University-Industry Linkages: The Gateway for Accelerating National Development in Africa

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Abstract

The role of scientific, technological, and engineering education in nations' political, economic, social, infrastructural, environmental and human developments cannot be over accentuated. They form the drivers that propel advancement of any nation. Africa presently ranks high among the continents with a high number of sovereign nations operating consumer-based economies. There is no doubt that the quality of its engineering and scientific education plays vital roles in its technological breakthroughs or retrograde. It is observed that engineering/ scientific education in Africa is theory and examination rather than outcome and solution based due to the continual disconnection between the industry and the academia. Bridging the industry-university gap is the sure solution to the challenges of advancing the development of the continent. In this paper, ways of achieving mutual collaboration, partnership, and industry participation in engineering learning processes are discussed to aid the production of quality solution-oriented graduates to drive the wheels of her development.

Keywords
Africa, Industry collaboration, Engineering education, Outcome based education

1. Introduction

Engineering development is the bedrock of Africa's socio-techno-economic and environmental development. There is no reason why Africa should be listed among the poor of the world, following its natural endowments ranging from its landscape, climate, and mineral deposits to human resources. Despite the presence of these natural endowments, poverty, underdevelopment, and economic slavery remain endemic in the continent. Ironically, the development of the world's economic giants rests on Africa's resources (human and materials inclusive) ferried across its shores. One major contributor to its economic and industrial decline is the deficiency

in its technical (engineering) education foundation. Whereas the challenges facing scientific and engineering educators, their graduates and the educational systems in Africa have been discussed extensively in literature (Mitchell et al 2019, Onoyase 2019, Oketch 2016), it is observed that not many studies have been carried out on the industry-university collaboration to achieve solution-based engineering and science based education. The result of this malady is the ever-increasing mass unemployment of engineering graduates due to lack of skill-based technical training.

1.1 Objectives

The objective of this paper is to discuss some tenable areas the industry-university scientific & engineering education collaborations can be encouraged and the benefits therefrom.

2. Literature Review

2.1 State of Scientific and Engineering Education in Africa

2.1.1 Quality of programmes and graduates

The quality of engineering graduates is one of the ways to portray the quality of the training impacted on them through the formal institutional learning process. Although there are many factors affecting the quality of graduates turned out of African universities in science and engineering disciplines, it is obvious that the quality of learning given to students is poor. Employers in Africa have reported that graduates who present themselves for employment are 'half-baked' with 51-63% reported in about 5 East African countries in 2014 (Mohamedbhai 2016). This, however, is not unconnected to the quality of those who teach in the tertiary institutions who are also the products of the same system that employ them. At times the employment process is compromised at the expense of quality, productivity, and proficiency due to connections with the political class. Universities struggle for economic sustenance due to lack of funding by the government and the private sector. The overall quality of education has continuously fallen while the number of graduates has kept increasing. Consequently, the number of "half-baked" graduates attempting to enter the workforce has skyrocketed. However, few good engineering graduates compete with the large 'half-baked' ones, resulting in poor standards among the general population. Multinationals now prefer to hire expatriates and bring them into the country. Most companies now find it difficult to hire young graduates following the cost of retraining. The cost of hiring and training a new graduate is high and is even higher when the new graduate lacks skills that can be immediately impactful at the entry level. Companies, therefore, no longer want to take risks hiring new graduates. Consequently, it is a common observation to see many good graduates who look for engineering jobs for several years without success only to resort to alternatives even if they have nothing to do with engineering.

2.1.2 Curriculum

There is a global call by accreditation boards and educational stakeholders for the integration of transversal competencies in engineering and scientific education curricula so as to prepare intending graduates for the engineering labour market (Cruz et al 2019, UNESCO 2010). The contents of the engineering and other disciplines' curricula are structured to make students pass exams and not based on relevance and societal needs. They have not been structured to impact on students to be self-reliant as well as create employment on graduation (Ozor and Mbohwa 2019). For instance, the labour market's demand (which is dynamic) is not continuously surveyed, reviewed, and consulted when developing or revising engineering and related curricula by universities (Mohamedbhai 2016) and other tertiary institutions turning out graduates always.

Furthermore, the curriculum is developed to create disparity in speciality areas whereby some disciplines are looked down upon while others are upheld as more lucrative, rewarding and satisfying. Hardly do you see inter-related course sharing across disciplines beyond the 2nd year. For instance, in Nigeria, civil engineering and mechanical engineering departments hardly share courses up to 3rd or 4th year levels. Even within the same discipline, specialization begins as early as the 2nd year until graduation.

2.1.3 Dearth of Entrepreneurial skills

The curriculum of tertiary education is structured to focus on examination and ability to reproduce knowledge at the expense of entrepreneurial skills capable of qualifying the graduate for employment. It is so demanding on engineering education systems to always develop dedicated technical knowledge while at the same time, it is mainly focused on the teaching of theory and technical disciplines with very too emphasis on the teaching of personal, interpersonal and professional skills (Anderson and Anderson 2010, Sheppard et al 2009)
Lack of employable skills by graduates is identified as one of the major factors responsible for unemployment (Onoyase 2019) because students who have undertaken 4-5 years of engineering studies have their studies

structured to work in big conglomerates. Every engineering undergraduate looks forward to being employed in companies known for fat salaries such as oil and gas industry, marine transportation, aviation etc. Hardly do you see students who make up their minds to go into private practice from graduation because they lack skills required to create jobs. Recently, some Nigerian universities introduced entrepreneurial studies but much is to be achieved as most instructors themselves teach from head knowledge having not established any workable business venture. Entrepreneurial skill development begins with experts who have years of business oriented industrial experience.

2.1.4 Paucity of Industry collaboration

There is a wide gap between industries and university systems in Africa. Due to some government and economic policies, some industries are struggling to survive while many have gone moribund. The existence of a stringent unconducive environment for the effective operation of companies, such as poor, expensive, and inconsistent energy supply, makes it very difficult for industries to participate in the tertiary education learning process. Findings have shown that there is no effective collaboration between universities and labour employers in Africa in providing relevant skills required for employability and employment fulfilment of university graduates (Longe,2017). It is also observed that the curriculum is not structured to have industry experts take part in course delivery even at a short-term period. The industrial experience programmes, established by the government, to aid students engage in holiday work experience is not enough of industry participation in students training. Most times, many students are not fortunate to get industries that will absorb them early enough to ensure maximum use of the time. Furthermore, hardly do you find industry funded university research focused on industry problems. Research activities going on in many tertiary institutions are based on imaginary proposals for the purposes of graduating students rather than on actual industry problems. Both staff and students are constrained to embark on research that is not results oriented for the purposes of graduation. This results in research that ends up in institutional shelves due to incomplete, shallow and non-utilizable outputs. Lack of or inadequate university industry linkages is one of the major hampers of quality engineering graduates output followed by inadequate funding, inadequate mentoring of engineering lecturers and lack of special remunerations to engineers, (Oloyede et al 2017).

2.1.5 Infrastructural decay

Learning environment and the available facilities have an effect on the quality of education. Owing to poverty and underdevelopment, tertiary institutions in Africa are continually experiencing infrastructural decay. Both students and lecturers lack the necessary and basic facilities such as well-furnished classrooms, adequate teaching and learning aids, constant electricity, water supply, campus security, functional and affordable transportation system. In most universities and polytechnics, students and lecturers' accommodation are seen as luxury and 'favour' rather than necessities. Students spend almost ¼ of the semester seeking for institutional residence which also are characterized by lack of basic facilities. Many a times academic activities have been disrupted following students' unrest as a result of search for basic amenities to keep students going.

Due to government's control of tertiary institutions, its sole funding of education has led to periodic disruption of academic programmes arising from pressure groups and trade union agitations for better working conditions. For instance, in Nigeria, the Academic Staff Union of Universities (ASUU), Non-Academic Staff Union of Educational and Associated Institutions (***NASU***) and Senior Staff Association of Nigerian Universities (SSANU) have been in loggerheads with the government over poor funding of tertiary education, infrastructure and staff remuneration, resulting to protracted strike actions by the unions. It also leads to the completion of academic calendar under crash programmes. Africa belongs to the developing world characterized by limited financial resources although saddled with huge financial responsibilities. Government funding of tertiary institutions is not sustainable.

Academic staff remuneration and working conditions affect the productivity of university teachers. Figure 1 shows a comparison of average (sometimes the maximum) salaries of university professors across some countries vis-à-vis those of chief executives in the private sector.

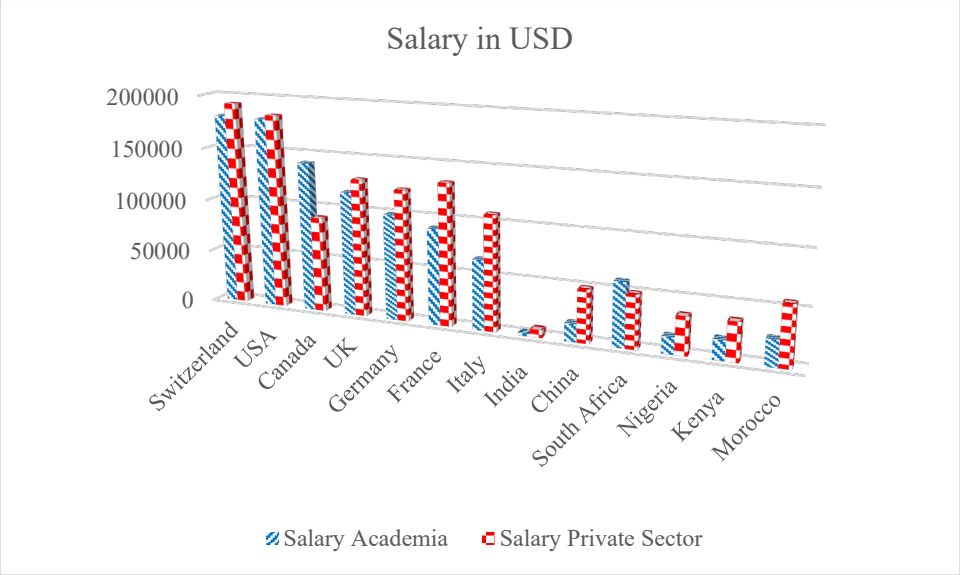


Figure 1. Comparison of annual salaries of Professors and top executives in the private sector in some selected countries

It can be observed that the trend decreases as one moves from developed to developing countries. Nigeria, Kenya, and Morocco show typical examples of African countries where academic staff wages are below their equivalent in the private sector. South African example is exceptional because of government incentives to encourage post-apartheid education among her citizens. Due to poor remuneration most university dons hold supplementary jobs and businesses especially in other institutions, to make up for the shortfalls in their monthly financial needs.

Inadequate infrastructure includes but not limited to buildings, road network, recreation/sporting facilities, laboratory equipment and consumables, aesthetic landscape and library facilities, staff housing etc. Students' enrolment status increases (Mihyo et al, 2016, *Mohamedbhai* 2015 and 2016), while the facilities have remained fixed. Lectures and exams have been taken in overcrowded, roof leaking, broken windowed classrooms with dilapidated seating facilities.

Inadequate organized campus transportation system cannot be overlooked. Although this does not apply to some universities in South Africa, most other African universities do not have an adequately organized transport system for non-vehicle owners.

2.2 Effects of engineering education loopholes in Africa

2.2.1 Youth unemployment

Figure 2 shows a summary of Africa's unemployment status per country. The high rate of graduate youth unemployment in Africa is an indication of the underdevelopment problem of the continent (Longe, 2017, Balogun (2016) and the world in general. It is estimated that about 60% (African news 2020) of the young people in Africa are unemployed. Out of this, the unemployment rate of North Africa is higher than that of sub-Saharan Africa which suffers most from under employment. It is reported that out of the 38.1% total working poor in sub-Saharan Africa, young people account for 23.5% (ILO 2020).

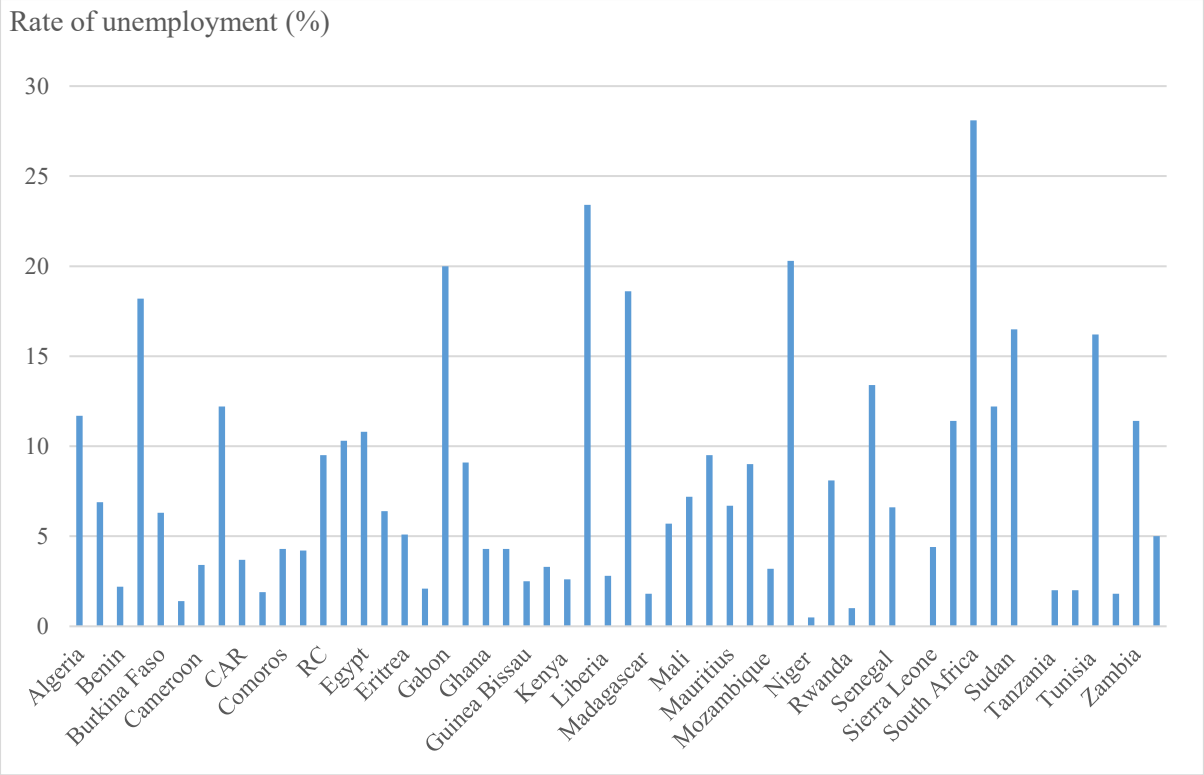


Figure 2. Graduate unemployment rate of African countries

Even though the continent has experienced consistent economic growth and development in recent years, youth unemployment has continued to rise as about 11 million youths join the labour force annually (Mohamedbhai 2016). Among several contributing factors to graduate youth unemployment, poor engineering education is of paramount importance. Education has a great influence on the employability of a population.

2.2.2 Brain drain

Africa loses her best brains to the international community by students studying at different levels outside their countries and continent. For instance, China offered 50,000 scholarships to African students from 2018 to 2021 but total African students enrolment of 81,562 in 2018 was recorded (Study International 2020). Quality and affordability are the attractions. Similarly, University world news (2020) shows that about 432,589 African students studied abroad in 2015. Most times these students stay back to pick jobs after their studies thereby contributing to the economic development of their host countries at the expense of their native countries.

3. Results

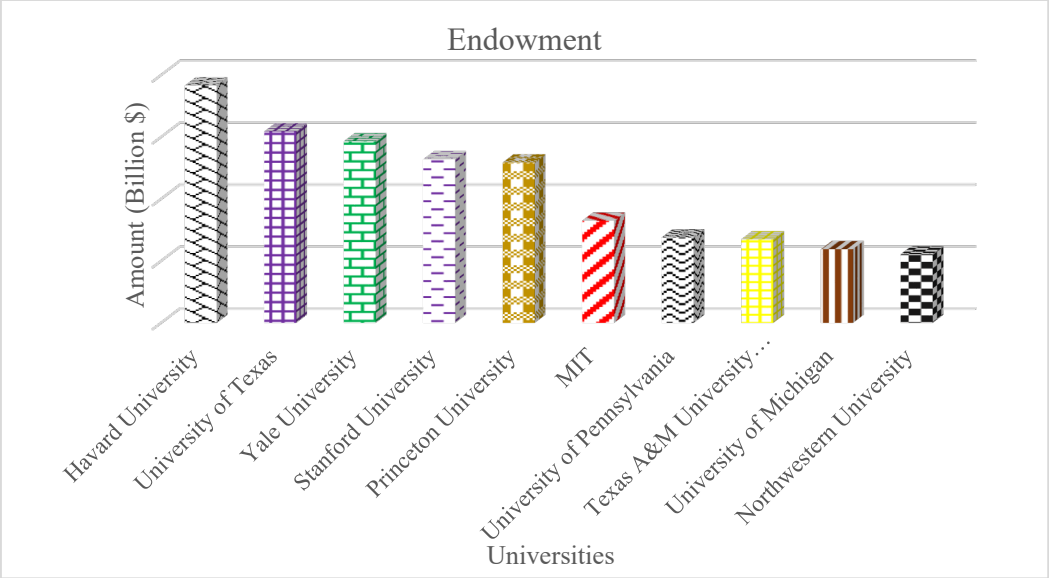
Industry-academia collaboration

Basic relationship between industries and universities has ab-initio existed. No industry can function meaningfully without input from engineering and scientific education for the personnel. In the same way, engineering or scientific education cannot be complete and meaningful without input from the industry through i) industrial experience opportunities for engineering trainees and ii) tasking of institutions with industry-based problems. Africa and the rest of the world have differing experiences.

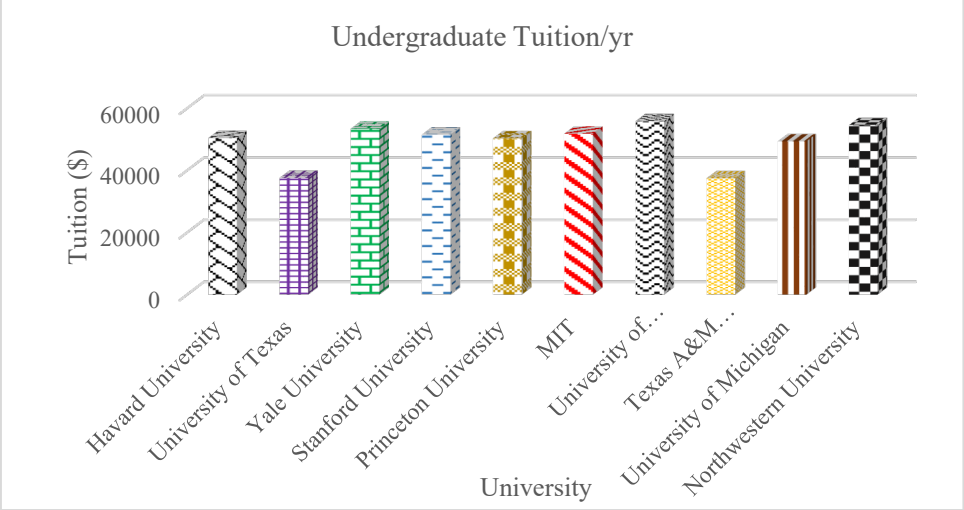
3.1 The international experiences

The integration of scientific research and technological innovation in promoting economic growth has been experimented in developed nations since the mid-20th century (Parker 1992) through the establishment of industry-university collaboration. This led to the establishment of science parks, techno parks built close to the universities with a view to collaborating with host institutions on translating research findings into tangible solutions to society's needs. According to Parker, (1992), the University of Salford hosts one of England's most diversified programs of industry-university linkages. The US, Japan, European Community, Netherlands, Germany etc are all involved in university industry collaborative research which drives their economy and industrial productivity. Most universities in the developed countries are run by different endowed funds from charities, industries, financial institutions, family foundations etc. Endowments to universities or tertiary institutions are money and/or financial assets donated to the academic institutions (Phung 2020) for running and

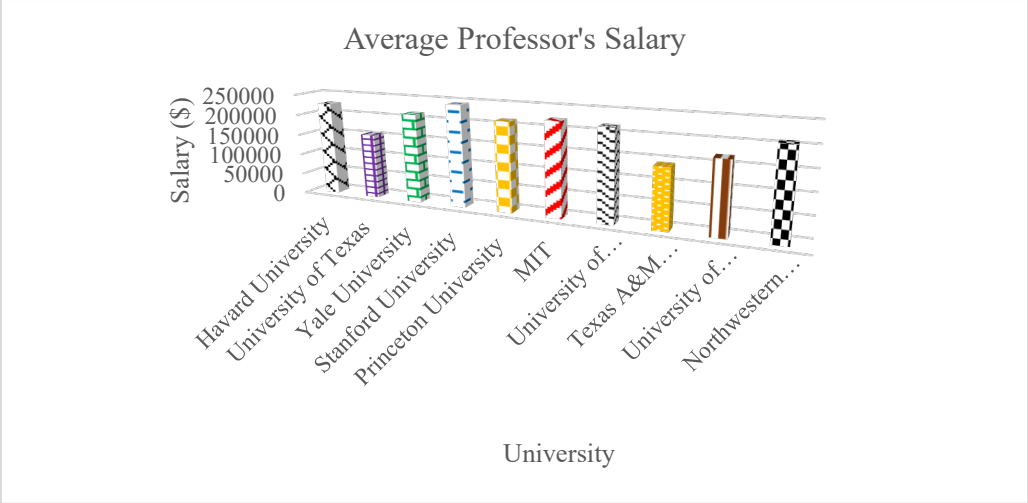
carrying out research in them. In the US, total endowments of universities are in Billions of Dollars Figure 3 shows the financial status of the top 10 universities in the country. The Northwestern University endowment of $11.08 Billion in no doubt is by far larger than the total annual education budget of many top African countries and in no doubt higher than the annual budget of some smaller countries in the continent. Although the students' tuition is high (Fig 3b) compared to African institutions, donations by industries, philanthropists and charity organizations make a great impact as this reflects on staff remunerations (Figure 3c). The financial strength of any institution affects the quality of education and graduates that will be produced from it.



(a): Endowment



(b): Undergraduate tuition per year



(c) Salary of professors

Figure 3. The financial status of the first ten universities in the US in 2020 (Barham 2021)

In Sri Lanka, (Asia), interesting collaborative initiatives between industries and universities have been ongoing (Malik and Wickramasinghe 2015) although the institutions lack the infrastructure, skills and resources required to fully support academic entrepreneurship. Chinese research universities and international enterprises established joint R&D institutes (Ma 2019) to drive the wheel of innovation in China and are the most mature types of research and development partnership existing between Chinese research universities and the international enterprises (Li 2005, Huang 2015).

University-Industry collaboration is an inevitable critical constituent of engineering education practice that drives innovation in the modern-day regional development in Europe, giving rise to university technology transfer offices (TTOs), licensing, intellectual property rights units, etc. Furthermore, development of human capital (that is Education), production of new knowledge (Research) and regional development by creating spinoffs and encouraging entrepreneurship among students are three main goals of industry-institution collaboration in the same region s (Fonseca and Salomaa 2019, Morrinson and Pattinson 2020).

3.2 African experience: prospective solutions

Having discussed the challenges of engineering education in African universities and polytechnics which depict deplorable conditions due to the sole management/funding of tertiary institutions by the governments, it is imperative to discuss ways industries can contribute to enhance technical education.

3.2.1 Collaborative Policy framework

The private sector (industries) as a matter of policy should be involved in the funding and management of higher institutions/education. One of the policy issues should be on company's profit sharing whereby they are required by legislative provisions to set aside a certain percentage of their annual profit for tertiary education funding. A central funds collection can be controlled by the government who disburses to institutions as needs arise. Currently, Nigeria's petroleum development trust fund (PTDF) and tertiary education trust fund (TETFund) are dedicated funds from oil and gas to fund tertiary education. However, these agencies are government owned and do not represent the private sector participation.

Establishment of joint university-industry centres of excellence mandated with industry-based research. The management of the centres will be composed of industry and academia experts although it is domiciled in the higher institutions. These collaborative centres of excellence will render dedicated services to the private sector, and direct the academia's work towards applied research.

As a matter of policy, engineering faculties/institutions should be mandated to establish industries that will commercialize their research outputs. In addition to this, every engineering institution is expected to establish an industrial park where there transfer of technology will be carried out between institution and the private sector.

Under the policy framework, industry funding of tertiary institutions should form part of the requirements for renewal of industries' operational licenses while the government reduces or waives some company obligations such as taxes, customs duties, and environmental levies as incentives.

3.2.2 Research collaboration framework

As obtainable overseas, industries in Africa, no matter how small, should begin to get the tertiary institutions involved in solving their industry related problems. Research seeks to find solutions to problems although the process may take long. By tasking institutions with real life problems, trainee engineers (students) will be familiar with the problems solving methods. Industries should be involved in sponsorship of research, conferences and workshops where intellectuals meet to transfer knowledge.

3.2.3 Curriculum development

Engineering curriculum is the foundation upon which engineering professional career and development are built. Although inherent natural endowments like creativity, imaginative thinking ability and strong analytical skills are vital in making a good engineer, institutional knowledge acquisition based on organized curriculum is inevitable. In order to reposition engineering contribution towards Africa's development, much is needed to be done on the current engineering curricula being used as the bases for engineering education across the institutions. Harmonised engineering curriculum based on outcome-based education (OBE) is proposed, which incorporates skills acquisition, development and entrepreneurial studies in it. In the OBE based curriculum, much emphasis is laid on inculcating in students the soft skills (e.g. communication, interpersonal, analytical, work attitude skills, etc) needed in jobs instead of examination and cumulative grade point averages. The students take responsibility for their own learning while their assessments of learning are based on the outcomes instead of the course contents (Rajee et al 2013). An advantage of the introduction of OBE engineering studies in Africa is to enable engineering graduates and engineers in Africa to practice engineering in sister and other countries of the world who are members of the Washington Accord without having to undergo professional examinations to be registered in that country. In fact, Engineers qualifications and competencies ought to be acknowledged and accepted across borders and in countries other than theirs. One way of achieving this is by harmonizing the ever dissimilar engineering regulations, education and training required of the engineering workforce.

In some universities, graduates of polytechnics with higher National Diploma (HND) cannot proceed to run master's degree programme on grounds of lack of basic engineering theories in the polytechnics. At the end of institutional training, the graduates of OBE based programmes become employable in the ever growing and competitive world. The curriculum takes into consideration the needs of the dynamic society, the industry, and the economic atmosphere of any prevailing environment.

In planning OBE based engineering curricula, the needs of the industries are considered paramount. It begins with analysis of in-country industries (Vedhathiri 2016) and the type of manpower they require to function very well, training of members of the faculty to fit into the various aspects of OBE framework, formation of consortium of industries with the institutions for joint projects where students can acquire industrial experiences etc. The curricula focus on two major outcomes viz: coursework measurement, examination results, course completion rates and employment on graduation, as first component while second outcome is based on learners' ability to express what they have learned and able to do (Tsai et al 2014) following their studies at school

3.2.3.1 The role of industry in OBE based engineering education

The industry, when given opportunity, should develop and teach at least a unit of engineering course in collaboration with senior engineers in the industry, graduate engineers and human resource managers as is done in Australia (Male and King 2014). In this model, the industry and university/polytechnic benefit from each other as the industry is paid for the services. The industry should throw her doors open to absorb trainee students on internship (industrial training). In the present traditional engineering education systems, engineering undergraduates are required to embark on 12 months industrial experience which is spread across 3, 3 and 6 months period obtainable during holiday periods starting from the students' second year. One major challenge faced by students is non-availability of industries to absorb them. Many students spend almost half of the time searching for companies to offer them placement. This follows because the industries, ab-initio, were not part and parcel of the design for industrial training programme. In the new dispensation of engineering education in Africa, the authors encourage the industries to be fully involved in the planning of students' internship. It is also proposed that the number of student trainees absorbed by industries through internship programmes should form one of the company performance evaluation criteria among others for the purposes of renewal of operational licenses.

3.2.3.2 Role of the university

In order to achieve the expected engineering education development in the new proposed OBE curriculum, engineering faculties should establish and maintain effective industry engagement in their engineering degrees.

Course teaching sharing with engineers in the industry is highly encouraged. The university should encourage inter-disciplinary studies, multi-disciplinary students' projects where every engineering profession is valued for its professional relevance. The university owes it as a duty to let the students be aware that in the real world, one will not find any company that has only one category of engineers working there. Every company exists because it has an underlying need or a problem or set of problems, something of value to offer to the society, and earns money selling those products or services to target customers via well designed business models. It is hard to find any product these days that has purely mechanical components. For example, the days are gone when vehicle transmission systems (gear and clutch systems) are solely made of mechanical components. The vehicles driven these days have a combination of mechanical, electrical and electronic parts. In the oil and gas industries, it will be realized that engineers not only compete against other engineering disciplines, but are also competing against people with science backgrounds like physics, mathematics majors, geologists, etc.

Postgraduate research projects should be targeted towards solving an existing problem facing local/African/developing countries or even global industries or helping specific companies solve real problems facing them, with the ultimate goal of creating new opportunities. This approach not only makes the university and the research engineers and lecturers super wealthy, attracts investment interest from private equity firms and think tanks, but also ends up in the birth of real businesses (SMEs and corporations) that will employ thousands of new graduates. The university should actively seek new areas of research by proactively going to companies to ask what their immediate pressing problems are and assembling students to focus on the problem as their research projects, PhD projects and case studies, to find solutions for the Companies.

The engineering departments need to include some entrepreneurial, financial analysis and management courses, business model analysis, business case presentation modules in their curriculum. Engineers need to be groomed to think of running small start-up and early-stage businesses, versus just being employees. This will completely change the perspectives of our graduates

3.2.4 Suitable learning environment

Poor infrastructure in our universities/polytechnics is a setback to quality engineering education which the industries can help to solve. Many academics in African institutions who studied outside the continent dream to have such facilities like conducive accommodation for staff and students, equipment for teaching and learning, social amenities (water, uninterrupted electricity, campus security, transportation, internet services etc), laboratory supplies etc in African institutions. The level of infrastructural decay in the institutions requires urgent attention of not only the government but the private sector. The private sector should leverage on institutional endowment fund programmes to register their contribution towards funding engineering education for national development. Multinational companies should take up the building of laboratories, classroom blocks with modern facilities, staff offices, and sporting facilities to aid the government. These help to condition the minds of students and teachers towards excellence. Scholarship opportunities to indigent students are motivations towards excellence.

4. Conclusion

The overarching importance of university –industry collaboration in the development of Africa cannot be over discussed. In this paper, the challenges and overriding effects of government's sole funding if tertiary education are discussed as well as the private sector contribution to ameliorate the problems discussed. If quality education, engineering graduates and wealth creation are to be ensured, then industry participation in providing quality teaching, infrastructure and curriculum development should be pursued with vigour.

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Biography

Edmund C. Okoroigwe holds Ph.D degree in Mechanical Engineering and is an Associate Professor of Mechanical Engineering, University of Nigeria. He was formerly the Acting Head of Department of Mechanical Engineering, University of Nigeria, for two years. His research is in applied renewable energy. He was formerly a Research Fellow at the National Centre for Energy Research and Development, University of Nigeria, Nsukka, Nigeria under the Energy Commission of Nigeria. He was a recipient of Fulbright Scholar award to Michigan State University, East Lansing in 2009/2010. He is a recipient of NRF Postdoctoral Fellowship at University of Cape Town South Africa on ERAfrica Project 2014 – 2016. He is a registered engineer with the Council for the Regulation of Engineering in Nigeria (COREN), a member of the Nigerian Society of Engineers (NSE), member of the Solar Energy Society of Nigeria (SESN). He is currently the Chairman, Nigerian Society of Engineers, Nsukka Branch and the pioneer Coordinator, Nigerian Institution of Mechanical Engineers (NIMechE) Nsukka Chapter. He has visited China, USA, Tunisia, Benin Republic, Rwanda, and South Africa.

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Chinyere N. Okoroigwe holds a B.Sc degree in Home Science, Nutrition and Dietetics of the University of Nigeria, Nsukka and currently a Postgraduate student of the Vocational Technical Education and an Instructor in the Department of Home Science and Management. Her research includes inter relation with human coexistence and the environment; renewable energy integration in human capital development and home management applications. She has interests in industry-academia relationship for scientific and human development.