Societal and Environmental Factors as Inputs in the Development of Sustainable Engineering Curriculum in a Developing Nation: A Case Study

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(Received 8 December 2016; Revised 31 January 2017; Accepted 9 March 2017)

Abstract: There has been a unanimous call for a home-grown engineering curriculum against the backdrop of seeming inefficiency of the graduates of tertiary institutions in developing nations. This paper presents the results of the study conducted to investigate the effects of peculiar social and environmental issues for a sustainable engineering curriculum in Nigeria as a case study. The factors considered were the environment of the mind, the physical environment, relevance of non-engineering courses, the need for studies in classical languages and human administration, as well as the study of past inventions. A well-structured questionnaire was prepared and administered to respondents who are mostly engineers. From the results, the respondents agreed that: (i) consideration to be given to the study of the Nation’s peculiar material and physical environment, (ii) including technological and non-technological ones to help graduates work with cross disciplinary engineering issues in multi-cultural circumstance, (iii) the working knowledge of either Latin or Greek should be incorporated into the curriculum, (iv) core of policy making curriculum to enable engineers to realise that public policy affects which technologies are funded and chosen for development and adoption and (v) study of past inventions and promotion of original research works should be promoted for sustainability of engineering. It can be concluded that these factors should be taken into consideration in the development of sustainable engineering curriculum.

Keywords: Curriculum, Engineering, Environment, Language, Society, Sustainable, Nigeria

1. Introduction

According to Holliday (2016), engineers run toward problems and solve problems. Since the dawn of civilisation, the problems that engineers have been called upon to solve, ranging from the mundane to the sublime. Engineering principles are not only global in applications, but have also played an indispensable role by interfacing with other disciplines like computer, science, law, social sciences, etc. in shaping humans’ social and economic development. For engineer to be able to solve problems, he must be trained to acquire necessary skills, techniques and equipment. Although there are innumerable problems presently confronting the nations of world (Monte et al., 2016), the engineers in developing nations of the world, in relation to their counterparts in the developed nations, seem to be ill-equipped and incompetent to confront the challenges of their various localities.

The International Bank for Reconstruction and Development (IBRD) classified about 81% of the nations of the world - including Nigeria where this investigation was conducted - as developing nations (Todaro, 2016). Classified as developing, because of following societal structural features: (i) lower per-capita income, (ii) low levels of human capital, (iii) high levels of poverty and under-nutrition, (iv) higher population growth rates, (v) predominance of agriculture and low levels of industrialization, (vi) low level of urbanization but rapid rural-to-urban migration, (vii) dominance of informal sector, (viii) underdeveloped labor, financial, and other markets (Kumara, 2016). The inability of engineers in developing nations to wipe out the characteristics displayed by the developing nations has been attributed to inadequate and ill-equipped training (Akintola et al., 2010).

According to Parashar and Parashar (2012), engineers ought to have the ability to tailor engineering solutions to the local social, economic, political, cultural and environmental context and to understand the impact of local action on the wider world. In Africa generally and particularly in Nigeria, Botha (2015) attributed this to:
deficient education training that is incapable of imparting skills and producing scientific and technological expertise, an environment that is plague with social and political instability that weakened the collective resolution and capacity to confront common problems, and global marginalization due to seeming bondage to policies that are driven from outside the continent resulting in exploitation of her resources and raw materials. Others include inability to abstain from aids that indigenous capacity cannot afford and sustain, absence of wholly indigenous infrastructure to use as platform for further development, and the seeming tendency for African countries to negotiate with other countries from a weak position. Continual reliance in the illusion of technology transfer instead of developing a home-grown technology, amongst others, is the reason why Africans engineers are ill-equipped to face challenges (Botha, 2015).

In Nigeria, this inadequacy in training is reflected by the fact that engineers now take up appointment with banks, accounting outfits and other non-engineering outfits (Onwuka, 2009). They ought to have used their engineering skills to create and develop companies, products, processes and services; as well as improve the engineering technologies to enhance the capacity of local manufacturing industries, power supply and other aspects of infrastructure in the society (Buhari, 2016). It is the failure to do these that necessitates the urgent need to domesticate the curriculum in the engineering institutions in order to ensure that the students can adapt what they learn to the vagaries of the Nigerians diverse environment (Ugochukwu et al., 2013; Akinsanya and Omotayo, 2013 and Adamu, 2015). This will be in agreement with stand of Grudzinski-Hall et al. (2007) that the curriculum for engineering studies ought to be developed to address this problem, so that consideration would be given to the cultural, political, and economic climate in which they would be implemented.

2. Deficiencies in Engineering Curriculum in Nigeria
Prior to the development of a new curriculum, careful assessment of the existing one ought to be carried out to identify deficiencies and shortcomings (Carew and Cooper, 2003). As reported by researchers (Rao, 1998); Landis, 2006; Griggs, 2013; Chandler, 2015; Driscoll, 2015 and Vanauspa and Splitt, 2015), there are several deficiencies in the current curriculum that need to be taken into consideration and their effectiveness assessed.

2.1 Environment of the Mind
That is, behavior and attitude in relation to the end of engineering as a career. In developing a sustainable curriculum, the issue of the environment of the mind of typical Nigerian engineering students has to be considered. In Nigeria, gravitation towards engineering is primarily because of perceived economic gains, obviously because of relative poverty. The weighty issue of one’s contribution to the growth and development of the society is rarely the primary reason as their motivation for choosing engineering as career. This is a veiled inference that people with wrong career goals are in the engineering profession in Nigeria.

2.2 Knowledge of Material Constitution of the Physical Environment.
That Nigeria curriculum lacks appreciation of the engineering knowledge and understanding of the material from environment (land, minerals and other raw materials), and thus is unable to impact the skills and develop processes and techniques as well as engineering equipment necessary to tame and harness this environment for developmental purpose. The curriculum, being a colonial heritage (Falade, 2006), was developed for a different environment.

2.3 Recognition of Nigeria Peculiar Society
That Nigerian engineering curriculum used the template that is foreign by ignoring domestic peculiarities and local pattern of growth of the Nigeria society. It does not train engineers to function and operate within the context of the Nigeria society – to create opportunities by solving local problems – but to function by looking out for foreign jobs or model of. It was further stated that in Nigeria, the engineering curriculum, obviously inherited from Britain (Falade, 2006), when compared with the curriculum of Universities in America – a leading engineering nation of the present civilization, did not recognize the place of her own peculiar heterogeneous societal needs in the structure of her engineering curriculum.

2.4 Lack of Appreciation of the Relevance of the Studies in the Classical Languages to Development and Growth of Engineering
The formulator of the curriculum of engineering education failed to recognize the importance of studies in the classical languages of Greek and Latin as necessary condition to unlock some of the secrets of Engineering that are preserved in these languages (Steinmetz, 1910). According to (Driscoll, 2015) that what has been preserved is meant to serve as guide in charting the direction for the future. He further averred that learning Latin, in particular, is not only to have access to the mind and spirit of the Romans and the Greeks, but also improve the ability to communicate in English, in order to participate in engineering on a global scale. This will remove their vulnerability in international relations (Todaro, 2016). In addition, learning the classical languages will help to capture the thought patterns and thought forms of the original thinkers to learn principles of, for example, the Roman machines, engines, bridges, building, and civil/structural engineering of Caesar years. These thought pattern and forms can then be stretched further, or used in a new or novel way, or modify to
accommodate some factors that were not taken into considerations in their time, in an attempt to solve local problem(s). These fundamental subjects for engineering are: mathematics, Physics, Chemistry and English language (Olafuyi and Adewale, 2005), and their terminologies are entirely based on Latin and Greek words and roots (Steinmetz, 1910).

2.5 Human Resources and Management issues of Engineering

Engineers have little or no input in policy formulation that would improve engineering practices. The curriculum did not contain adequate (i) quantitative and qualitative studies of human resources (different skills level and natural diversities) which could have given an insight into how leadership skill and actions are learned to inspire and motivate a diverse group to bond together to achieve a desirable result, and (ii) elemental principles in the art and science of human administration, that would have made engineers worthy of consultation of capable of assumption of leadership position at any level in future. This is a natural consequence of ability to bond with others.

2.6 Lack of Knowledge of Previous Indigenous Engineering Technology as Important to Sustainable Engineering

The inability of Nigerians to keep and control their own original inventions weakens her quest for sustainable engineering. It is said that a person can only consume another man’s invention but unable to grow, improve, or sustain it. The present curriculum lacks necessary modules that showcase the study and appreciation of past invention. The study of past indigenous inventions will help to bring to fore what we had, and a need to improve and sustain them will be birthed. Sustainable engineering is possible on the platform of what Nigeria has had her own, and not on what she does not have. A curious look at the benchmark minimum academic standard (BMAC) for accreditation of engineering programs in Nigeria Universities as set by the accreditation body - the Council for the regulation of Engineering in Nigeria (COREN, 2014) – showed that the above were not considered as important for accreditation purposes. Previous studies on engineering curriculum for developing nations by (Jha, 2007) and (Akintola, et al., 2010) also failed to address the issues above. Thus, the extent to which the recognition or non-recognition of these, are factors in the development of sustainable engineering curriculum in Nigeria is the subject of this study.

3. Methodology

3.1 Population and Sample Size

The target population for this survey consisted of all the practicing engineers in Nigeria, irrespective of the disciplines, working in both private and public sectors, in the academia and in the industry, without consideration of

\[ n = \frac{n'}{1 + \frac{n'}{N}} \tag{Eq.1} \]

\[ n' = \frac{p \times q}{\nu^2} \tag{Eq.2} \]

Where \( n \) = the required sample size, \( n' \) = the first estimate of sample size, \( N \) = the population size, \( P \) = the proportion of the characteristic being measured in the target population, \( q = 1 - p \), and \( \nu \) = standard error of sampling population.

In order to get the maximum sample size for this work, the values of \( p \) and \( q \) were taken as 0.5. The standard error was also set equal to 10% to determine the sample size. This value represents the maximum standard error allowed (AlSalman, 2004). The Nigerian Society of Engineers (NSE) has a gross membership of 53,776 (NSE, 2015). On the other hand, the Council for the Regulation of Engineering in Nigeria (COREN) has about 45000 members on their register. The NSE and COREN are the two bodies that regulate engineering practice in Nigeria. To obtain a reasonably large sample size for this work, the value of 53,776 was used. On the basis of this, the minimum sample size of 25, using Equations 1 and 2 was obtained.

3.2 Statistical and Data Analysis

A set of questionnaire was designed for data collection. It was structured into eight sections. Out of 186 questionnaires distributed, a total number of 97 questionnaires, representing about 52% of the total, and more than the required minimum of 25 as computed earlier, were returned. The data collected from the returned questionnaire were statistically analysed qualitatively and quantitatively. In order to estimate the internal consistency of the defined Likert scale, Cronbach’s alpha method of estimating internal consistency, reliability expressions of equation 3, as used by Ekoku (2016) was used.

\[ \alpha = \frac{N}{N-1} \left( 1 - \frac{\sum_{i=1}^{N} \sigma_i^2}{\sigma_T^2} \right) \tag{Eq.3} \]

Where, \( N \) is the number of test items or questions, \( \sigma_i^2 \) is the variance for each test item, and \( \sigma_T^2 \) is the total variance. Cronbach’s alpha reliability coefficient normally ranges between 0 and 1, and the closer Cronbach’s alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale. The statistical tools employed for questions in section 3 – 7 were mode, median and inter quota range (IQR) for the descriptive analysis while Mann-Whitney U test was used for quantitative analysis. These are statistical tools that are considered as suitable for ordinal scale (Archilleias, 2013 and Archilleias, 2014).
Questions in Sections 3-7 were structured in ordinal form of a 5-point Likert scale consisting of five responses, each with a different weighting for statistical analysis purposes: Strongly agree (SA) = 5, Agree (A) = 4, Undecided (U) = 3, Disagree (D) = 2, Strongly disagree (SD) = 1. Although the questionnaire was designed in such a way as to capture the probability of branch of engineering, academic qualification, and years of experience as factors that influenced the responses of the respondents, these are discussed only where they failed to agree with the general pattern of responses. All the analysis was carried out with the SPSS and MS-Excel software packages.

4. Results and Discussions
4.1 The Profile of the Respondents
The characteristics and background information of the respondents were presented in Table 1. From Table 1, it can be observed that the combined percentage of respondents who were Civil, Computer, Electrical and Mechanical Engineers is 81%. When this figure is compared with the annual output of engineering graduates from Universities and Colleges in which the four disciplines usually account for at least 67% of all engineering graduates (DE, 2007; Abdullahi, 2013), then the sample can be considered to be representative of practising engineers in Nigeria. Also the fact that Nigeria is still a developing country requiring massive construction of basic developmental infrastructure requiring the services of the four disciplines Civil, Computer, Electrical and Mechanical Engineers (Poothia, 2010), the high combined percentage of engineers in the four disciplines among the respondents is to be expected.

In addition, 10 of the respondents, representing 10.3% had doctoral degrees in their respective discipline, reflected a fair representation of both the industry and academia in the survey.

<table>
<thead>
<tr>
<th>Branch of Engineering</th>
<th>No.</th>
<th>AQ</th>
<th>PQ</th>
<th>Practising Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>HQ</td>
<td>No.</td>
<td>S</td>
</tr>
<tr>
<td>AGR (5%)</td>
<td>5</td>
<td>PhD</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MSc</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BSc</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HND</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CVL (34%)</td>
<td>33</td>
<td>PhD</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MSc</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BSc</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HND</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>CPE (2%)</td>
<td>2</td>
<td>PhD</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MSc</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BSc</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HND</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>EEE (23%)</td>
<td>22</td>
<td>PhD</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MSc</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BSc</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HND</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>IDE (2%)</td>
<td>2</td>
<td>PhD</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MSc</td>
<td>1</td>
<td>1</td>
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<tr>
<td></td>
<td></td>
<td>BSc</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HND</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>MEC (23%)</td>
<td>22</td>
<td>PhD</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MSc</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BSc</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HND</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>MME (5%)</td>
<td>5</td>
<td>PhD</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MSc</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BSc</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HND</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MTR (6%)</td>
<td>6</td>
<td>PhD</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MSc</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BSc</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HND</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

Keys: AGR = agricultural engineers, CVL = civil engineers, CPE = computer engineers, EEE = electrical engineers, IDE = industrial engineers, MEC = mechanical engineers, MME = metallurgical engineers, MTR = mechatronic engineers, AQ = academic qualifications, HQ = highest academic qualifications, PQ = professional qualifications, S = Nigerian Society of Engineers, R = Council for the Regulation of Engineering in Nigeria, N = NONE.
Only 22 respondents (representing 22.6%) are yet to be certified by any of the engineering regulation bodies in Nigeria. Thus the fact that the majority of the respondents – 77.4% of the respondents – are certified by the engineering regulations bodies that is an indication of ability to give reliable response to the survey questions. Also significant is the fact that 79.38% of the respondent have working experience of more than five years, and thus in a position to give reliable response, confirming the adequacy or otherwise of the curriculum that underpinned their training and certificates. When viewing the background data of the respondents collectively, it can be inferred that the data obtained for this research work can be relied upon. This is because all the respondents are highly educated, with recognisable academic and professional qualification, as well as substantial years of working experience.

4.2 Reasons for Choosing Engineering as a Career

The responses of the respondents as to their choice of engineering as career are presented in Figure 1. It can be seen that the most common reason cited for choice of engineering as career was to solve the problems of the society. This choice is consistent across branches of engineering, educational and working experience groupings. This result, with particular reference to Nigeria, conflicted with the earlier held notion that engineers in developing nations are in engineering, solely for the economic reasons. Moreover, only about 4% gave economic reasons as the reason for their choice of engineering. Thus, the reason for the seeming relative incompetence of Nigerian engineers is to be sought in domain apart from pursuits of economic interests, because awareness of engineers’ professional responsibility to their society (Vanasupa and Splitt, 2015) is shown by the majority of the respondents.

![Figure 1. Reasons for the choice of Engineering as a Career](image)

4.3 Issues in Development of Sustainable Engineering Curriculum

The summary of the responses to questions on five broad issues of: (i) knowledge of the environment, (ii) problems of the society, (iii) necessity of the classical languages, (iv) human management skills for engineers and (v) sustainability issues of engineering; are presented in Table 2. The reliability tests measured through Cronbach’s alpha reliability coefficient gave a value of 0.969. The 0.969 suggested an excellent internal consistency of the items in the scale and that items in the test are highly correlated (Gliem and Gliem, 2003).

4.3.1 Environmental Awareness

With over 98%, mode and median each of 5 and IQR of 1, the respondents were unanimous that the knowledge of the materials and physical environment was relevant to engineering (see Table 2). There was also consensus that the curriculum in Nigerian engineering schools did not make adequate provision for the acquisition of Nigeria’s material and physical environment. This is represented by IQR value of 1. Thus there is need for the curriculum to address this deficiency. The Universities in the developed countries recognised this that are evidenced in the work of (Hack, 2012; Ethics Tamu., 2016).

4.3.2 Problems in Nigeria Society

While about 87% of the respondents, with IQR 1 agreed that the curriculum gave adequate exposure to peculiar Nigeria problems (about 23 was itemised), there was also consensus that the same curriculum was deficient in in-depth theoretical principles and requisite skills as necessary to solve these problems. It is now being acknowledged that the principles and skills required to solve society problems are to be founded on engineering education that is built on the base of multi disciplines, including technological and non-technological ones, in order to help its graduates work with cross disciplinary engineering issues in multi-cultural circumstances (Ye, 2010; Iqbal-Khan et a., 2014; Holliday, 2016; Monte Jr, et al., 2016). Engineers must not be ignorant of his society and the way that society works. This can be seen from the fact the United States of America (USA) – the leader in this technological age – consider it more desirable to dedicate more than 20% of the time in teaching the subjects in humanities and social sciences (Rao, 1998). In Nigeria, the figure is 7% (Falade, 2006). Engineering curriculum in Nigeria, then, should be, broadened to include both theoretical and working knowledge of non-technical content. Some topics suggested by (Falade, 2006) included: Communications Skills; Management Skills; Economics, Business Practices; International Cultures and Languages; Community Sensitivities; as well as Environmental and Sustainable Development Issues. These nontechnical topics are seen as desirable by most sections of the engineering profession. They are usually identified by industrial employers of engineers as attributes, which they perceived were lacking in traditional engineering graduates.
Table 2. Summary of Issues in the Development of Sustainable Engineering Curriculum

<table>
<thead>
<tr>
<th>Theme</th>
<th>Propositions</th>
<th>SA (5)</th>
<th>AG (4)</th>
<th>UD (3)</th>
<th>DA (2)</th>
<th>SD (1)</th>
<th>Mode</th>
<th>Median</th>
<th>IQR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of the Environment</td>
<td>Engineering knowledge of the materials and physical environment are necessary for sustainable development in Engineering</td>
<td>60</td>
<td>36</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>The curriculum make adequate provision for acquiring the knowledge of Nigeria’s material and physical environment</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>47</td>
<td>34</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Problems of the Society</td>
<td>Curriculum gave adequate exposure to the problems in the Nigerian society.</td>
<td>39</td>
<td>48</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>The curriculum equipped engineers to solve the problems in Nigeria</td>
<td>12</td>
<td>16</td>
<td>18</td>
<td>28</td>
<td>23</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Curriculum contains modules that impact skills required in the local society</td>
<td>18</td>
<td>14</td>
<td>5</td>
<td>44</td>
<td>16</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Necessity of the classical Language of either Latin or Greek</td>
<td>Study of either Latin or Greek is necessary for the unlocking of the fundamental principles of engineering.</td>
<td>21</td>
<td>11</td>
<td>40</td>
<td>15</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>The current curriculum makes adequate provision for acquiring a working knowledge of it.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>97</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Human Management for Engineers</td>
<td>Engineers should take part actively in Human Administration as a means to drive sustainable engineering</td>
<td>46</td>
<td>35</td>
<td>9</td>
<td>6</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>The curriculum exposure one to duties and obligation involved in the human administration</td>
<td>18</td>
<td>20</td>
<td>11</td>
<td>25</td>
<td>23</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>The curriculum contains sufficient elements in the arts and science of human governance in the curriculum</td>
<td>10</td>
<td>12</td>
<td>23</td>
<td>22</td>
<td>30</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>The business of human administration should be left out of the curriculum</td>
<td>5</td>
<td>13</td>
<td>11</td>
<td>47</td>
<td>21</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Sustainability issues in Engineering</td>
<td>Knowledge of past indigenous invention necessary for sustainability in engineering</td>
<td>57</td>
<td>30</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>There are modules, in the curriculum dealing with the study of past indigenous invention as means to ensure sustainability.</td>
<td>63</td>
<td>30</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Control and ownership of engineering equipment is necessary for sustainability</td>
<td>25</td>
<td>41</td>
<td>2</td>
<td>22</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Keys: SA = Strongly Agree, AG = Agree, UD = Undecided, AG = Agree, SD = Strongly Disagree, IQR = inter quartile range.
Figures in the parenthesis represent the percentages in relation to the total.

4.3.3 Classical Languages

Though not presently in the curriculum up to PhD level, respondents seemed to be undecided on the desirability of the study of classical language with the mode and median each of 3. However, with IQR of 2, respondents seemed to be favourably disposed towards it, probably due to the
contribution of the PhD holders’ engineers among respondents (see Table 3). It can be seen that all the respondents (100%) with PhD degree thought the study of classical languages of Latin or Greek should be introduced into the curriculum. About 67.7% of MSc holders agreed. The undecided was in the lower academic rung – the BSc and HND holders. However, the value of the study of Classics in engineering education has long been recognised by educators, because of its considerable utilitarian value, since the terminology of science is entirely based on Latin and Greek words and roots (Steinmetz, 1910).

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>MSc</td>
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<td>4</td>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
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<td>2</td>
<td>15</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>HND</td>
<td>0</td>
<td>3</td>
<td>16</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

### 4.3.4 Engineers as Administrators

From Table 1, the majority of the respondents agreed that engineers should operate actively in the domain of human administration; and that its learning should form part of the curriculum. However, it is the opinion of the respondents that elements of the arts and science of human governance, as well as exposures to the broad issues of duties and obligations in a society that is diverse in composition, and in which they are supposed to function, are not covered in the curriculum.

The curriculum did not equip the students with the technological and public policy skills to make substantive contributions to this public policy discussion. The consequence of this is that engineers are completely ignored, as unworthy of consultations during policy formulations by all the tiers of government (Atume, 2010). It is the realization that public policy affects engineering practice that Universities in advanced countries included “Engineering and Public Policy” as part of the curriculum (Helble, 2016). Students will study the core of the engineering curriculum as well as the core policymaking curriculum so as to realize that public policy affects which technologies are funded and chosen for development and adoption.

### 4.3.5 Sustainability Issues

Sustainability issues of the investigation was anchored on the premise that a person may not legally improve or be intellectually sustained with what belongs to another without first acquiring permanent ownership of it, and also demonstrate the ability to protect it permanently. For the word of (Holliday, 2016), “protection of one’s technology” is the rule in the engineering and technological world. Nigeria presently consumes nearly everything, including knowledge and products of other nation’s intellectual efforts. It is thus not surprising then that the respondents gave overwhelming support for the study of past original local inventions, no matter how modest, is relevant to the sustainability issues of engineering. It is not presently covered in the curriculum. This can be seen from Table 1 with the mode and median each of 5 and IQR of 1. This is similar to the program titled “Inventions and Inventors” been mounted by Yale University in which focus was on American inventors (Chandler, 2015). Modules in the curriculum dealing with this will give the students opportunity to discuss their ideas. Students will know who the inventors were, the inventions and the progress it brought as well as the problems it created. In this way students will be challenged about the need to carry out inventions that do no harm to the environment.

### 4.4 Suggestions for the Development of Sustainable Curriculum

In order to know some of the thoughts not captured by the questionnaire, the respondents were asked to suggest ways to achieve sustainability in engineering education in Nigeria. The suggestions with frequency of five and above were shown in Figure 2. It was found that two suggestions are worth being commented on. The suggestion that some basics of engineering should be taught at the secondary school levels, if considered, will create space for other non-technical courses that may be included at the University level. Also the suggestion of sustained investment and funding of original research by Government, if implemented, will not only turn Nigeria into producer of knowledge (instead of consumer), but will also enhance sustainability in engineering curriculum.

### 5. Conclusions

The results of this investigation showed that Nigeria engineers are aware of their professional responsibility to their society. The inability to functionally perform those responsibilities is traceable to some deficiencies in the curriculum that underpinned their training. These deficiencies are:

1. The curriculum is failed to appreciate the relevance of the engineering study of Nigeria’s physical and material environment;
2. The curriculum is lacking in society-relevant non-engineering contents;
3. The curriculum made no effort to provide; linkage to its engineering root and foundation through the teaching of Latin or Greek;
4. The curriculum failed to equip engineers in the nuances of public policy and decision making processes, and
5. The curriculum ignored the relevance of the study of past inventions as a mean to ensure sustainability of engineering.
Moreover, sustained investment and funding of original research by Government will not only turn Nigeria into producer of knowledge (instead of consumer), but will also enhance sustainability in engineering curriculum. Although this research was conducted in Nigeria, the findings are also applicable to Nations with similar colonial educational system.

References:

![Figure 2. Some of respondents’ suggestions towards sustainable engineering curriculum](image-url)
Olafuyi, O.A. and Adewale, E.S. (2005),
Olafuyi, O.A. and Adewale, E.S. (2005), A Review of Petroleum Engineering Education Curriculum in Nigeria, University of Ibadan, Nigeria

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