

Engineering Education and Capacity Development for Contextual Innovation in Rural Africa

Dr. Kehdinga George Fomunyam

Teaching and Learning Development Center, Mangosuthu University of Technology, Durban, South Africa.

Abstract

Addressing rural poverty and infrastructural lack calls for greater capabilities everywhere in society: in individual human capital, in communities, groups, organizations, sectors and institutions. A comprehensive framework equipped to overhaul the deficient methods and structures currently adopted in Africa is needed. Thriving Innovation achieved through restructuring and adoption of modern engineering research and teaching techniques focused on addressing current and emerging issues in rural Africa through proper capacity development methods is of paramount importance. This paper reviewed numerous published literature and concluded that the poor educational system severely limits capacity building processes in Africa as most countries fall under the medium capacity bracket. It also outlines key initiatives and recommendations for African tertiary institutions and public and private establishments geared towards achieving better learning and research techniques, improved training methods and facilities as well as reduction in failure of infrastructure and an adoption of development techniques and structures for the purpose of creating an enabling environment for contextual innovation to thrive in rural Africa.

Keywords: Capacity Development, Contextual Innovation, Engineering Education, Africa.

INTRODUCTION AND PROBLEM

Much of Africa's challenge to successfully implement development programmes especially in rural areas, which are predominantly ignored and excluded, stems from capacity weaknesses, limited knowledge as a result of poor education and inadequate funding. Mastering and understanding the fundamental skills, concepts and intricacies of engineering is an integral part of solving many of Africa's technological and economic problems. Engineering can still be considered to be at an embryonic stage in the majority of African countries. This is so because a lot of the tools needed to impart knowledge in different subjects related to STEM are absent in the educational system in Africa.

Contextual innovation in rural Africa can be effectively stimulated by building the technical capacity of their workforce, through quality engineering education programs. A competent technical workforce base can then provide

several paths to innovation: attraction of technically oriented multi-national companies, who can invest effectively in the rural areas once there is a cadre of qualified local employees available; effective utilization of available funds and providing a legacy of appropriate infrastructure projects and technically competent people to operate and maintain them; and small business start-ups by technically competent entrepreneurs. Technical capacity building efforts should be aimed at developing and creating incentives for well educated and certified engineering graduates to settle in rural areas. Effective and widespread engineering education is needed to develop technical capability in rural Africa to curb poverty and unemployment. African countries with a large pool of qualified engineers are more likely to innovate new technology and also engage effectively in the global economy. Indigenous science and technology capacity is needed to ensure that resources are utilized effectively and efficiently – for research and innovation relevant to rural economic needs, initial project implementation, for long-term operation and maintenance, and for the development of capacity to do future projects (Jones, 2007).

Capacity development is an endogenous process of improving individual skills and abilities, ensuring organizations that are productive, and creating institutions that optimize utilization of human, financial and physical resources for attaining individual, organizational, institutional and societal goals (GTZ, German Technical Cooperation, 2009). 'capacity development' is believed to better express an approach that builds on existing skills and knowledge, driving a dynamic and flexible process of change, borne by local actors.

Innovation encompasses anything from implementing new processes to completely re-inventing a business. Technology innovations need to be put into context for true value creation (Lisle). Context first, then product. Context Innovation, because the innovation process doesn't start with the invention, it instead starts from classical branding research finding the true needs and great passion among a groups of users. What is working well for them, later proves to be working well also for other groups of people with other lives and parallel interests (Brandflight, 2020). Rural transformation ought to be seen as part of a broader process of economy-wide structural transformation, which alters the structure of landholdings, the technologies in use, the capabilities of rural women and men, and the distribution and dynamics of the population and labour force (IFAD 2016). In

2012, The Royal Academy of Engineering published a comprehensive report entitled 'Engineers for Africa: Identifying Engineering Capacity Needs in Sub-Saharan Africa'. The report is based on a literature review, an electronic survey of 113 professional engineers and 29 decision-makers from 18 African countries, and interviews with 15 engineering stakeholders with experience of leading projects in various SSA countries. The report covered mainly Anglophone African countries. A key conclusion of the study is that there is a severe shortage of skilled and experienced engineers in SSA, and that "this lack at every level of the profession is a substantive obstacle to achieving almost all the development goals, from the provision of basic sanitation to the reduction of rural poverty".

One of the main features of inequality in developing countries is the persistent income and productivity divide between urban and rural residents, which results in concentrations of poverty in rural and peri-urban areas due in part to the fact that a lot of the tools needed to impart knowledge in different subjects related to STEM are absent in the often deficient educational system in Africa. Confronting these challenges require bold measures to accelerate rural transformation in order to increase the participation of rural communities in mainstream economic systems of developing countries, and improve the prospects of achieving many of the other sustainable development goals (IFAD 2016 ; UNCTAD 2016). Increasingly, states are recognizing the potential value of harnessing innovation to the inclusive developmental task in order to build sustainable communities.

Economic and structural stagnation as well as increased rate of failure in engineering infrastructure in Africa necessitated the call for capacity development and identifying Africa's engineering capacity needs as tools to promote innovations and engineering solutions that directly address rural Africa's particular fundamental, foundational and structural challenges. This study conceptualizes the role of engineering education aided by strategic capacity development in promoting contextual innovation for rural transformation. There is a need for the exploration of different areas of innovation in relation to rural transformation, in order to broaden our understanding of how such processes can contribute to fostering social and economic inclusion of marginalized communities (see Heeks, Foster, and Nugroho 2014).

SUMMARY OF SITUATIONAL ANALYSIS OF ENGINEERING EDUCATION IN AFRICA

After numerous and extensive research by scholars across the continent the situation of engineering education and training in SSA can be summarised as follows: Shortage of engineers, yet unemployment of engineering graduates in some countries, lack of funds to procure laboratory equipment and other facilities, out of date curricula and old methods of teaching as well as poorly educated graduates who are sometimes unemployable and grossly unable to compete internationally with foreign trained colleagues, lack of academic staff with industrial experience; difficulty in

recruiting and retaining staff because of poor salaries and employment conditions, weak university-industry partnership, lack of opportunities for industrial experience for engineering students (Mohamedbhai, 2014). Some of the causes for the low capacity include: a low level of public investment in engineering infrastructure projects over several decades, lack of adequate legislation to uphold engineering standards through requirements for professional registration, lack of regulatory laws to enforce foreign companies to effect knowledge transfer to local engineers, deficiency in resources of the engineering institutions to support engineering activities, poor quality of engineering education, based on outdated curricula and teaching methods not relevant to local needs, and being too theoretical as the tertiary education institutions lack resources for adequate laboratory experiments, acute shortage of opportunities for engineering students to gain prequalification experience through short placement in firms, inadequate training once they graduate and poor salaries for professional engineers, resulting in brain drain of engineering talent to other sectors or countries. There is also the overstretching of research and teaching-learning and managerial capacities (Ushie, 2016).

In his opening address at the Pan African Conference on Education in April 2018, the assistant director general for education at the United Nations Educational, Scientific and Cultural Organisation (UNESCO), Firmin Matoko, said: '*We need to help Africa tap into scientific inventions and discoveries that are happening around the world, and step up investments in scientific research to enable Africans be producers of knowledge rather than consumers by embracing the advancement in technology and equipping the youth with relevant knowledge and skills the 21st century demands.*' (Accounting and Business Magazine, 2018).

Besides engineering skill and knowledge, the attitudes of both teachers and students play a great role in engineering integration in the African education system and subsequently into society. While engineering has been introduced in the education system in most African countries the expansion and its adoption remains slow due to a lack of effective education policies, teacher capacity, and financial resources. The need for engineering-based innovation is a global resolution particularly relevant to Africa in its struggle to strengthen its economy. Engineering education is directly related to growth and development in various sectors of the economy across African countries with focus on rural Africa. According to the World bank (2014), a nation's growth can be hinged on the functionality of the infrastructure, which is a direct index of efficiency of the human and material resources and invested capital. The bulk of the maintenance and development of such infrastructural innovations are entrusted to engineers who are held accountable for failures.

LITERATURE REVIEW

A sufficient pool of engineers can enable a developing country to address numerous rural needs including poverty reduction, employment, entrepreneurship, job creation and

skills acquisition. In order to stimulate job formation in developing countries a technical workforce pool is needed, made up of people who are specifically educated and prepared to engage in entrepreneurial start-up efforts that meet local needs. Effective engineering education facilitates technical capacity development which enables developing countries to carry out proper research, experimentation, training and skills acquisition and also innovate technology and solutions which facilitate effective engagement in the global marketplace (Jones, 2007). Falade (2016) states that engineers are supposed to solve societal problems in sustainable ways and for them to do so they need to be sufficiently informed in engineering concepts and application of engineering theoretical principles to practical problems. Our inability to tackle the challenges appropriately in Africa have put us at a low level in technology. The difference between developed, developing and undeveloped countries borders on the ability of the developed countries to use engineering to convert scientific ideas to technology locally while the developing and underdeveloped countries are yet to effectively do so.

In Africa, the training of engineers has witnessed some challenges ranging from poor funding to inadequate facilities both quantitatively and qualitatively at the training institutions, inadequate and obsolete equipment, non-availability of adequate human capacity, adoption of traditional pedagogy, brain drain and poor staff training and retention profiles. Others include weak university/industry partnership, defective curricula, poor industrial attachment program, non-availability of local codes and monitoring standards for the training of prospective engineers and an inadequate ICT environment as well as weak linkages with international engineering community (Falade, 2016).

Capacity represents the potential for using resources effectively and maintaining gains in performance with gradually reduced levels of external support (LaFond and Brown, 2003, p7). It is the potential to perform (Horton et al, 2003, p18). It is also the ability of people, organizations and society as a whole to manage their affairs successfully (OECD, Organisation for Economic Co-operation and Development, 2006, p12). Capacity is that emergent contribution of attributes that enables a human system to create development value (Morgan, 2006, p8). It is also the ability of a human system to perform, sustain itself and self renew. Project evaluations and research studies clearly prove that the failures in implementation of technologies are mainly found in non-technical reasons and very often related to lack of awareness and lack of capable human resources (Rehling *et al.*, 2004). Effective and sustainable training and education and, in a broader sense Capacity Development, need to be adapted to the local market demand (Buss, 2010). Thus, adequate capacity development is necessary for effective contextual innovation to occur.

An innovation in rural context results from the exchange and use of knowledge introduced in economically or socially relevant process (OECD, Organisation for Economic Co-operation and Development, 1999). In this view, the nature of interaction between and among the rural actors is an important

aspect for consideration. The interaction may be exchange of goods and services, new technology and sharing of information and knowledge (Spielman et al., 2011). In this consideration, rural innovation is closely related to information flow, learning and interaction process. The term innovation includes not only the adoption of a new process or practice by rural people, but also a range of other processes, such as the use of a new learning method, the integration of ideas and knowledge to solve the problems and the introduction of a new technique and skills into rural people. Innovation stimulates economic growth and development of the nation (Edquist, 1997; Freeman, 1987; Hall et al., 2003; Spielman, 2005). In rural context, innovation is most likely defined as to give a new way to solve the problems of rural people (EOL, 1997). The majority of rural people suffer from poverty, poor infrastructure facilities, poor human resource development and poor accessibility of information and services (Maxwell, 2001). However, the facts remain that there is a remarkable contribution of rural sector for social as well economic development of any nation, particularly in developing countries (Chamber, 1983). Thus, there is a need to look on rural innovation concept, as it helps to improve the life of rural poor people by providing new opportunities of development. It is necessary to explore new development activities and functions that create more employment opportunities in and outside agriculture in the rural sector (Sonne, 2010).

Thus, rural innovation emerges as an outcome of 'different way of thinking and a different way of doing things' (Knickel et al., 2008). On the other hand, innovation in rural context involves technology as well as strategic, marketing, organizational and management aspect that help in rural development. The above literature review shows that rural innovation is defined as to give better ways to solve the problems of rural people through exploiting new opportunities that leads to entrepreneurship development (Singh, 2015) and according to Jones (2007), Indigenous science and technology capacity is needed to achieve this.

ENGINEERING EDUCATION AND CAPACITY DEVELOPMENT AS A TOOL FOR CONTEXTUAL INNOVATION

Higher education institutes' role in innovation processes is based on their research-based knowledge creation, training of new skilled individuals for the private sector and other wide variety of roles in an innovative economy. Nowadays, although still rare in an African context, entrepreneurial universities focus on the advancing systematic incubation of knowledge to innovations and transforming students and staff members to entrepreneurs that have an influence on the innovation culture of the region. According to innovation theories, higher education institutes are supposed to maintain an important role in innovation development in Africa because they are central institutions in research and development and an endless source of new human capacity (Hooli, 2019). Effective reform of engineering education and

research systems in African countries may require institutional restructuring, the introduction of new teaching methods, and changes in staff incentives, rewards and mobility. It is also important for developing countries to nurture indigenous engineering capability which confers upon them the ability to experiment and come up with contextually relevant ideas that can be taken up for industrial application (Organisation for Economic Co-operation and Development, 2006).

William Easterly in his book "The Elusive Quest for Growth" (MIT Press, 2002) argues that there are two areas that can likely lead to the desired economic growth in developing countries, and can lead them toward economic self sufficiency: utilization of advanced technologies, and education that leads to high skills in technological areas. The role of the university includes conducting of applied research leading to innovation and economic development. According to a report by the Science, Technology and Innovation Task Force of the Millennium Project "*Universities are vastly underutilized and potentially powerful vehicles for innovation in developing countries, particularly with respect to science and technology. If both universities and industry are encouraged to work actively together, universities will be able to assume new roles that could accelerate local and national development*".

According to Jones (2007) the requirements for this to occur are; a large enough pool of high quality, accredited engineering graduates. This is necessary to address the major need of job generation strategies and economic development lacking in most of rural Africa while making the needed investments to enhance the quality and quantity of engineering graduates. Engineering education in developing countries should include significant coverage of entrepreneurship – how to start, operate, and grow a small business. Engineering graduates should be equipped to take a path of creating jobs rather than seeking one if they wish to do so. Returning emigrants from the diaspora who often see new opportunities in their home countries, also contribute greatly to technological growth with their wealth of experience and contacts. In addition to increasing the number and quality of engineering graduates, and pursuing strategies to have good local jobs available, developing countries need mechanisms to apply research and development results from local universities and companies for relevant innovation and economic gain. Such mechanisms as incubators and small business development financing are needed in the mix. Many of the societal, human and economic needs of rural Africa can be resolved by innovating solutions arising from proper research, widespread engineering education and capacity development to fill skills gap. Useful programs being developed by the (WFEO) World Federation of Engineering Organizations committee on Capacity Building to address a significant subset of those needs include; engineering education workshops; development of accreditation systems; entrepreneurial training, stimulation of internship programs; electronic delivery of courses; formation of Engineers Without Borders cells; and faculty and student exchange programs.

Education and research priorities must be aligned to address local developmental needs. This also means that researchers should be able and willing to participate in entrepreneurial processes, which can be supported through policy-driven incentives. ICT can be used as a tool for promoting interactive learning and research in engineering education and capacity building through the use of online library catalogues, archives of materials through creating online laboratories for sharing teaching materials and lecture videos (OECD, Organisation for Economic Co-operation and Development, 2006). Engineering education and training of an innovative, skilled and adaptable workforce and support for their enterprise development should be prioritized by governments and the private sector in African countries with particular focus on rural communities (Serdyukov, 2017).

A US and UNESCO program strategy to promote human and institutional capacity building in engineering emphasized on the need for: strengthening engineering education, training and continued professional development; standards, quality assurance and accreditation; development of curricula, learning and teaching materials and methods; distance and interactive learning (including virtual universities and libraries); development of engineering ethics and codes of practice; promotion and public understanding of engineering and technology; development of indicators, information and communication systems for engineering; addressing women and gender issues in engineering and technology; inter-university and institutional cooperation, including fellowships; development of engineering and technology policy and planning.

Jones further posits that capacity building key points include: providing pathways for the technical and professional societies of the developed world to make their expertise available to local engineers in the developing world – including technical publications, conferences, codes of practice, and ethics, utilizing state-of-the-art distance learning technology to receive needed information and interactions from engineers and engineering educators around the country, strengthening engineering education, both initial and lifelong learning, in developing countries – including observing available global best practices in curriculum reform and engineering practice, maintaining an information resource for teaching and learning materials, laboratory equipment, software, etc. for the engineering education needs of rural African communities, promoting collaborative efforts between institutions in the developed and developing world, generating a technical work force that stimulates Africa's economy and that of each country in the region with focus on stimulating entrepreneurship. To foster professional mobility of well qualified engineers within the region (through national and regional accreditation and mutual recognition agreements. State-of-the-art science and technology capacity must be built in African countries if they are to be able to explore innovation and compete effectively. A well-educated and trained technical indigenous workforce pool must also be in place to attract investors and sustain technically based

industrial operations in developing countries. In addition, they are needed to fuel entrepreneurial start-up efforts that meet local needs. Well-educated engineers and scientists in developing countries will find appropriate ways to extend R&D results to marketable products and services responsive to local needs.

Thus, according to Jones (2007), it is clear that African countries need their own indigenous technological expertise. They cannot afford to buy it from developed countries, and even when technical expertise from developed countries is provided by external funding it is often ineffective in appropriately responding to local needs and constraints. Capacity building of technical expertise through engineering education in rural Africa, is key to enhancing their ability to innovate and pass on knowledge .

IMPEDIMENTS TO CAPACITY DEVELOPMENT IN ENGINEERING EDUCATION

Most funding for capacity development is spent in the capital on national level programmes and activities (which may have an ambition for decentralized outreach). Also, most services are designed at the national level in interaction between the funder and the service provider, far away from local level clients' needs. Capacity development support providers tend to be concentrated in one or two major towns. At the sub-national level one often finds small(er) NGOs or temporarily-funded programmes. With regard to the type of services, training in standard modules is the norm combined with technical advice and project management. More advanced services are very rare (Organisation for Economic Co-operation and Development, 2006). There is also a large knowledge gap between national and local actors, both about professional capacity development and about the 'market' for capacity development-related services and funding. In terms of prices capacity development in its present form is an expensive product for clients at the sub-national level most of whom cannot afford 'national' consultancy fees, allowances, long-distance travel costs, and so on. For sub-national actors the capacity development 'market' is largely inaccessible, not transparent, and the quality of services on offer is unpredictable. According to Hooli (2019), universities in Africa have scarce resources to conduct international peer-reviewed research; they barely are included in the governments' strategies, and they concentrate on education at the bachelor's degree level [33]. According to the ACBF 2015 report capacity development outcomes are difficult to achieve because most African countries allocate few resources to capacity building. Therefore, engineering related research and innovations developed with the universities have been scarce. Engineering faculties in African tertiary institutions are often underfunded by their governments and receive insufficient financial support from the private sector as well, thereby limiting the extent of teaching and research they can engage in and consequently their ability to innovate as well.

BENEFITS OF CONTEXTUAL INNOVATION IN RURAL AFRICA

Rural innovation ought to be seen as part of a broader process of economy-wide structural transformation, which alters the structure of the technologies in use, the capabilities of rural women and men, and the distribution and dynamics of the population and labour force (IFAD 2016). Multiple benefits that go beyond rural areas are generated as by-products of contextual rural innovation. The structural changes involved in rural transformation often require the harnessing of technological knowledge in order to broaden the range of productive activities that rural workers can engage in. It creates new economic opportunities and encourages the development of entrepreneurship (Knickel et al., 2008), which is one of the effective tools of economic development and solutions of poverty reduction (Bruton et al., 2013; Drucker, 1985). In rural context, innovation is not only related to raising production and increasing competitiveness in the market. But also link to the development of new activities and functions that go beyond the production, such as enhance accessibility of information and service, create employment opportunities and support to rural entrepreneurship development (Hosseini, et al., 2012; Mapila et al., 2012; Spielman, 2005; EOL, 1997; Knickel et al., 2009). Rather than contributing to growth and industrialization only, innovation can be a key factor in addressing urgent developmental challenges, such as providing access to drinking water and sanitation, eradicating neglected diseases, reducing hunger or providing appropriate healthcare and education (OECD 2010, 2015). Innovation can also contribute to sustainable development by addressing environmental challenges through the introduction of new technologies and non-technological changes (OECD 2011, 2015).

METHODOLOGY

The research methodology is based on a literature review of both descriptive and statistical information. 36 research papers and publications all published between 1997– 2020 were reviewed to examine and establish the relationship between the state of engineering education in Africa and Africa's capacity development level in relation to contextual innovation especially in rural Africa. The following combination of key terms used to search references via the internet was performed; Engineering* OR Engineering Education* OR Capacity Development* OR Innovation* OR Rural Africa*. Data obtained from the Africa Capacity Report (2017) shows the capacity development index for 44 African countries for 2016. The study also reviews the status of STI (Science, technology and innovation) in Africa and also highlights Africa's growth level in STI between 2015 – 2016. We can infer that the poor state of education generally in Africa and the continents capacity challenges inhibits the spread of innovation across both rural and urban Africa.

Table 1.1: Africa Capacity Index, 2016

Rank	Country	ACI 2016 value	Rank	Country	ACI 2016 value
1	Morocco	71.6	24	Gabon	52.3
2	Tanzania	68.8	25	Zambia	52.3
3	Rwanda	68.2	26	Djibouti	51.5
4	Mauritius	67.3	27	South Africa	51.1
5	Cabo Verde	62.6	28	Mozambique	50.8
6	Tunisia	62.6	29	Madagascar	50.7
7	Gambia	61.7	30	Togo	50.4
8	Mali	61.0	31	Guinea	50.1
9	Malawi	60.7	32	Senegal	49.0
10	Burkina Faso	58.8	33	Cameroon	47.3
11	Niger	57.4	34	Chad	46.4
12	Liberia	57.1	35	Zimbabwe	46.3
13	Ethiopia	56.5	36	Comoros	45.9
14	Namibia	56.2	37	Botswana	44.1
15	Lesotho	56.1	38	Côte d'Ivoire	43.6
16	Egypt	55.8	39	Nigeria	43.4
17	Kenya	55.2	40	Congo, Rep.	43.1
18	Ghana	54.1	41	Guinea-Bissau	41.8
19	Uganda	54.0	42	Mauritania	40.8
20	Burundi	53.4	43	Swaziland	35.3
21	Sierra Leone	53.3	44	Central African Republic	33.1
22	Algeria	53.2			
23	Benin	52.6			

Source: ACBF 2016a.

The results of ACBF's Africa Capacity Building STI Survey (2016) of 44 countries confirm the increasing recognition of the importance of STI strategies and capacity development in African countries. For instance,

FINDINGS

The results of ACBF's Africa Capacity Building STI (Science, Technology & Innovation) Survey (2016) of 44 countries confirm the increasing recognition of the importance of STI strategies and capacity development in African countries. For instance, 65% of surveyed countries have a strategy for promoting STI, for 28% such promotion is part of their National Development Plan, and only 7% have no strategy. Moreover, among respondents, capacity development is part of that strategy, with clear objectives, **for 67% of the countries surveyed capacity development is part of the strategy**, but without clear objectives, while capacity development is not part of the strategy for 7%. But these less than stellar rates also point to the need for further efforts by stakeholders in all African countries. The bulk of countries have Medium capacity. Most countries (75%) fall within the Medium (yellow) bracket, 20.5% are in the High bracket, and 4.5% are in the Low bracket. Capacity development outcomes remain the most pressing issue. About 84.4% rank in the Low or Very Low brackets, against 91% in 2015. As reported in previous ACRs, capacity development outcomes are difficult to achieve because most of the countries allocate few resources to capacity building. Capacity scores have slightly improved since 2014. The average score across all surveyed countries rose from 49.9 in 2014 to 52.0 in 2015 and to 52.7 in 2016. The likely reasons are increasing investment in elements related to capacity building and more widespread awareness of the importance of enhancing the elements related to capacity building. In 2015, 8.9% of countries were in the Low capacity bracket, compared with 4.5% for 2016. Thus a higher proportion of countries (75%) have Medium capacity while the number of countries in the High category has edged up from eight to nine. Of the 44 countries surveyed in 2015 and 2016, 26 (59.1%) saw an improvement in capacity while 18 (40.9%) saw their capacity scores deteriorate.

STATUS OF STI IN AFRICA, AND THE CONTINENT'S CAPACITY CHALLENGES.

For ACR (Africa Capacity Report) 2017, the term "STI" encompasses all systematic activities that are closely concerned with the generation, advancement, dissemination, and application of scientific and technical knowledge in all fields of science and technology (S&T)—the natural sciences, engineering, medical, and agricultural sciences, and the social sciences and humanities. Africa's vision for socioeconomic transformation is driven by science, technology, and innovation (STI). **The status of Africa's STI capacity on a global scale is still very low**, despite recent gains. The Global Innovation Index (GII) captures the multidimensional facets of innovation by measuring the innovation capacity of countries across the world. In 2015's GI ranking, of the 141 countries surveyed, 12 African countries were among the world's top 100 innovation achievers. These countries are demonstrating rising levels of innovation inputs and outputs, driven by improvements in institutions and the business environment, greater effort to leverage STI policies, and rising innovation potential. Their strong performance can be

attributed to the growth in general infrastructure, business and market sophistication, and improved knowledge and technology output.

In the 2015 report, **the performance of SubSaharan Africa was particularly poor. Of the 31 regional countries surveyed, 30 appeared in the bottom half of the NRI rankings.** The top performers were Mauritius, Nigeria, South Africa and Seychelles. North African countries also recorded low performance, lying in the bottom half of the NRI with Morocco, Egypt, Algeria and Kenya taking the top positions in the 2015 global ranking amongst North African countries. The 2016 NRI saw some improvement in ranking among some Sub-Saharan African countries, including South Africa, which moved up 10 places to 65th, Côte d'Ivoire, up 9 places to 106th, and Ethiopia, which jumped 10 places to 120th (WEF, Cornell University, and INSEAD 2015). Africa is the lowest-scoring region globally on the NRI, and worryingly, its top-performing countries are improving, while its worst-scoring countries are trending down.

We can infer from the information above that the poor state of engineering education in Africa is directly related to and partly responsible for the predominantly medium and low capacity development obtainable in African countries.

CONCLUSION

Targeted capacity development achieved through a reform in engineering teaching techniques and methods is a fundamental requirement for contextual innovation to occur and innovation is necessary for effective and sustainable development in rural areas. Challenges facing higher education in Africa, call for creative solutions for education to be relevant in addressing existing and emerging challenges. Educators need to familiarize themselves with complex adaptive systems thinking and be able to make effective decisions under different strategic and risk scenarios. Part of the requirements for this to happen is consistent capacity development across institutions and organizations in the public and private sector all geared towards creating an enabling environment for innovation to thrive in all sectors and areas of the economy including rural communities which are often ignored or underfunded and underutilized, thereby inhibiting the exploration and realization of their full capacity. Universities also need to effectively make use of technological and communication tools at their disposal in knowledge sharing, research, experimentation and liaising with the government, private organizations and the rural communities.

Proper capacity development and an upgrade of engineering education methods is vital for supporting effective and sustainable development. Africa needs to reposition universities to become the centres for new ideas that support this development. Among global regions, Africa invests least in research and development and also imports and uses technology the least. Its Science, Technology and Innovation (STI) (including engineering education) potential remains untapped, and its ability to generate new opportunities and meet emerging challenges is low. Africa needs to improve its STI capabilities and build capacity among researchers,

industry, communities, and individuals to tap into new and emerging opportunities in engineering and capacity development in order to improve innovation, increase living standards and promote job creation and development in Africa's rural communities.

RECOMMENDATION

Firstly, there is a critical need for the creation of students and community mentoring, internship and training programs in African communities tailored to encourage rural innovation that also transfer knowledge from the current generation of engineering teachers, professors, school leaders and experts to the next. There is also a need to adequately finance engineering faculties in order to strengthen staff and equip faculties and students with skills to address emerging and current rural community challenges. Having higher education institutions use rural challenges to define the curriculum and content of engineering programs in their areas of location will encourage innovative response to indigenous challenges including technical, structural or infrastructural issues. Partnerships between higher institutions and corporations sponsoring engineering students internship programs to rural areas would help clarify key areas of need where capacity and infrastructural innovations should be focused. With proper engineering education integration in the classroom, students would be able to engage themselves in interactive tasks with a wider range of information and knowledge during their learning. Students and graduates alike, should be offered incentives that encourage them to spread knowledge gained to rural areas, which are often ignored and lack structures and infrastructures necessary to bring innovative ideas to life. Governments in partnership with private organisations should fund engineering scholarships, leadership development, research and innovation projects favourable to rural innovation. They should also liaise on creating unique models for capacity development of engineering faculties in tertiary institutions that generate individual capacity in terms of skills, knowledge and competences. Resources should also be channelled towards tertiary institutions to help develop faculty, library facilities, lecture room facilities, modern teaching aids (e-learning, distance learning, group learning), ICT innovations (video conferencing facilities) and laboratories. Organizational capacity is also needed to help universities develop the leadership they need to build skills in networking across professional groups in order to build partnerships with the private sector and civil society. Such partnerships could help tackle the problem of unemployment that is so critical for Africa's development especially in the rural areas. Communities also have to cultivate a culture of implementation and maintenance to keep innovation and change from breaking down. Policy reforms are needed to align education policy to emphasize rural development priorities. Tertiary institutions, public and private sectors should form strategic partnerships with communities who are in a better position to indicate innovative path to pursue in terms of desired projects, infrastructural, capacity development and training needs. Developing countries need to build a critical mass of well-trained scientists and engineers for technological advancement to occur. In order for

engineering and capacity development to contribute significantly to innovation in the rural African communities through job creation, the workforce must be equipped with the skills to learn and deploy new knowledge. Furthermore, in both rich and poorer countries, education and training provision needs to be responsive to changing global and national trends in technological development, and the consequent shifts in labour markets (UNESCO, 2009). Indirect innovation policies are also needed to establish an enabling environment for the development of innovative enterprises. These relate to, amongst others, trade, investment and competition policies, industrial (or other sectoral) policy, labour policy, and – crucially – education, training and research policies that ensure an appropriately skilled and knowledgeable supply of labour (UNESCO, 2009).

CONTRIBUTION OF NEW KNOWLEDGE

Education is evolving and academia needs to take advantage of new and emerging trends in ICT and digital education to explore more effective and sustainable teaching, research and experimentation options through innovations like gamification and immersive technology. Integration of IoT end-devices, process automation and AI into engineering education via adoption of educational apps will transform teaching and learning methods. Adoption of AI in capital development will also facilitate complex customized production tasks and continuous accumulation of new knowledge, skills and competencies in capital development.

REFERENCES

- [1] Akinsanya, O.A; Omotayo, K.F. (2013) Falling Standards of Engineering Education in Nigeria-Causes and Recommendation. Retrieved from: <https://www.google.com/url?q=http://www.ijoart.org/docs/Falling-Standard-of-Engineering-Education-in-Nigeria--Causes-and-suggestions>
- [2] AUDA (2019) Capacity Development. Retrieved from: <https://www.nepad.org/programme-details/1012>
- [3] Brandflight (2020) Context Innovation. Retrieved from: <http://brandflight.com/context-innovation/>
- [4] Buss, I. (2010). Best Practices in Capacity Building Approaches. Retrieved from: https://www.google.com/url?q=https://openei.org/w/images/8/80/Best_Practices_in_Capacity_Building_Approaches.
- [5] Falade, Funso (2016) Advancement of Engineering Education in Africa: AEEA Perspective. Retrieved from: <http://www.ifees.net/dvancement-of-engineering-education-in-africa-aeaa-perspective/>
- [6] Hooli, L., Javi, A., Taajama, V., Jauhiaine, J. (2019) Contextualising Innovation in Africa: Knowledge Modes and Actors in Local Innovation Development Retrieved from: https://www.researchgate.net/publication/331864003_Contextualising_Innovation_in

- _Africa_Knowledge_Modes_and_Actors_in_Local_Innovation_Development
- [7] Horton et al (2003). Evaluating Capacity Development: Experiences from Research and Development Organizations around the World. Retrieved from: <https://www.idrc.ca/en/book/evaluating-capacity-development-experiences-research-and-development-organizations-around-world>
- [8] Habiyaremye, A, Kruss G, Booyens, I. (2019). Innovation for inclusive rural transformation: the role of the state. Retrieved from: <https://www.tandfonline.com/doi/full/10.1080/2157930X.2019.1596368>
- [9] Jones, R. Capacity Building Through Engineering Education. Retrieved from: https://www.worldexpertise.com/Capacity_Building_through_Engineering_Education.htm
- [10] Jones, R. (2007) Engineering Capacity Building In Developing Countries. Retrieved from: <https://peer.asee.org/engineering-capacity-building-in-developing-countries.pdf>
- [11] Knickel, K., Brunori, G., Rand, S. (2009). Towards a Better Conceptual Framework for Innovation Processes in Agriculture and Rural Development: From Linear Models to Systemic Approaches. Retrieved from: <https://www.tandfonline.com/doi/full/10.1080/13892240902909064?src=recsys>
- [12] Kaplan, H. B. (1999). Toward an understanding of resilience: A critical review of definitions and models. Retrieved from: <https://psycnet.apa.org/record/1999-04168-002>
- [13] Lisle, D. Contextual Innovation. Retrieved from: <https://medium.com/@dionlisle/contextual-innovation-95dfcad5e394>
- [14] Lafond, AK., Brown, L. (2003) A Guide to Monitoring and Evaluation of Capacity-Building Interventions in the Health Sector in Developing Countries Retrieved from: <https://www.measureevaluation.org/resources/publications/ms-03-07>
- [15] Malyan, R., Jindal, R., (2013) Capacity Building in Education Sector: An Exploratory Study in Indian and African Relations. Retrieved from: www.sciencedirect.com
- [16] Malyan, R., Jindal, L (2013). International Relations Conference on India and Development Partnerships in Asia and Africa: Towards a New Paradigm (IRC-2013)
- [17] Matthews, J. (2017) Understanding Indigenous Innovation in Rural West Africa: Challenges to Diffusion of Innovations Theory and Current Social Innovation Practice. Retrieved from: <https://doi.org/10.1080/19452829.2016.1270917>
- [18] Mohamedbhai, G (2014) Improving the Quality of Engineering Education in Sub-Saharan Africa. Retrieved from: https://www.google.com/url?q=http://www.gedcouncil.org/sites/default/files/content/GMohamedbhai,Report%2520on%2520Engg%2520Education%2520Version%25202_0.pdf&sa=U&ved=2ahUKewiH15-nivTpAhVM6uAKHenVCAIQFjAAegQIAhAB&usg=AOvVaw1cVI9W3Bue3iMGdttsmRvL
- [19] Nyemba, W., Chikuku, T., Hoko, Z., Mabunda, E. (2013). Towards Capacity Building and Sustainability in Engineering Education in Southern Africa. Retrieved from: https://www.researchgate.net/publication/323935089_Towards_Capacity_Building_and_Sustainability_in_Engineering_Education_in_Southern_Africa
- [20] OECD. Capacity Development in Practice (2006).Retrieved from: <https://books.google.com.ng/books?>
- [21] OECD. Entrepreneurship in Education. Retrieved from: https://www.google.com/url?q=https://www.oecd.org/cfe/leed/BGP_
- [22] UNESCO (2009) Science, technology and engineering for innovation and capacity-building in education and research. Retrieved from: https://unctad.org/en/Docs/ecn162009d3_en.pdf
- [23] Ushie, O., Ogbulezie, J., (2016). Teaching and Learning Methodologies in Engineering Education in Nigerian Universities.
- [24] Potts, Olivia (2019) Top 5 Trends in 2019. Retrieved from: <https://www.rocketpace.com/corporate-innovation/top-5-innovation-trends-in-2019>
- [25] Ravindra, Savaram (2018). Role of IoT in Education. Retrieved from: <https://www.kdnuggets.com/2018/04/role-iot-education.html>
- [26] Sima, V., Gheorge, I., Subic, J., Nancu, D., (2020). Influences of the Industry 4.0 Revolution on the Human Capital Development and Consumer Behaviour: A Systematic Review. Retrieved from: <https://www.google.com/url?q=https://ecdpm.org/wp->
- [27] Sonne Lina (2010). Pro-Poor, Entrepreneur-Based Innovation and it's Role in Rural Development. Retrieved from: https://www.researchgate.net/publication/46433656_Pro-Poor_Entrepreneur-Based_Innovation_and_it's_Role_in_Rural_Development
- [28] Spielman, D., Ekboir, J., Davis, K. (2009). The Art and Science of Innovation Systems Inquiry: Applications to Sub-Saharan African Agriculture . Retrieved from: https://www.researchgate.net/publication/248493574_The_art_and_science_of_innovation_systems_inquiry_Applications_to_Sub-Saharan_African_agriculture
- [29] Singh, S., Bhowmick, B., (2015) An Exploratory Study for Conceptualization of Rural Innovation in Indian Context.

- [30] Serdyukov, P. (2017) Innovation in education: what works, what doesn't, and what to do about it? Retrieved from:
<https://www.emerald.com/insight/content/doi/10.1108/JRIT-10-2016-0007/full/html>
- [31] Sullivan (2008). Defining Innovation. Retrieved from:
https://www.google.com/url?q=https://www.sagepub.com/sites/default/files/upm-binaries/23137_Chapter_1.
- [32] The African Capacity Building Foundation (2016). Africa Capacity Report 2017. Building Capacity in Science, Technology and Innovation for Africa's Transformation. Retrieved from:
<https://www.google.com/url?q=https://elibrary.acbfpact.org>
- [33] The World bank (2014), Improving the Quality of Engineering Education and Training in Africa. Retrieved from:
https://www.google.com/url?q=http://documents.worldbank.org/curated/en/773831468007776683/pdf/860620BRI0WB0H00Box382147B00PUBLIC0.pdf&sa=U&ved=2ahUKEwiq3b_LpvTpAhXE8eAKHXpiBgAQFjAAegQIAhAB&usq=AOvVaw0htsu2eh6Z2fFTMluFuXr
- [34] Tidd, 1997; Voss, 1994. An Exploratory Study for Conceptualization of Rural Innovation in Indian Context.
<https://www.sciencedirect.com/science/article/pii/S1877042815053045/pdf?md5=45c9a4f1f65b3ce9eef1cb9e4d9f450&pid=1-s2.0-S1877042815053045-main.pdf>
- [35] Ubels, J. Fowler, A. Baddo N (2010). A Resource Volume on Capacity Development. Retrieved from:
<https://books.google.com.ng/books?id=f57mbjF57bIC&pg=PA1&lpg=PA1&dq=rganizations,+sectors+and+institutions>.
- [36] Yusuf Kayode (2018) A lack of good education in STEM subjects is holding back African growth and depriving its youth of career opportunities. Retrieved from:
<https://www.accaglobal.com/in/en/member/member/accouting-business/2018/06/insights/stem-education.html>