Abstract
This paper examines the role of engineering in the context of national development and takes a look at it globally. Globalisation can be said to mean the well-accepted objectives of engineering education, which are not defined by national views only but by worldwide scope of the development of engineering and technology. The implications of globalisation to developing countries are highlighted while its associated problems and sustainability in the third world countries are discussed. The paper notes that some changes are required in Nigeria for her quest to launch into the global trend and such participation should take cognisance of national development.

Introduction
Different definitions have been proposed for engineering depending on the age and time, however certain themes run through all such definitions, namely: (i) engineering deals with the practical application of knowledge (ii) it deals with design, construction or production of some machines or processes (iii) it addresses problems that are of concern and use or value to man and society.

Engineering deals with solving of society's problems in a sustainable way. The problems to be solved are defined by the society, which also defines the acceptability of any prescribed solution(s). The proffered solution(s) must satisfy conflicting requirements on cost, safety and efficiency. The application of engineering to solve problems in a sustainable way is essentially cultural and often localized. What is a good engineering solution in one context may be bad in another. For example, deployment of a combine harvester to rural community that has no means of maintaining or sustaining it, is a bad engineering solution to an agricultural problem while introduction of motor vehicle transport where there are no roads would be an impossible solution to the rural transportation problem.

Globalisation has not been defined precisely but one comes near to the meaning of this term when the modern types of organization are described to advance worldwide cooperation and competition of commerce and industry, which are not controlled primarily by national organization. Globalization can be said to be a new word for the well-accepted objectives of engineering education, which are not defined by national views but by worldwide scope of the development of engineering and technology. The idea behind globalisation arises due to the perception that the tasks facing the international community can no longer be solved alone by a nation or country. Nations must be able to communicate with one another. Professionals, including engineers, must work together and must be able to function as part of an international team. Hopp (2000) noted that the aim of globalisation is to produce engineers who can think in terms of international, technical, social and financial relationship in addition to possessing expert knowledge. According to him, apart from their native tongue, engineers must be proficient in at least two foreign languages including English. Riemer (2002) indicates that the global engineers must be able to easily cross national and cultural boundaries.

Requirements for globalisation
In order to adequately prepare new engineering graduates for effective careers in international arena, engineering education needs to be multi-dimensional in addition to the traditional mathematics and science application skills, which have been the basis for the past generation of graduates. Jones (1998) enumerated the requirements for globalisation of engineering as follows:

i. Foreign language proficiency (written and spoken fluency in at least one foreign language preferably two).
ii. Cultural background development (education concerning the cultural background of people in the region of the world where engineer may practise)
iii. International business issues (competitiveness, free market development, multi national companies, varying ethical norms and varying consumer protection mechanism)
iv. Technical issue (measurement systems, varying standards and codes, environmental concerns etc.) Multimedia and adequate computerization
Globalisation of standards through ISO (International Standards Organization)

It is believed that these requirements will ensure cross-border engineering practice.

**Implication of global curricula**

- Global curricula will alleviate problem of accreditation, which is prevalent in some countries because of lack of adequate information on the affected programmes and might even completely eliminate the need for accreditation process within each country. All accredited degrees will be recognised at the global market.
- Mobility of staff and students in the global arena enhances cross-border movement.
- Adoption of Global standard through ISO and introduction of the ‘CE’ mark for products.

**Benefits**

Participation in globalisation will provide the following:

- Globalisation ensures a level of uniformity in the various curricula on offer e.g. similar course units and hours of lecture.
- Sharing and transferring teaching facilities between institutions at a distance.
- It is perceived that globalisation would assist developing countries worldwide but the level of assistance is unknown keeping in view the fact that the same regions have lost many of their experts to developed countries through the brain drain syndrome.
- Building a bank of resources (course ware, teaching ware etc.), which could be adopted and utilized by other institutions.
- Saving time and financial resources in the development of course materials.
- Mutual participation in teaching at all levels (under and postgraduate as well as PhD students) enriching the content of lectures and enabling the international standardization of programs of education.

**Challenges in developing global curricula**

The development of global curricula may pose some problems in the following areas:

- Removing problems found in traditional engineering programme.
- Identifying core features for inclusion.
- Building curricula suitable for global application with minor adjustments to suit local conditions.
- Creating curricula that is globally transferable and marketable.
- Providing subjects that will enhance students' knowledge and skill to solve engineering problems.
- Resource consumption.
- Human and material resources availability.
- Impact on the present and future generation.

**Sustainability**

In the developing countries a lot of problems may jeopardize the achievement of the set goal for globalization of engineering education. Some of these problems are:

- Inadequate funding which has been the bane of education worldwide particularly in developing countries and Nigeria in particular.
- Resource development and recovery.
- Mobilization of resources and consumption pattern.
- Production and transportation system.
- Inadequate infrastructure e.g. power supply.

**Current trends in Nigeria**

(a) **Engineering Curriculum**

Engineering curricula in Nigerian universities like other commonwealth universities were modeled after engineering curricula in Britain. Concerning engineering in Britain, Finniston (1980) wrote:
'Education of engineers is unduly scientific and theoretical; that newly graduated engineers lack awareness of the real life constraints to textbook solutions, that they are oriented too much towards research and development work and are not interested in working in production or marketing function.

Presently in Nigeria, the structure of engineering curricula on the average comprises:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Basic Sciences</td>
<td>15%</td>
</tr>
<tr>
<td>Engineering Sciences</td>
<td>25%</td>
</tr>
<tr>
<td>Technical Arts</td>
<td>8%</td>
</tr>
<tr>
<td>Applied and Design engineering</td>
<td>45%</td>
</tr>
<tr>
<td>Miscellaneous subject</td>
<td>7%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
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</tbody>
</table>

In the design of engineering curricula, industrial attachment which spans for a total of 40 weeks, is included to allow the students acquire on-job experience. With the problem of quality placement of students during the training period the entire programme can best be described as being theoretical restricting the students to application of theories to classroom problems rather than real life problems.

The curricula also contain very little knowledge and training in business aspects of engineering. Even where courses in management and economics have been included in the curricula, these courses are often taught as isolated textbook courses divorced from actual engineering practice.

When the current curriculum structure is compared with those of developed countries it is observed that the meeting point for the formulation of global curriculum would be somehow difficult but not unachievable.

Rao (1998) presented the existing structure of engineering curriculum in U.S.A. (a key player in globalisation of engineering):

<table>
<thead>
<tr>
<th>Subject</th>
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</thead>
<tbody>
<tr>
<td>Basic Sciences</td>
<td>25%</td>
</tr>
<tr>
<td>Engineering Sciences</td>
<td>25%</td>
</tr>
<tr>
<td>Technical Arts</td>
<td>2.8%</td>
</tr>
<tr>
<td>Applied and Design engineering</td>
<td>22.2%</td>
</tr>
<tr>
<td>Humanities and Social Sciences</td>
<td>22.2%</td>
</tr>
<tr>
<td>Thesis</td>
<td>2.8%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
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In U.S.A no time is allocated for courses on workshop, drawing and computer programming. The most probable reason for this is that most students who opt for engineering have done some workshop practice and computer programming at the high school level. Drawing is not considered to be an essential subject any more presumably because of the availability of many software packages for drafting and drawing.

In Nigeria, considerable time is spent on applied design subjects in Engineering in which a fair amount of empirical information is included. This is not considered essential in U. S. A. instead, they consider it more desirable to dedicate more than 20% of the time in teaching to subjects in humanities and social sciences. Nguyen et al (1997) wrote:

*In the increasingly global market, engineering graduates require a far broader range of knowledge and skills than merely the technical capability that was formerly demanded.*

In that paper, there was a well-argued case for broadening the undergraduate curriculum to include significant non-technical content. The range of topics proposed include: Communications Skills; Management Skills; Economics, Business Practices; International Cultures and Languages; Community Sensitivities; as well as Environmental and Sustainable Development Issues. These non-technical, 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.
(b) Codes of Practice and Standards

These are documents, which set minimum requirements for properties of engineering materials, design, construction procedures and manufacturing techniques to ensure quality outputs. Training in engineering and its application are universal but its practice is localised to solve the problems in the society in the area where it is being practised. Generally, codes and standards are dependent on the environmental factors such as humidity, temperature, pressure and atmospheric particle density prevailing in their country of origin.

In Nigeria, we rely on Codes and Standards from British Standards Institutions and American National Standards Institute for the training of our students and professional practice.

(c) Information Technology

The use of multimedia technology offers potential for reduction in time needed for formal instruction. The computer aided instruction packages provides on-job-training. They enable graduate workers access to new technological innovation taking place around the world. They also provide a comfortable training environment where each trainee can take time to check references or repeat particular section of the training programme. The Internet has introduced a new method of disseminating information. Information on engineering education can be disseminated on World Wide Web within a matter of minutes. The global trend in engineering is information technology dependent. The acquisition of the new technologies is inevitable for the training of engineers to provide engine for industrialization of the nation. These facilities are grossly in adequate in our Faculties of engineering and in some instances non-available. Olunloyo (2002) noted that the impact of the information technology revolution would make it possible for an individual to participate in distant economies without physically relocating to the host countries.

Necessary changes

In order that Faculties of engineering discharge their responsibilities adequately in the areas of research, development and transfer of information, prepare for global trends and for the graduates to be job creators rather than job seekers, the following issues must be given adequate attention:

(i) Funding

The problem of underfunding manifests in every area of engineering education (inadequate research facilities, inadequate classrooms, poor lecture delivering facilities – blackboards, chalk, inadequate number of staff etc.). There must be a deliberate effort by the government to fund education properly. Each university should also endeavour to look for other sources of fund rather than depending wholly on government.

(ii) Curriculum

In order that engineering faculties contribute effectively to the national manpower development, the stakeholders (engineering faculties, industry leaders and government agencies) must get together to develop appropriate curricula which will guide the university teachers in the training of the graduates. The thrust of the document should be to produce engineers who will be job creators and not job seekers. Such changes in the curricula should anticipate its relevance for globalisation.
Figure 1 provides a relative proportion of course content allocated to different levels of the stakeholders in the development of global curricula.

(iii) Codes of practice and standards

There is urgent need to develop codes and standards that are based on the local materials and environment. The professional bodies (The Nigerian Society of Engineers (NSE) and Council for the Regulation of Engineering in Nigeria (COREN)) should work together with their counterparts in academics to formulate appropriate codes and standards for the practice of engineering in Nigeria.

(iv) Involvement of academics in government developmental projects

In many countries around the world, senior members of academic staff are employed on government projects (engineering) where they work with representatives of industrial sector. Apart from their supervisory role, they are also supposed to gather data which can be used as baseline to update codes and standards where they exist or as a basis for developing draft codes and standards for a nation where they are not yet available but unfortunately such arrangement is not in existence. The disparity in the codes used for the training of engineers, and the situation they meet in practice makes it difficult for some of them to function well.

(v) Over-enrollment of students

Large students’ enrollment as a result of high demand for engineering education while the necessary facilities are inadequate results in overloading of faculty members. In order to alleviate this problem, enrollment should be matched with the available facilities. Faculties should also embark on recruitment drive and also staff development scheme.

(vi) Quality assurance

The government has recently approved that those candidates that sat for the entrance examinations to the Universities conducted by the Joint Admission and Matriculation Board (JAMB) and have performed well be subjected to further examination by their universities of choice. This is a step in the right direction to ensure that only good candidates are admitted into the universities. This would ensure that good students are admitted. The quality of Lecturers and their mode of teaching must be assessed through a system of rating. The quality of assessment and mode of releasing results must be uniform.

(vii) Research Materials and Teaching Aids
These facilities are currently very expensive in the market; efforts should be made to bring the unit price of textbooks and instruction materials down considerably, import duty free with necessary subsidy.

Universities/Industry partnership

In order to make progress university/industry partnership, which is currently lacking must be strengthened to allow the industry to make sufficient input in the manpower development. The observed misalignment in the graduates produced and the graduates the industry needs can be partly attributed to this missing link. A good linkage will enable the university to produce graduates with sufficient skill that will make them function in the industry immediately after graduation from the university. Bordogna proposed that the 21st century engineer should have the following qualities:

i  Innovation and synthesis - creating and implementing useful systems and products including their designs.
ii  Analysis - critical thinking that underlies problem definition (modeling, simulation, experiment, and optimization) derived from an in-depth understanding of the physical, life and mathematical sciences, as well as the humanities and social sciences.
iii Integration - recognition of engineering as an interactive process in which analysis and synthesis are supported with sensitivity to societal need and environmental fragility.
iv  Contextual understanding - appreciating the economic, industrial and international environment in which engineering is practised and the ability to provide societal leadership effectively.

Conclusions

From this study, the following conclusions are made worldwide:
1. Steady progress is being made to globalize engineering education.
2. Developing Countries may not be able to sustain globalization of engineering because of inadequate funding and necessary facilities.
3. Changes are required for Nigeria to launch into global trend in engineering education.

Recommendations

1. Nigeria should participate in the global trends but efforts should be made to reflect national and local needs in the engineering curricula.
2. Modern technology should be adapted to aid in the dissemination of information.
3. Eradication of custom duties on textbooks and teaching aid materials is necessary to reduce costs to allow for free flow of knowledge.
4. Researchers should be encouraged to embark on qualitative production and development of books and journal locally.
5. Pending the implementation of global curriculum, the existing curriculum should be overhauled in line with the prevailing realities on ground keeping in view the needs of the industry.
6. The acquisition of new technology is expensive. The facility is a sine-qua-non for effective training of engineers and in preparation for globalisation of engineering, therefore the government and private sector should come to the aid of the universities. Without effective information technology base, it will be difficult for Nigeria to launch into global trend in engineering education.

References


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