHIP
1	Abubakar Tafawa Balewa University, Bauchi	1988	Federal
2	Afe Babalola University, Ado Ekiti	2009	Private
3	Ahmadu Bello University, Zaria	1962	Federal
4	Akwa Ibom State University, Nkpot Enin	2004	State
5	Ambrose Alli University, Ekpoma	1980	State
6	Anambra State University, Uli	2000	State
7	Bayero University, Kano	1975	Federal
8	Bells University of Technology, Ota	2005	Private
9	Caritas University, Amorji-Nike	2005	Private
10	Covenant University, Ota	2002	Private
11	Cross River State University of Technology, Calabar	2004	State
12	Ekiti State University, Ado-Ekiti	1988	State
13	Enugu State University of Science & Technology, Enugu	1981	State
14	Imo State University, Owerri	1992	State
15	Federal University of Agriculture, Abeokuta	1988	Federal
16	Federal University of Petroleum Resources, Effurun	2007	Federal
17	Federal University of Technology, Akure	1981	Federal
18	Federal University of Technology, Minna	1982	Federal
19	Federal University of Technology, Owerri	1980	Federal
20	Federal University, Oye-Ekiti	2011	Federal
21	Igbinedion University, Okada	1999	Private
22	Kano State University of Science & Technology, Wudil	2000	State
23	Kwara State University, Malete	2001	State
24	Ladoke Akintola University of Technology, Ogbomoso	1990	State
25	Lagos State University, Ojo	1983	State
26	Landmark University, Omu-Aran	2011	Private
27	Madonna University, Okija	1999	Private
28	Michael Okpara University of Agriculture, Umudike	1992	Federal
29	Modibo Adama University of Technology, Yola	1988	Federal
30	Niger Delta University, Wilberforce Island	2000	State
31	Nigerian Defence Academy, Kaduna	1985	Federal
32	Nigerian Turkish Nile University, Abuja	2009	Private
33	Nnamdi Azikiwe University, Awka	1992	Federal
34	Obafemi Awolowo University, Ile-Ife	1962	Federal
35	Olabisi Onabanjo University, Ago-Iwoye	1982	State
36	Osun State University, Osogbo	2006	State
37	Rivers State University of Science & Technology, Port Harcourt	1979	State
38	University of Agriculture, Makurdi	1988	Federal
39	University of Benin, Benin City	1970	Federal
40	University of Ibadan, Ibadan	1948	Federal
41	University of Ilorin, Ilorin	1975	Federal
42	University of Lagos, Lagos	1962	Federal

43	University of Maiduguri, Maiduguri	1975	Federal
44	University of Nigeria, Nsukka	1960	Federal
45	University of Port Harcourt, Port Harcourt	1975	Federal
46	University of Uyo, Uyo	1991	Federal

TABLE II ADMISSION REQUIREMENT INTO ENGINEERING PROGRAMMES IN NIGERIAN UNIVERSITIES WITH RESPECT TO FURTHER MATHEMATICS (JAMB, 2015)

S/No	UNIVERSITIES	Admission Requirement with Respect to Further Mathematics
1	Abubakar Tafawa Balewa University, Bauchi	Requires O' level credit in Further Mathematics for Computer and Communication Engineering
2	Afe Babalola University, Ado Ekiti	Requires O' level credit in Further Mathematics for Computer Engineering
3	Bayero University, Kano	Requires O' level credit in Further Mathematics for Computer Engineering
4	Bells University of Technology, Ota	Requires O' level credit in Further Mathematics for Computer Engineering
5	Caritas University, Amorji-Nike	Requires O' level credit in Further Mathematics for Computer Engineering
6	Covenant University, Ota	Requires O' level credit in Further Mathematics for Computer Engineering. Requires credit in either Further Mathematics, Biology and Technical Drawing for Electrical/Electronics Engineering
7	Ekiti State University, Ado-Ekiti	Requires O' level credit in Further Mathematics for Computer Engineering
8	Elizade University, Ilara Mokin	Requires O' level credit in Further Mathematics for Computer Engineering
9	Federal University of Technology, Minna	Requires O' level credit in Further Mathematics for Computer Engineering
10	Federal University, Oye-Ekiti	Requires O' level credit in Further Mathematics for Computer Engineering
11	Igbinedion University, Okada	Requires O' level credit in Further Mathematics for Computer Engineering
12	Kwara State University, Malete	Requires O' level credit in Further Mathematics for Computer Engineering
13	Ladoke Akintola University of Technology, Ogbomoso	Requires O' level credit in Further Mathematics for Computer Engineering
14	Madonna University, Okija	Requires O' level credit in Further Mathematics for Computer Engineering
15	Nigerian Turkish Nile University, Abuja	Requires O' level credit in Further Mathematics for Computer Engineering
16	Obafemi Awolowo University, Ile-Ife	Requires O' level credit in Further Mathematics for Computer Engineering
17	Olabisi Onabanjo University, Ago-Iwoye	Requires O' level credit in Further Mathematics for Computer Engineering
18	Rivers State University of Science & Technology, Port Harcourt	Requires O' level credit in Further Mathematics for Computer Engineering
19	University of Benin, Benin City	Requires O' level credit in Further Mathematics for Computer Engineering
20	University of Lagos, Lagos	Requires O' level credit in Further Mathematics for All Engineering Programmes
21	University of Maiduguri, Maiduguri	Requires O' level credit in Further Mathematics for Computer Engineering
22	University of Uyo, Uyo	Requires O' level credit in Further Mathematics for Computer Engineering

In the first year of a five-year Bachelor degree programme in an engineering discipline, a student takes courses in Mathematics and natural sciences. From the second year most of the courses taken are in the engineering sciences.

Examples of engineering science subjects are:

- Strength of Materials
- Fluid Mechanics (Fluid Statics, Gas Dynamics, Experimental, Computational and Theoretical Fluid Dynamics)
- Thermodynamics
- Digital Signal Processing
- Instrumentation
- Circuit Theory
- Engineering Mechanics
- Theory of Machines
- Manufacturing Science
- Ergonomics
- Elasticity and Plasticity
- Solid Mechanics
- Structural Mechanics
- Heat Transfer

Some subjects in engineering sciences have branches e.g. Fluid Mechanics in the list above.

Out of the 56 credit units prescribed as general engineering courses to be taken from 200 to 500 levels in the COREN Benchmark Minimum Academic Standards (BMAS) (COREN, 2014), 21 credits (37.5%) are for courses in engineering sciences while 12 credits (23%) are for Mathematics and Statistics courses.

The percentage of engineering science courses listed in COREN BMAS (COREN, 2014) for engineering disciplines, apart from general engineering courses, are shown in Table III. The percentage varies from 43.8% for Mining engineering to 88.8% for Communication engineering showing that most of the hours spent by the students receiving lectures and carrying out practical work are spent on engineering sciences relevant to that discipline. Note that only Mining Engineering has a percentage below 50%.

TABLE III PERCENTAGE OF CREDIT UNITS FOR ENGINEERING SCIENCE COURSES, APART FROM GENERAL ENGINEERING COURSES, IN ENGINEERING DISCIPLINES LISTED IN COREN BMAS.

Discipline	Percentage of credit units for engineering science courses
Aerospace Engineering	86.6
Agricultural Engineering	73.6
Automotive Engineering	77.7
Biomedical Engineering	59.1
Ceramic Engineering	71.0
Chemical Engineering	84.5
Civil Engineering	55.2
Communication Engineering	88.8
Computer Engineering	76.1
Electrical & Electronics Engineering	72.7
Environmental Engineering	64.8
Food Engineering	58.5
Gas Engineering	70.1
Industrial & Production Engineering	63.5
Industrial Engineering	65.4
Marine Engineering	60.0
Mechanical Engineering	74.0
Mechatronics Engineering	70.9
Metallurgical & Material Engineering	80.0
Mining Engineering	43.8
Petrochemical Engineering	73.9
Petroleum Engineering	85.7
Production Engineering	69.4
Public Health Engineering	65.5
Refrigeration & Air Conditioning Engineering	67.9
Structural Engineering	51.0
System Engineering	68.6
Textile & Polymer Engineering	72.8
Water Resources Engineering	68.3
Wood Products Engineering	78.4

The recent trend towards training students in narrower engineering disciplines than the broad based disciplines such as Civil, Electrical/Electronics and Mechanical Engineering can be noticed in Table III.

3. ENGINEERING SCIENCES AT POSTGRADUATE LEVEL

Many universities in Nigeria now run postgraduate programmes in Engineering. The course work and research are largely in engineering sciences.

Some postgraduate students go to research institutes to make use of some state –of-the-art equipment not available in their universities, for their research. An example of such Research Institute is Engineering Materials Development Institute (EMDI) at Akure which is one of the Institutes of National Agency for Science and Engineering Infrastructure (NASENI).

Some universities, through TETFUND project, are now acquiring some of these state-of-the-art equipment but academic and technical staff need to be trained to use these equipment.

A few private laboratories are available in Nigeria to render laboratory services to postgraduate students and other researchers, e.g. Springboard Laboratory Research, Awka, Anambra State .

Some postgraduate students in Nigerian Universities are able to go to universities in developed countries for a few months to do some of their research work especially laboratory work. Many universities especially those who have signed Memorandum of Understanding (MoU) with Nigerian Universities have their doors open for such collaboration if funding is available for the researcher from Nigerian Universities to come.

COREN is compiling a list of state-of-the-art equipment available in Nigeria and where they are located to help researchers in engineering science know where they can go to make use of the equipment they need.

Bist (1956) observed that one of the mathematical difficulties that are encountered in engineering sciences is nonlinearity. The nonlinear differential equations used to model complex engineering systems have usually been solved by numerical methods on computers. Several commercial numerical codes are now available. It appears there is a paradigm shift from the postgraduate student writing his own computer programme to making use of commercially available software packages in his research. It should be noted that using commercial codes requires some skills too and that it frees the student from focusing on writing computer programme so that he can concentrate more on the engineering problem. However, the absence of a supercomputer or high performance computing facility in Nigeria still needs to be addressed for computational work in engineering sciences like is done in world-class universities to be possible in Nigerian Universities.

4. PUBLICATIONS AND RECOGNITION OF WORKERS IN ENGINEERING SCIENCES IN NIGERIA

Many researchers working in various areas of engineering sciences have had their work published in international and national reputable journals. Nigerian Society of Engineers (NSE) Technical Transactions is one of the reputable national journals for engineering sciences. Most faculties of engineering and technology also publish engineering sciences papers in their journals. See Table IV for the list of Journals published in Faculties of Engineering in some Nigerian Universities.

TABLE IV LIST OF UNIVERSITIES AND JOURNALS PUBLISHED BY THEIR FACULTIES OF ENGINEERING

Institution	Faculty Journal
Abubakar Tafawa Balewa University, Bauchi	Nigerian Journal of Tropical Engineering (NJTE)
Ahmadu Bello University, Zaria	Nigerian Journal of Engineering
Ambrose Alli University, Ekpoma	Journal of Engineering Science and Applications (JESA)
Bayero University, Kano	Journal of Engineering and Technology
Ekiti State University, Ado Ekiti	Nigerian Journal of Mechanical Engineering**
Federal University of Agriculture, Abeokuta	Journal of Natural Science, Engineering and Technology*
Federal University of Technology, Akure	FUTA Journal of Engineering and Engineering Technology (FUTA JEET)
Federal University of Technology, Minna	<ul style="list-style-type: none"> Nigerian Journal of Technological Research* Nigerian Journal of Engineering and Applied Sciences (NJEAS)
Federal University of Technology, Owerri	Engineering and Technology Quarterly Journal
Ladoke Akintola University of Technology, Ogbomosho	LAUTECH Journal of Engineering and Technology (LAUJET)
Modibbo Adama University of Technology, Yola	Nigerian Journal of Engineering Science and Technology Research (NJESTR)
Nigerian Defence Academy	Academy Journal of Science and Technology
Nnamdi Azikiwe University, Awka	Journal of Engineering and Applied Sciences
Obafemi Awolowo University, Ile-Ife	Ife Journal of Technology
Olabisi Onabanjo University, Ago-Iwoye	OOU Journal of Engineering and Environmental Studies
Rivers State University of Science and Technology	Newviews Journal
University of Benin	Journal for Engineering Development (JED) Journal of the Nigerian Institute of Production Engineering (Society Journal)
University of Ibadan	Journal of Applied Science, Engineering and Technology (JASET)
University of Ilorin	<ul style="list-style-type: none"> Nigerian Journal of Technological Development Journal of Research Information in Civil Engineering**
University of Lagos	Journal of Engineering Research
University of Maiduguri	Arid Zone Journal of Engineering, Technology and Environment (AZOJETE)
University of Nigeria, Nsukka	Nigerian Journal of Technology
University of Uyo	Journal of Research and Innovations in Engineering

* Journal Published by the University

** Journal Published by a Department

A few Nigerian lecturers teaching in Nigerian Universities have written text books on some engineering science subjects, e.g.

1. **Fluid Mechanics** by Olu Ogboja, Published by UNESCO in 1996, having 582 pages, and
2. **Mechanics and Strength of Deformable Materials** by Olufemi A. Bamiro, Published by Ibadan University Press, supported by TETFUND in 2014, having 764 pages.

The recent effort by TETFUND to support text book writing will encourage more Nigerian lecturers to write text books.

Some Nigerians have been recognized for work done in Nigeria in engineering sciences. For example, Prof. Ayodele Awojobi (a Mechanical Engineer) had international recognition for his work in the field of vibrations (Dynamics). Prof. Alfred Akpoveta Susu (a Chemical Engineer) won the Nigeria Liquefied Natural Gas (NLNG) science prize in 2004 for his work on Real-time Computer Assisted Leak Detection/Location Reporting and Inventory Loss Monitoring. Professor Akaehomen Ibhadode (a Mechanical Engineer) also won the 2010 NLNG science prize for his work on development of new methods for precision die design (manufacturing science).

5. LEARNED CONFERENCES

In the late 80's and early 90's many engineers participated in the annual conference of Science Association of Nigeria under the banner of Engineering Section of Science Association of Nigeria (ESSAN). In those conferences engineering science papers were presented. ESSAN is now moribund.

In the annual conference of the Nigerian Society of Engineers many engineers especially from universities present engineering science papers. A few Faculties of Engineering and Technology also organise conferences in which papers on engineering science research findings are presented, e.g. Faculty of Technology conference at Obafemi Awolowo University, Ile-Ife, and Federal University of Technology, Minna. The first Nigerian Congress of Theoretical and Applied Mechanics was held at University of Lagos in September 1976. Efforts are being made to revive this congress and make it an annual event hosted by different universities.

6. IMPROVING RESEARCH AND INNOVATION IN ENGINEERING SCIENCES – THE WAY FORWARD

Over the years the relationship between industries and academia in Nigeria has been very poor. Industrialists in Nigeria should stimulate research in engineering sciences relevant to their needs by making use of human resources in Nigerian tertiary institutions and research institutes to solve their problems. Such collaboration will also help to transform what is developed through research in engineering sciences to marketable products. The current effort by the Committee of Deans of Engineering and Technology in Nigerian Universities (CODET) in reaching out to Manufacturers Association of Nigeria (MAN) is a move in this direction.

Since many Universities are being approved for take-off and many of them are interested in running engineering programmes, there is shortage of man power for teaching engineering sciences. Training of more lecturers at Ph.D. level can be accelerated by providing funding for Ph.D. students being trained in Nigerian Universities to visit research laboratories for 3 to 6 months in foreign Universities to carry out some of their work. Post-doctoral fellows who completed their Ph.D. work in Nigerian Universities can also be sponsored for such visits to Universities in developed countries.

7. CONCLUSION

The current state of engineering science in Nigeria has been discussed. There is need to encourage the teaching of Further Mathematics in more secondary schools in Nigeria for engineering students to have good background for taking engineering science courses. To enable Nigerian engineers apply their knowledge of engineering sciences to solve many problems in the country, it is necessary to provide high performance computing facilities; more state-of-the-art equipment for teaching and research; sponsorship of research in Nigerian tertiary institutions by industries; and sponsorship of Ph.D. students and post-doctoral fellows to travel abroad for research visits of three to six months.

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