ENGINEERING AND HUMAN-CAPACITY BUILDING: FLEXIBILITY OF INNOVATION IN HUMAN CAPITAL DEVELOPMENT IN NIGERIA

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DOI: 10.36108/ljerhrm/0202.02.0180

Abstract

The difference between developed and developing societies could also be captured in the area of engineering innovations for human-center development. Engineering is one of the drivers of sustainable development in the world; it has substantial impacts on building and sustaining human capital. Nigeria, like other developing societies, is confronted with challenges of utilizing human resources maximally for her national development. Hence, this paper investigates engineering and human capacity building as the flexibility of innovation in human capital development in Nigeria. This study applied a theoretical method; information was sourced through secondary means like content analysis journals, textbooks, and electronic resources. This study anchor on modernization, human capital, and scientific management theories. Findings showed that apart from the purely academic angle, Nigeria has no made outstanding progress in the area of training and institutional support. The paper recommends broad-based engineering applications in every facet of human capital. This will attract foreign investors to the economy, and the local ones can use their technical skills to ensure maximum utilization of resources through engineering techniques. As the World Federation of Engineers is sustaining pressures on the engineering body among the member states. Nigeria cannot afford to be isolated in the area of sound engineering training. This paper will be useful to the International Labour Organisation, World Federation of Engineers, ministries of employment and capacity development, National Directorates of Employment, the Nigerian Consultative Council and researchers in the field of Human Resources and engineering management could initiate research from here.

Keywords: Engineering, human-capacity building, innovations, human capital development, Nigeria

Introduction

The application of engineering covers different areas of human activities; the history of the development of human society is traced to improvement in engineering. According to Asian Development Bank (2017), engineering work has existed since ancient times, when humans devised inventions such as the wedge, lever, wheel, and pulley, engineering is a derivative of the word engineer, which itself dates back to 1390 when an engineer (according to a layman; one who works on engine) means a constructor of military engines (Tamgid& Mohammed, 2019).

Every society requires a competent and sophisticated workforce as drivers of its mission and vision for national advancement.

The need for engineering is to develop different spheres of human-capacity. As established by Burges & Rola-Rubzen (2018) human capacity is the improvement of human endeavors through the establishment of enabling environment through training, re-training, motivation and employee assessment or evaluation in order to realize high performance in the work environment. The development of industrial society was traced to the events in the 18th and 19th in Europe, where there were fewer emphases on the manual agricultural practices and there was a movement towards applications of engineering products to drive agricultural activities. The mechanical devices were the products of engineering professionals (Levinger, 1996). The major two events; the French Revolution and Industrial Revolution are responsible for the advancement of human societies and they have an outstanding influence on the human standard of living at the regional and global level. According to Pak, Kooij, Large & Veldhoven (2019) engineering is the body of knowledge, principles, and practices in order to practically solve problems.

Most countries in the world depend on engineering services to address their critical challenges. One of those challenges is the human-capacity building, which deals with ways of utilizing human resources in a bid to achieve the best from them for organization or society to achieve expected progress with the limited resources. Every country faces the daunting changes in scarce resources; one of the factors of production is human capital. Engineering has to be deployed to maximize the available and limiting factor of production in a bid to achieve efficiency. One of the viable ways of improving human capacity-building is through qualitative and sound education. The developed nations in the world have achieved enviable progress in their educational sector. As affirmed by Pollyn (2016) their education is characterized by stable academic sessions, well-motivated staff, dynamic and suitable curriculum, excellent infrastructures, sound research and development and exposure to trainees to practical problem-solving through systemic engineering regime.

The products from this educational establishment will become problem-solvers and entrepreneurial engineers that will contribute to the development of their society in particular and the global economy in general. Nigerian tertiary institutions produce more than 500,000 graduates per annum, coupled with another training establishment, less than ten percent of them get employment (Mohammed & Tokalu, 2018). Why the rest constitute burdens to society. This is a reflection that educational system has been devilled with some intrigues, the system is unstable; industrial actions are the order of the day, infrastructural deficit, poorly remunerated staff, endemic corruption, poor funding, and the national budget on education is far below the United Nations Educational Scientific and Cultural Organization (UNESCO) recommendation of 10% of national budget on education. Most of the organizations both private and public recruit their workforce from the products of this educational sector. Hence, this study assessed engineering and human capacity-building as innovation for the improvement of human resource management in Nigeria. The study will be guided broadly by the research question; what are the roles of engineering on human capacity development.

Methodology

The study was based on theoretical method; content analysis of textbooks, journals and internet resources and secondary source of data. Information concerning engineering and human capital was obtained.

Literature Review

This gives the explanations earlier works, and knowledge gaps to be covered

Engineering is the innovative usage of science, mathematics analysis, and empirical research to the creation, designs, usage and maintenance of structures, tools, machines, vehicles, organizations, processes establishment. A field of engineering has many fields each field has a particular focus and specialization. The field of engineering covers the following areas; chemical, civil, electrical and mechanical engineering.

The Greatest Achievement of Engineers. According to engineers of different fields have the following achievement cuts across the various engineering disciplines.

Table 1: The Twenty Greatest Engineering Achievements

S/N	Achievements	S/N	Achievements
1.	Electrification	11.	Highways
2.	Automobile	12.	Spacecraft
3.	Airplane	13.	Internet
4	Water supply and distribution	14	Imaging
5	Radio and television	15	Household appliances
6	Computers	16	Health technologies
7	Telephone	17	Petroleum and petrochemical technologies
8	Agricultural Mechanization	18	Nuclear Technologies
9	Air conditioning and refrigeration	19	High performance materials
10	Electronics	20	Laser and fiber optics

Source: modified by the author.

From Table 1, The twenty greatest achievements of the engineering have impacted on human capital development in Nigeria and other parts of the world, electricity of one the drivers of human capacity in the world, in Nigerian poor electric generation and distribution accounts for low industrialization, in automobile industry, Nigeria still depends on importation of used and new vehicles, airplanes facilitates movement of people from one location to another, from water supply and laser fiber optics represent facilities that can make work faster and better.

Human-Capacity Building: Human capacity is the knowledge, experiences, and skills which employees require to perform their duties effectively. The goal of every employer of labor is to maximize the best from his or her employees (Treuren, 2017).

Ways of Enhancing Human Capacity Development

According to Yuanju, Xinguo, Yanrong, Xiuzhen, Zhiwen, L., Xianyu, and Xie (2018) human capacity is like a machine that requires consistent maintenance and reformation to stimulate their maximum contribution to organization progress.

Education: Education is the transformation of knowledge for the development of total persons; this is the liberation of human minds. Education could be formal and informal, there may yardsticks that are used in measuring the quality of a nation's educational sector. These include the employability of the products of the system and how the learners are given necessary facilities, training equipment, and the ratio of male to female, the number of student to a teacher and their level of contribution to the body of knowledge in terms of publications, innovation, and self-reliance through technical skills.

Training: This is an alignment of the knowledge and skills of the employee to the mission and vision of an organization, training, and retraining of workforce is essential for them to know new processes and procedures for doing their job effectively. As argued by Sawaneh & Kamara (2019) the following are the forms of training;

Induction Training: This type of training is giving to new entrants into a system. The essence of induction training is to acquaint the recruits into an organization about rules and regulations of the company and some procedural principles, as they are spelled out in staff book or bylaw. It may include wages and salaries structures, methods of expressing a grievance, refreshment facilities and another ethos of an organization (Mouallem & Analoui, 2014).

On-the-Job Training: This version of the training is giving to existing employees of an organization. It might result from an unsatisfactory performance or the need to know new techniques of achieving better output from the production processes. This training requires a sound mentor that will put the trainees thorough various training sessions in terms of practical demonstration to achieve the objectives of the training (Marimithis, Arokiasmi & Ismail, 2009). On the job training could be job rotation; in this regard, new employees will be exposed to different aspects or departments in an organization. For example, a newly recruited graduate maybe a post to the Production Department this week and the Sales Department in the following week; this will enhance the flexibility of the workforce.

Off-the-job training: This type of training takes place outside the workplace and control of employer could be given through special seminars, workshops or conferences, corresponding courses, and internet training methods.

Table 2: National Summary of Statistics on Teacher/Pupil Ratio in Public Primary & Junior Secondary Schools in Nigeria (2016-2017)

Year	Category	2016	2017
Teacher/Pupil Ratio	Primary Schools	1:88	1:90
Teacher/Pupil	Junior Secondary Schools	1:120	1:120

Source: www.proshareng.com/news/Nigeria-Economy/NBS-Universal retrieved 10 June 2017, modified by the author

From Table 2, in 2016 the ratio of teacher to student in technical and other forms of education was 1:88; this accounts for poor productivity by the teachers in the primary schools, in the same year, the ratio of teacher to student was 1:120 in the public secondary schools, this was a negative trend in the educational sector

Importance of Human Capacity Building

Human capital is indispensable in the development of a nation, they are the engines that move the nation forward either in private or public capacity, and they are significant in the following aspects as indicated in (Aladejebi, 2018).

Structural Employment: As affirmed by Alshrah & Mohammed (2017), human capital development improves structural employment because it equips employees with the necessary training and experiences to enhance the dexterity of employees. Individuals with inadequate capacity training may find it difficult to gain employment. In this regard, the engineering profession will block the loopholes by offering practical training to the workforce to enhance their capacity to address practical problems in societies (Yuanju et al., 2018).

Economic Development and National Productivity: Highly trained workforce or active labor group contributes immensely to the development of the economy and they serve as drivers of the engine room of economy to the point of productivity and efficiency. When employees are given the requisite training couple with tools to work with, their job morale will be stimulated and their productive output will correspondingly enhanced (Khan, 2014).

Reduction in Human Capital Flight: The world is globalized, with the aid of internet; globally competitive workforce could seek employment in any part of the world, especially those with cogent work experiences and training as indicated in Lombardo (2006) a nation that has highly trained workforce but limited economic capacity to absorb graduates from tertiary institutions, the stands the risks of losing its workforce to economically buoyant nations. Developing countries like Nigeria experience capital flight in key arrears like nursing and medicine (Pollyn, 2016).

Utilization of Resources: One of the merits of human capacity development or human resource is that it is a vital variable in production. With highly empowered human capital, abundant resources will be fully utilized in the overall interest of a nation.

Table 3: Countries and their Expansions of Engineering Educational Opportunities for Younger Generations (Department of Economic and Social Affairs, 2002).

	Countries	Score for those aged <65(0—100)	Score for aged>65(0—100)
1.	Iran, Islamic Republic	27	40
2.	Saudi Arabia	31	38
3.	Tunisia	12	38
4.	Algeria	10	37
5.	Botswana	21	34
6.	Korea Republic	48	33
7.	Nepal	11	33
8.	Nigeria	19	33
9.	Egypt	30	33
10.	Cameroun	24	32
11.	Gabon	34	32
12.	Bahrain	43	32
13.	Malaysia	43	31
14.	Singapore	51	31
15.	Lao PDR	24	27
16.	EL Salvador	39	27
17.	Morocco	18	27
18.	Bolivia	47	27
19.	Mauritania	11	25
20.	Serbia	47	25

Source: Global Human Capital Report 2017, World Economic Forum, modified by the author.

From Table 3, Singapore has the highest in terms of provision of engineering education for the people that less than 65 years, followed by the Korea Republic, Algeria score the least score (10); exceeded Nepal by a point. Concerning the provision of engineering education to the adults, Iran has the highest, while Malaysia has the least score. This shows that countries that provide better engineering training for their youths will exceed others in human resource management and can compete with their contemporaries all over the world.

Interface between Engineering and Human Capacity Development

As opined by Bemnerlem-Lox & Peter, (2009) the following are some of the areas where engineering is assisting in human-capacity development

Creation of Tools: One of the influences of engineering on human capital development is the creation of tools and machines. These resources will enable the workforce to put in their best for efficiency and productivity.

Creation of Entrepreneurship Opportunities: Aside from tool creation, engineering creates opportunities for economic self-reliance. This is achieved through the development of high technical skills and training

Creation of Structures: Aside tools and entrepreneurship capacity development, engineering provides social structures for human-centric development, examples of those structures are effective road network, electricity projects, waterworks and structural designs that will facilitate human capacity building and their application to the sustainability of our environment (Bison & Gaur, 2018).

Globalization of Human Capital: Engineering has dismantled barriers among people of the world; the world has become a global village, there are unlimited interactions among people from various places and regions, this is possible through engineering achievements in the areas of internet and other information communication technology devices. Examples are the development of high-tech soft wares and satellite equipment that have assisted in the removal of artificial and natural hindrances to global human interactions (Merrick, 2010).

Improvement of Human Intelligence: One of the areas of engineering interventions in human capacity development is development of human intelligence with the provision of enabling environment for workforce and training and retraining in line with current innovation around the world, globally competitive companies will tailor their the intelligence of their workers to develop according what is fashionable in the international market to make their companies or organizations` sustainability (Pollyn, 2016).

Resource Efficiency: As posted by Matbubar& Marhed (2016) another area where human capacity development is influenced by engineering is prudent utilization of resources; resources scarcity is one of the challenges that confront people in the world, engineering creates innovations that ensure optimum utilization of resources including human resources to avert or reduce the wastage of time, money and energy. A typical example is a computer. This device has assisted in human capacity efficiency across various organizations.

Table 4: Regions and their Smallest Opportunity Gap in Engineering Education and Employment (Alshrah, and Mohammed, 2017).

REGIONS	SCOERE(0—100) %
North America	26%
Western Europe	29%
Eastern Europe and Central Asia	33%
Eastern Asia and the Pacific	34%
Latin American and the Caribbean	40%
Middle East and North America	44%
South Asia	46%
Sub Saharan Africa	47%
Global Average	38%

Source: Global Human Capital Report, 2017, World Economic Forum, Modified by the author

From Table 4, Sub Saharan Africa has the highest deficiency in the area of engineering education(47%), followed by South Asia (46%), and North America has the lowest gaps (26%), this accounts for low level of human capacity development in Sub Sahara Africa induced by marked gaps in engineering education.

Challenges of Engineering in Human Capacity Development in Nigeria

According to Bemnerlem-Lox & Peter (2009), the following are some of the stumbling-blocks to human resources development in Nigeria as maintained

Poor Funding of Educational Sector: One of the drivers of human capacity development is poor funding of education in Nigeria, sound and qualitative education is crucial for the development of human resources, Nigerian education is bedeviled with poor funding, mismanagement of the limited funds, infrastructural decay and other socio-economic issues Sawaneh& Kamara (2019) these challenges result in shabby training of the students and their inability to function effectively in the industries. The national budget is overtaken by the recurrent expenditure, incessant strike which destabilizes academic calendar, slim exposure of students to practical training are some of the issues that frustrate educational development in Nigeria. There are limited funds budgeted to research and development.

Bad Leadership: A leader is important in the development of human capital; good leaders recognize the need for the motivation of employment through realistic welfare packages. They give employees their rights and privileges and the adoption of technologies to human capacity development (Tamgid& Mohammed, 2019).

Economic Constraints: One of the impediments to contributions of engineering to human capital development is limited financial resources, most of the organizations and government agencies lack the financial capability to invest in latest technologies like computers and internet, and this affects the growth of human resources in Nigeria (Treuren, 2017).

Endemic Corruption: As noted by Uzon (2012) corruption has eaten deep into the fabric of Nigeria, this negatively affects the development of the engineering profession in Nigeria. The national budget on engineering is not fully implemented those that fully implemented, are not of international standards. The investment in engineering is poor and corruption deters foreign engineering investment in Nigeria.

Policy Inconsistencies: These are no gainsaying that political decisions influence the development of engineering practice in a country. The administration of the country is characterized by inconsistency in policies and programmes of government on science and technology (Yamoah, 2014). Each government initiates policy and when a new administration comes into power they jettison them. Some of the issues that frustrate the contribution of engineering to human-capacity development.

Poor Infrastructures. In the work of Mamno&Baskara,(2017) social amenities like stable electricity supply, effective road network system, the security of lives and property, potable water supply the major amenities required for the development of engineering for effective human capacity development.

Theoretical Framework

This study is guided by the following theories:

Modernization Theory: Modernization theory posits that society develops from traditional means of production to the modern mode of production. According to Treuren (2017) , as society advances, their mode of production improves and this influences their social interactions, engineering changes the development spate of society, as a country adopts modern engineering techniques its human capacity develops and this positively affects national productivity (Gilman, 2003).

Human Capital Theory: This theory deals with the concept of development of the human factor of production through adequate knowledge and enabling variables. This economic theory affirms that the contribution of labor to the production and national development is measurable. There is a direct link between human capacity development and labour productivity (Calkin, 2018). Going by this theory, the rate of investment in human resources could be assessed. When engineering resources are fully deplored into human resources, it will not only boost their morale but also enhance their productivity (UNO, 2018).

Scientific Management Theory by Fredrick Taylor sighted in David (2013) it is based on the carrot and sticks model, according to Taylor, employees will be productive when they are giving enough enabling environment to operate and targets to be met within a specific period. This is achievable in through effective applications of engineering innovations like computer, internet and into production (Chuanqi, 2012; Ferreira, 2014).

Table 5: World University Rankings 2018 by Engineering and Technology (1-10 positions)
(Calkin , 2018; Peach, & Leask, 2016).

Rank	Name of the University	Country/Location	Number of Students	Number of Student per Staff	International Students in Engineering	Female: Male Ratio in Engineering
1	Stanford University	United State	15,845	7.5	22%	42:54
2	California Institute of Technology	United State	2,209	6.5	27%	31:69
3	University of Oxford	United Kingdom	20,409	11.2	38%	46:54
4	Massachusetts Institute of Technology	United States	11,177	8.7	34%	37:63
5	University of Cambridge	United Kingdom	18,389	10.9	35%	45:55
6	Princeton University	United States	7,955	8.3	24%	45:55
7	Peking University	China	42,136	8.9	16%	47:53
8	National University of Singapore	Singapore	30,602	17.0	30%	51:49
9	ETH-Zurich-Swiss Federal Institute of Technology	Switzerland	19,233	14.6	38%	51:49
10	Imperial College London	United Kingdom	15,857	11.4	55%	37:63

Source: <https://www.timeshighereducation.com/world-university-rankings/2017>, retrieved 20 June 2018, modified by the author

From Table 5, Stanford University is one in terms of provision of engineering and technology education, the student population stands at 15,845, international student percent in engineering

was 22, California Institute of Technology came second and the Imperial College in London, achieved the tenth position, none of the higher education in sub-Sahara Africa featured among the ten countries this explains poor human capital development in Africa, especially Nigeria, that resulted for low engineering education and practice.

Discussion of Findings

In answering the research question concerning the relationship between engineering and human capital development; going the work of engineering has impacted on human capital development through training and retraining of personnel and innovations that electricity; this provides energy to drive industries, and reduces expenditure on diesel, thereby creating opportunities for enhanced net profits for the employers of labor to take proper care of human resources.

Another area is internet connectivity; this promotes flexibility among employees of different countries through the sharing of ideas, innovation and technical support in many areas of human endeavor, from Table 1, other aspects of engineering innovation that drive human capacity flexibility are radio and television. This enhances the dissemination of information across the regions especially people at the local level. However, despite these contributions of engineering to human capacity development, it faces some challenges like funding and other socio-cultural barriers. Nigeria a country can take the advantages of the contribution of engineering to human capacity development by developing her educational sector through the empowerment of human resources and improvement of the teacher to student ratio based on the recommendations of the United Nation Educational Social and Cultural Organisation (UNESCO)

Conclusion and Recommendations

Findings show that at the primary level of education in Nigeria in 2016 and 2017 the teacher to pupil ratio is disproportionate, teachers in public schools in Nigeria are over-utilized, however, at Stanford University the teacher and student ratio is seven students to a teacher. Nigeria has more than 162 universities and other specialized training institutions. The tertiary institutions produce more than 500,000 graduates annually; out of this figure, less than ten percent of them are gainfully employed. Hence, there is a need to improve the quality of our university graduates in the areas of engineering skills. The major achievements of engineering are fraught with entrepreneurship potentials. There is a need to look for practical solutions to our problem of human-capacity through engineering. This study will be useful to the Nigerian government at various level, educational institutions and researchers in the field of engineering and human resource development.

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