

Engineering and Sustainability Education in Nigeria

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ABSTRACT

Since gaining independence in 1960, Nigeria has witnessed spiralling engineering infrastructural developments, such as road construction and development of Ajaokuta steel plant and refineries. Nigerian Higher Education Institutions (HEIs) have trained engineers who occupy important engineering posts in the public service and private sectors that administer some of these projects. With Nigeria's ratification of several sustainability pacts, it is pertinent to consider the extent to which sustainability education is reflected in its engineering education. This paper presents a review of Nigerian engineering education based on an analysis of the Benchmark Minimum Academic Standards for Undergraduate Engineering Programmes in Nigeria (BMAS) document issued by Council for the Regulation of Engineering in Nigeria (COREN). The analysis finds that of the 30 engineering programmes listed in the BMAS document, none directly addresses sustainability. The paper therefore highlights the need to mainstream sustainability education into the Nigerian engineering education curriculum. A vital means of achieving such mainstreaming is through the inclusion of a sustainable engineering programme in the BMAS for engineering.

Keywords: Sustainability education, engineering education, sustainable engineering, professional accreditation

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INTRODUCTION

The impact of human development on the natural environment has been a cause of increasing concern in recent decades. An important outcome of these deliberations about the environment is sustainable development, which aims to reconcile economic growth and environmental protection. Engineering has been implicated in sustainability crises, including climate change, pollution and resource depletion. Sustainable engineering arose as a strategy to deliver positive engineering solutions and systems to benefit the environment, economy and society. Guiding it is a sustainability worldview which also necessitates sustainability education [1]. As the upshot of international declarations, sustainability education aims to induce in individuals the cognitive orientation needed for an increasingly complex and unpredictable world. The UN Decade of Education for Sustainable Development (UNDESD; 2004-2014) enhanced global efforts to mainstream sustainability education into various higher education institutions (HEIs). In 2004, the engineering education community issued the Barcelona Declaration, actively embracing sustainability education. The Declaration has since underpinned sustainable engineering education worldwide.

Knowledge of sustainability is now a learning outcome of engineering programmes defined by various accreditation bodies including the Engineering Council, UK, the Accreditation Board for Engineering and Technology, USA and the Council for the Regulation of Engineering in Nigeria (COREN). Being a signatory to a number of sustainability-related treaties and resolutions such as Agenda 21, UNDESD and UN 2030 Agenda for Sustainable Development, Nigeria has endorsed sustainability education. Since the colonial era however, Nigeria has engineered many infrastructure such as crude oil refineries, Ajaokuta steel plant, roads, railways, and many residential and office buildings. Nigerian HEIs have produced engineers who administer these projects. Nevertheless, Nigerian engineering education has not been assessed for its sustainability content. COREN, a body tasked with the accreditation of engineering programmes amongst other functions, has developed and issued Benchmark Minimum Academic Standards for Undergraduate Engineering Programmes in Nigeria (BMAS). This document presents an important resource and opportunity for a baseline assessment of the sustainability content of Nigerian engineering programmes.

The purpose of this paper is to appraise Nigerian engineering education with a view to assessing its sustainability content. The paper highlights engineering practice in Nigeria before discussing the education of Nigerian engineers. Nigerian sustainability experience and efforts including sustainability education initiatives are considered. Thereafter, the sustainability content analysis of the BMAS document is presented. Finally, the paper suggests possible sustainability education interventions for Nigerian engineering education.

1 ENGINEERING EDUCATION IN NIGERIA

1.1 Engineering in Nigeria

Engineering in Nigeria evolved as a necessary outcome of colonialism. Engineering activities were undertaken to advance the goals of colonialism centred on governing Nigerian territories [2]. Road and railroad construction, water supply, mining, dredging, housing, electrical and mechanical works featured prominently amongst recurrent projects in colonial Nigeria. The engineering legacy bequeathed to Nigeria by the British continued without much change. Indigenisation efforts progressed very slowly as British and other foreign engineers continued to direct various engineering works across the country. Over the years, Nigeria took full ownership of engineering practice

in the country. Professional associations emerged including Nigerian Society of Engineers, COREN, and Nigerian Academy of Engineering. These organisations acted as consultants to successive Nigerian governments and to the academia broadening the purview of engineering knowledge and ensuring professionalism. Engineering in Nigeria now occurs within the structure of governmental regulation and professional associations' guidance. Only registered engineers are legally allowed to practice engineering in Nigeria. Thirty engineering fields are presently recognised in Nigeria [3].

1.2 Educating Nigerian engineers

At independence in 1960, Nigeria had an educational system modelled on the British framework. Since then, successive Nigerian governments have made efforts to modify the colonial legacy for more effective and meaningful outcomes. Higher education institutions (HEIs) grew from only 2 technical colleges in 1944 to a total of 143 in 2016 comprising 40 federal universities, 42 state universities and 61 private universities [4]. Today, the Federal Ministry of Education (FME) has the mandate to formulate and oversee enactment of national educational policies. Educational policies formulated by FME shape the route to an engineering career in Nigeria. Students desiring to study any engineering field are required to take such science subjects as mathematics, physics, and chemistry at senior secondary level. A minimum of credit score in these subjects and in two others including English Language at the West African Examination Council-conducted examinations or the national equivalent is mandatory. Initially modelled on the British system that operates a 3-year programme, engineering degrees in Nigeria are now acquired over a 5-year period. General physical and chemical science subjects accompanied by one or two social science subjects including Use of English are taught to first- and second-year engineering students. Students are progressively exposed to the core of their chosen disciplines over the next 3 years. A compulsory industrial work experience scheme is sandwiched in the engineering programme. In the final year of their programme, engineering students undertake a research project either individually or collaboratively under the supervision of an academic. A Bachelor of Engineering or Bachelor of Technology in Engineering is typically awarded upon successful completion of the 5-year programme.

2 SUSTAINABLE DEVELOPMENT IN NIGERIA

2.1 Nigerian sustainability experience and response

Nigeria's interest in sustainability was piqued by an environmental disaster in 1987 in which about 4000 tonnes of toxic waste originating from Italy were deposited in Delta State. This incident prompted the enactment of Federal Environmental Protection Agency (FEPA) Decree and Harmful Waste Decree in 1988 proscribing dumping and trafficking in toxic wastes across Nigerian territorial boundaries including its Exclusive Economic Zone. The FEPA Decree led to the formation of an environmental agency tasked to protect and manage the environment. In 1999, the Federal Ministry of Environment (FME) was established to coordinate all environmental matters. FEPA metamorphosed into National Environmental Standards and Regulations Enforcement Agency in 2007 and was subsumed by FME. With a vision "to ensure a Nigeria that develops in harmony with the environment", FME has engaged in a number of sustainable development efforts [5]. Sustainable development concerns in Nigeria have followed the typical sustainability ideas' pattern of percolation into societies in which social and economic dimensions are preceded by the environmental component. Following its participation at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, Nigeria attempted to implement the outcome of the summit by drafting Nigeria's Agenda 21. In response to the emergence of MDGs

in 2000, Nigeria created the Office of the Senior Special Assistant to the President on MDGs [6]. The expiration of MDGs in 2015 ushered in the UN 2030 Agenda for Sustainable Development comprising 17 Sustainable Development Goals which Nigeria endorsed. Given the abysmal outcome of Nigeria's MDGs efforts, speculations are rife that the Sustainable Development Goals may not fare any better.

2.2 Nigerian sustainability education

Allusions to education in several sustainability-related documents such as Nigeria's Agenda 21 are either in reference to "education for all" or to "environmental education". Given such impression, Nigerian educational system has responded to sustainability education with chiefly environment-related courses. Lessons on such environmental subjects as natural resources, sanitation, and pollution permeate Nigerian primary education. The secondary schools are introduced to some relatively advanced environmental issues such as waste and land pollution, ecology and water pollution. The HEIs offer a variety of degree level environmental courses titled variously as *environmental engineering*, *environmental management*, *environmental technology* and *environmental resources management*. Sixteen Nigerian universities currently run these courses [7]. Sustainability education in the strict sense of Education for Sustainable Development (ESD) has not gained much recognition in the Nigerian educational system. Nigeria has no explicit sustainability education framework and there is no Nigerian HEI that offers a sustainable engineering degree, course or module². This absence of active ESD programmes in Nigeria is corroborated by a study that finds sustainability education to be slowly evolving in Africa [8]. The UNDESD Final Report suggests that "sustainable development is only an emerging interest among African HEIs" [9]. The prospect of an accelerated uptake of sustainability education in Nigeria has equally not been realised even with the existence of 4 UN-established Regional Centres of Expertise (RCEs) on ESD in the country. Although appreciable progress has been made in terms of the informal and non-formal ESD components, the formal element is inadequately attended to [10]. Contributing to this undesirability is the failure of the RCEs to successfully network with Nigerian HEIs thereby fragmenting the ESD initiative. Renewed networking is required to mainstream ESD into Nigerian HEIs. An important means of achieving such nexus is through FME, FMEnv and other HEIs stakeholders including COREN and National Universities Commission.

3 SUSTAINABILITY ASSESSMENT

Sustainability assessment in HEIs has been undertaken since the emergence of sustainability education. Several sustainability assessment tools have been developed to evaluate the sustainability efforts of various HEIs around the world. A number of these tools generally assess sustainability initiatives in the customary HEI functions of education, research, community outreach, and university operation [11]. However, some of the assessment tools focus exclusively on curriculum with sustainability content having a central importance.

3.1 Sustainability content

What qualifies as sustainability content is an important question in sustainability assessment research. The defining principles of sustainability have rightly guided most assessment tools. However, as sustainability concept is highly fluid, these principles are somewhat difficult to pin down. Hence, various measures of sustainability content in curriculum exist. The point of departure for most researchers is the use of expert-

² This is based on the Joint Admissions and Matriculation Board Brochure which contains all the courses offered in Nigerian HEIs.

derived sustainability themes which allows curricular sustainability content to be measured in terms of the spread of these themes. An example of such approach is the Sustainability Tool for Assessing Universities Curricula Holistically made up of 40 sustainability topics under the 4 categories of environment, economy, society and crosscutting themes [12]. Sustainability content can therefore be considered as the spread or coverage of sustainability topics or ideas in a curriculum highlighting the interdependence of environment, economy and society along with the multidimensional problem-solving strategies for addressing sustainability challenges. This operational definition guided the documentary analysis of the BMAS document.

3.2 BMAS document

BMAS is a document issued and reviewed episodically by COREN to set out standards for running undergraduate engineering programmes in Nigeria. A 367-page document containing over 100,000 words, the BMAS lists 30 approved engineering programmes with a description of all required courses for each programme. The scope of each course details prerequisite and co-requisite topics as well as admission requirements and list of laboratory equipment. Common engineering courses are equally detailed. The document is divided into 3 parts including general requirements section, specific requirements subdivision and accreditation score sheet. The BMAS is an outcome of deliberations by engineering practitioners and academics in Nigeria. Deans and heads of engineering departments from Nigerian universities as well as COREN management are involved in the development of the document. Each Nigerian HEI submits syllabus of its engineering programmes highlighting course contents, philosophy, and minimum facilities. A workshop is held to deliberate on these submissions. Courses are included in the BMAS on the basis of global best practice and contextual relevance. The BMAS standardises the syllabi and becomes the official guideline for all undergraduate engineering programmes in Nigeria. The preamble of the BMAS itemises 9 learning outcomes for engineering programmes. Item 6 states that “a graduate of an engineering programme accredited by COREN is expected to have *ability to consider the environment and sustainability in finding solutions to problems*” [3]. An interesting fact about the BMAS is that it informs all handbooks of engineering faculties in Nigerian HEIs. Furthermore, Nigerian HEIs refer to the BMAS for purposes of accreditation and curricular development. The BMAS is the basis upon which COREN accredits engineering programmes. The mention of sustainability as a competence expected of engineering graduates is, therefore, reassuring. However, this can only be effective with an actual integration of sustainability education in the programmes. The BMAS documentary analysis set out to discover if such alignment exists.

3.3 Analysis procedure

The question that informed analysis of the BMAS is whether or not sustainability topics are covered in the document. It was therefore of interest to analyse the mentions of a sustainability topic or idea in any engineering programme. The documentary analysis involved the use of NVivo 11. The BMAS document was converted to an editable PDF form and uploaded into the NVivo 11 software. Thirty engineering programmes listed in the BMAS with preamble and common engineering courses formed a total of 32 cases. A priori codes based on 4 categories of environmental concepts, economic concepts, social concepts, and multidimensional concepts became parent nodes. In line with the classification of Sustainability Tool for Assessing Universities Curricula Holistically, the environment node had 9 child nodes each being an important environment topic. Similarly, economic topics gave rise to 6 child nodes under the economic parent node, while the social parent node had 12 child nodes derived from myriad social issues like poverty, etc. The multidimensional node contained 10 child

nodes based on a range of crosscutting themes such as systems thinking, etc. The entire document was then scrutinised and coded at the cases and nodes. Words such as 'sustainable' used in the literal sense were not coded. Topics had to clearly embody sustainability ideas before being coded.

4 BMAS SUSTAINABILITY CONTENT

The analysis shows that the BMAS document has an extremely low sustainability content. Contained in merely 2% of the entire document, sustainability topics have not received much attention in Nigerian engineering programmes. Compared to 2 common engineering topics, namely engineering materials and engineering mathematics, which both cover nearly 5% of the BMAS, the 37 sustainability topics assessed in this study are poorly featured. Nonetheless, from Figure 1 and Table 1, economic and environmental concepts are featured in the BMAS document more than the social and multidimensional themes.

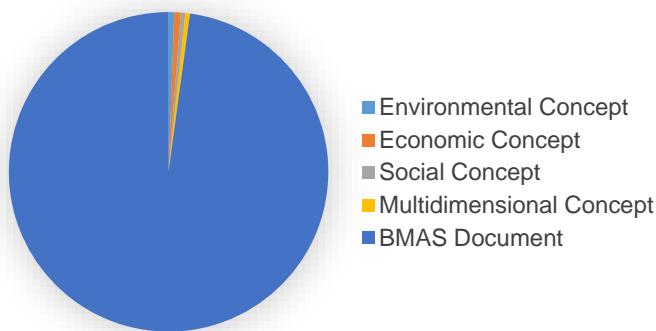


Table 1. Sustainability coverage

Sustainability Concept	Coverage
Environmental	0.57%
Economic	0.65%
Social	0.45%
Multidimensional	0.48%
BMAS Document	97.85%

Fig 1. Spread of sustainability concepts across BMAS Document

4.1 Environmental and economic contents

Figures 2 and 3 show the distribution of environmental and economic concepts across the engineering programmes in the BMAS document. Eleven programmes feature at least one environmental topic with Environmental Engineering containing 4 topics. Four environmental themes are completely absent in all of the programmes. Similarly, only 12 programmes cover economic topics and 2 economic themes, namely GNP and 'Accountability' are not mentioned in any of the programmes.

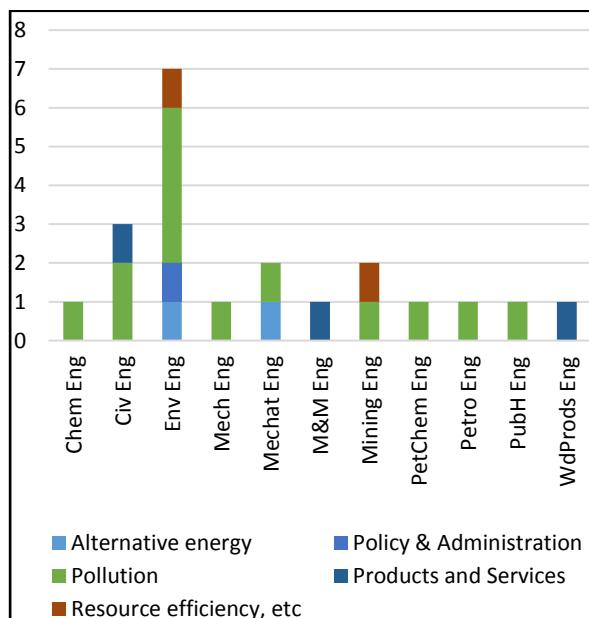


Fig 2. Environmental Concepts Distribution

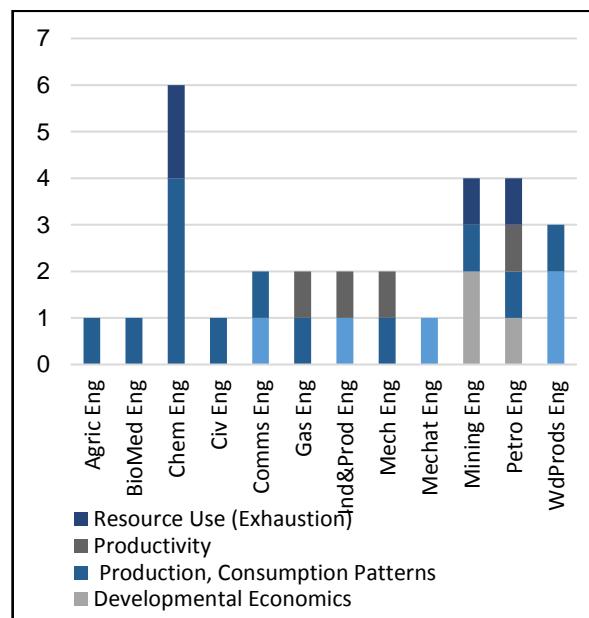


Fig 3. Economic Concepts Distribution

4.2 Social and multidimensional contents

Figures 4 and 5 present the spread of the social and multidimensional concepts in the engineering programmes. Whilst 9 programmes feature some social concepts, only 7 programmes mention at least one multidimensional theme. Equity and justice, long-term thinking as well as communication and ethics/philosophy are covered in the common engineering courses. Eight social and 6 multidimensional themes do not feature in any of the courses.

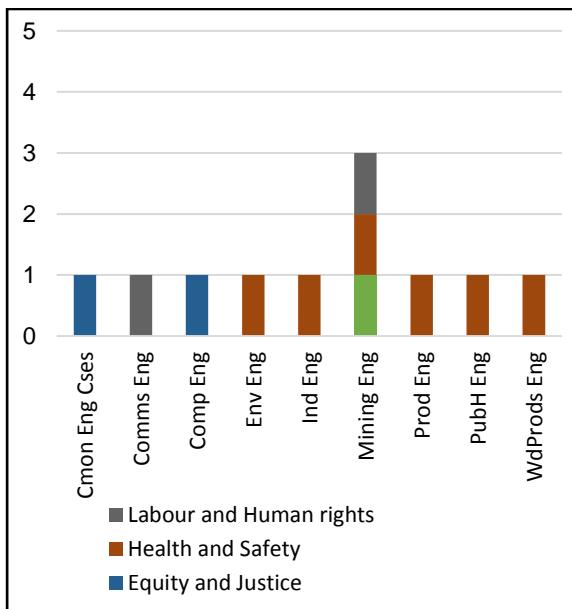


Fig 4. Social Concepts Distribution

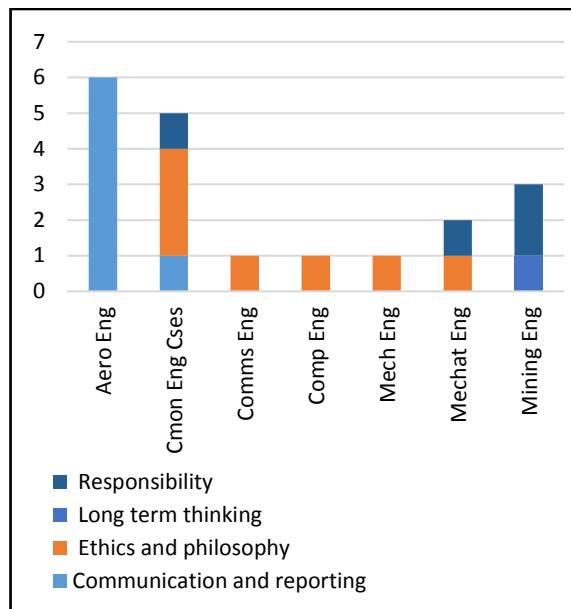


Fig 5. Multidimensional Concepts Distribution

5 SUSTAINABILITY EDUCATION INTERVENTION

The trajectory of engineering and sustainability in Nigeria is dotted with episodic interventions. Consequently, an education intervention to accommodate sustainability topics in the BMAS document is appropriate. The BMAS documentary analysis reveals dissonance between the required learning outcomes for engineering programmes and the imperative of sustainability education. Sustainability expertise has been clearly identified as a skill required of all engineering graduates, but the BMAS document shows no evidence of concrete sustainability education. Evidently, no engineering programme directly addresses sustainability. A possible intervention could be the substitution of the common engineering courses with sustainable engineering modules. Since the common engineering courses already feature some sustainability themes, albeit inchoately, sustainable engineering can aptly subsume these courses and give them the necessary sustainability finesse. Alternatively, COREN could insert in the BMAS a course entitled *Introduction to Sustainable Engineering* which could be made a core requirement from the third year onwards. This is because the third year marks the beginning of core courses for students of all engineering disciplines. Thus, beginning this stage with a sustainable engineering course could be an immensely effective sustainability education strategy. Such approach would ensure that sustainability eventually features in the final-year projects of engineering students.

6 SUMMARY

Engineering and sustainability education in Nigeria are as yet not properly aligned. Engineering has been practised in Nigeria since the colonial era. Nigerian engineers are trained in various HEIs across the country. The imperative of sustainability

education suggests a complex dimension for Nigerian engineering education. In spite of being a signatory to many sustainability pacts and its experience of an environmental disaster, Nigeria has no sustainability education framework. This paper appraised Nigerian engineering education and assessed its sustainability content based on the BMAS document. The paper highlighted engineering practice in Nigeria and discussed the education of Nigerian engineers. Nigerian sustainability experience and efforts were examined. Thereafter, the sustainability content analysis of the BMAS document was presented. Finally, the paper suggested possible sustainability education interventions for Nigerian engineering education.

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