

# Learning Factories as an Opportunity for Industrialization in Africa

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**Abstract:** Rapid development in modern industrial technology require pragmatic approach in the learning environments. Practical skills need to be imparted early among learners so that they are ready for industry practice. Because of research orientation of tertiary and higher learning institutions, they are at a vantage point to be aware of modern technologies earlier than industry. Taking a strategic initiative further to be technology transfer centers, learning institutions can adopt learning factories (LFs). Modern day economies are backed by emerging small and medium enterprises (SMEs). These SMEs are mainly founded by young graduates who have superior advantages in terms of trending technologies learnt in institutions that are practical and technology orientated. Africa industrialization agenda is better promoted through a strategic initiative of learning factories. The article seeks to promote learning factories among Africa's learning institutions as a strategic initiative to spearhead industrial development, innovation, and rapid growth of SMEs.

**Key words:** Industrialization, learning factory, technology transfer, innovation, engineering education, active learning, industry 4.0.

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## 1. Introduction

Industrialization is the backbone of manufacturing sector growth. Manufacturing industries play a crucial role in the overall Gross Domestic Product (GDP) in many countries. The contribution of the manufacturing sector to GDP in Africa has been suppressed for many years at around 10%. The booming of the Asian and Chinese economies has been attributed to significant growth in the manufacturing sector. In monetary value, Foreign Direct Investment (FDI) in the manufacturing sector has been increasing in some parts of Africa, such as Rwanda, Tanzania, Ghana, and Ethiopia. However, the percentage contribution of the sector to the GDP remains a paltry. Africa is classified as a booming population across the world. This creates a ready market if serious industrialization efforts are prioritized in the continent. Due to poor industrialization, many parts of Africa struggle to strike a balance of trade. More imports than what a country can export result in imbalance of trade. Overdependence on imports also makes Africa a dumping ground for sub-standard products. The majority of Africa is therefore swamped in debt. In most cases the poor nations are at the mercy of super powers, which craft unfavorable deals for bail out extensions and trade agreements. Until Africa attains high industrialization levels to gear up its manufacturing sector, its rich natural and wildlife resources will continue to be plundered. It's pathetic that younger generations may not savor the rich flora and fauna of their mother Africa in the near future.

Because of suppressed manufacturing activity across Africa, employment opportunities are very scarce. The young African population is worse than their elderly counterparts because of dwindling opportunities every day. It's either the few elderly cadres are holding on to any means of production, jobs, or political offices that remain in the continent. Consequences of limited economic activities on the younger generations are far reaching. Sooner or later the vast energy that younger generations have will be directed to disgraceful activities such as rampant crime, abuse of drugs, and cetera. Keeping these fresh minds in the factories, innovation hubs, research centers and learning institutions is the best initiative any responsible government can do. African governments do not necessarily need to fund all the initiatives, but creating conducive environments and acting responsibly can rescue a dire situation. History has proved that humanity cannot endure pain indefinitely. There is always a breaking point. Addressing the industrialization problem is one best approach to save the breaking point.

Some schools of thought praise the diaspora for injecting the precious foreign currency into their originating countries. However, the same human resource could have played greater economic roles in their beloved home, Africa. South Africa is one sub-Saharan African country that hosts many economic refugees from other African countries. Botswana and Namibia also fare well after South Africa in terms of hosting foreign nationals. The situation has not played out well for the past decades because of recurring xenophobic attacks. South Africa is well known for gruesome clashes between the citizens and other foreign nationals seeking economic refuge. Jealous and hatred brews among the different nationals, which result in clashes. Causes of xenophobia range from politics, job insecurity, locals' frustration, cultural misconceptions, poor living conditions, suppressed economic opportunities, and government insufficiencies [1]-[4]. Politically motivated incitement usually comes from political incumbents who point a finger on the supposedly unbecoming behavior from the accused foreign nationals. The support base respond by unleashing violence to the foreign nationals. Bluntly put, xenophobia is a case of starving dogs fighting over a small piece of bone. Africa generally loses its witty brains to continents that offer best opportunities. The number of Sub-Saharan immigrants in the USA rose from 130,000 in the 1980s to almost 1.8 million in 2015 [5]. These are the people who could have helped the African continent to fare well in world ranks economically and industrially. The human intellectuality is like an engine, if not run or put to use, it rusts off and turns obsolete. At least the diaspora community presents a starting point if Africa chooses to follow the responsible path and reinvents itself into an economic giant and industrial hub.

Industrial development helps nations to access world markets because of high quality and competitively priced products. African manufactured products are generally of lower quality than those from other continents such as Europe. Besides intellectuality, skill and quality systems, factories must be powered by advanced machinery in order to produce high quality goods. Investment in technology is poor across many African nations. Some African countries such as Zimbabwe have been blamed for lack of respect to human and property rights. Investors need guarantee that their investment is safe. If not secure, they will not invest optimally. Governments also play a key role in terms of regulation. Initiatives that encourage companies to import expensive modern equipment, such as duty waiver or subsidies, encourage industries to advance their factories. Africa must make its products competitive in terms of price and quality. Size of production facilities affect productivity, which in turn determines the economies of scale. China, for instance, offers incentives of bigger sizes of land for building factories. In Africa, land has become one of the priciest assets the government trades. Many aspiring manufacturers can only afford small sized portions of land, almost the size of backyard industries. Such misplaced priorities by African governments only worsen an already dire situation.

The article promotes the concept of learning factories (LFs) as an initiative to spearhead industrialization in Africa. Many universities in the USA, such as PennState, use the LF model in their Engineering Education

institutions. Sciences, Technology, Engineering and Mathematics (STEM) disciplines are practical oriented fields which must be taught practically. It's unfortunate that many African training facilities just offer mere classrooms for STEM education. The article uses case studies of other successful economies to demonstrate how Africa can industrialize, encourage kindergarten innovation and research.

## **2. Africa's Main Economic Indicators**

African economies are heavily dependent upon agriculture and mining. There is very little value addition across Africa. Most of the produce is exported in its raw form. This results in low earnings from exports. The manufacturing sector remains suppressed due to scarce raw materials. There is need to emphasize on value addition so that African exports can bring more income to originating countries. Building processing industries will also make raw materials readily available for other manufacturing activities, compared to the prevailing situation where few manufacturers have to import back the processed materials at higher prices than earned when the unprocessed materials were exported.

### **2.1. Gross Domestic Product (GDP)**

The world total nominal GDP for the year 2019 was projected to be US \$88 Trillion, about 3.8% growth from \$84.835 Trillion of the previous year 2018 [6], [7]. The top 5 countries in the world by nominal GDP are: United States (\$21.48 Trillion – 24.4%), China (\$14.172 Trillion – 16.1%), Japan (\$5.22 Trillion – 5.93%), Germany (\$4.117 Trillion – 4.67%), and India (\$2.957 Trillion – 3.36%). The top 5 countries contribute a total of 54.46% to the world nominal GDP. Other countries that feature in the top ten are France (3.23%), United Kingdom (3.19%), Italy (2.40%), Brazil (2.19%), and Canada (2.07%), respectively. The combined contribution of the top 10 countries to the world nominal GDP is 67.54%. Nigeria is Africa's largest economy, with a projected nominal GDP of \$447 Billion (0.508% share), followed by South Africa (\$385.53 Billion – 0.438% share). In 2018, the nominal GDP for Africa stood at \$2.337 Trillion (about 2.75% share of world nominal GDP) [8].

### **2.2. Foreign Trade**

Africa's exports are generally cheap because of little to none value addition. The total world proportion of Africa's foreign trade is very low. Other stronger economies that invest in industrialization add value to raw materials, as well as process them into finished goods and machinery. The finished goods become pricey when being exported back to Africa.

### **2.3. Foreign Direct Investment (FDI)**

FDI is important to the growth of African economies. African countries are low-medium income earners. The majority of the population are poor, and are characterized by serious economic disparities. This makes the economies look forward to FDI for growth prospects. More emphasis should be on investors who come to build high value-addition industries, not resource extraction and building malls or setting up shops that are filled with imported merchandise.

### **2.4. External Debt**

Most African countries are debt ridden. Although the situation has improved from the 1900s, most of the export earnings are being channeled towards servicing external debts. Initiatives such as the Heavily Indebted Poor Countries (HIPC) initiative and Multilateral Debt Relief Initiative (MDRI) often help some African countries to relieve their debts. By December 2017, Africa had a combined foreign debt of \$417 Billion, of which \$100 Billion (24%) was owed to the Chinese government and \$40 Billion (10%) owed to the Paris club governments [9].

## **2.5. Diaspora Remittances**

Diaspora remittances have become key indicators in overall economies in some parts of Africa. Instability and lack of economic opportunities in some African countries has pushed the skilled human capital to seek opportunities outside their borders. The gainfully employed economic refugees participate in their home country economies by remitting the dire needed foreign currency back to their homes. Most of the remittances will be going towards the upkeep of family members of the expatriates. In recent circumstances, foreign based nationals have taken active role in funding social causes, such as the Cyclone Idai, among other needs.

## **3. Learning Factories and Industrialization**

Industrialization requires a pragmatic approach that stems from kindergarten right through higher learning institutions. This approach ensures the involvement of all key stakeholders. The learners are the bedrock of the future economy and therefore must be the main focus of any change efforts. Today's manufacturing sector is characterized by fierce competition, short life cycles, frequent product introductions and demand variations [10]. The modern industry is very dynamic and uses advanced technology, which even seasoned industrialists could be witnessing for the first time. This positions the education and training facilities as the best point of contact with real world technology. Waiting until the learners go out in industry may be far damaging. There is need to retain interest, trigger innovation, and build expertise among the learners. When the cohort of learners attach high value to practicality, they are likely to venture into new enterprises that major in technologies they mastered during training. Those that may not be enterprising will advance the same concepts and skills in existing enterprises. Currently many firms in Africa are worry of new cohorts of graduates that are not conversant with practical technologies being used in industry. Many of these young graduates will be interacting with the technologies for the first time. Industries specialize in certain aspects of engineering practice, hence depending on where the leaners or graduates find jobs, they are likely to miss out on wide exposure. More aspects of LFs and industrialization are discussed in the next sections.

### **3.1. Industrial Revolution**

Industrial development has gone through four (4) revolutions in historic times. The humankind has been at the center stage of evolving the technology and resources used to make products. Necessity is the push factor that stretches the human mind to become innovative. As highlighted in the introduction, humankind cannot endure discomfort indefinitely. In times of need for better production means, advanced machinery is launched, whilst a threatening scarcity triggers optimization or substitution of resources. The phases of industrial revolution are denoted as 1<sup>st</sup> industrial revolution (industry 1.0) through 4<sup>th</sup> industrial revolution (industry 4.0). Many factories in Africa were set up during the industry 2.0 and early industry 3.0 phases. These were times when Africa had abundant resources just discovered by the colonial settlers. Heavy investment was poured in during those times since the superior colonial masters had authority to safeguard their investment. The equipment in these factories deteriorated over time. Little refurbishments were done in most of the factories, which today have become obsolete.

Industrial revolution occur under the seven tenants;

- availability of natural resources,
- transport or distribution network,
- surplus investment,
- skilled human resource,
- basic inventions, and

- favorable government policy.

Africa has abundant natural resources to sustain manufacturing endeavors. Annually, a significant proportion of natural resources are looted to support value addition in economies with thriving manufacturing sectors. Perennial problems of infrastructure, lack of investments, unique talented human resource base and weak governmental policies, hinder industrial development in Africa. Self-consolation over availability of resources is no reason enough to relax and think every investor is attracted to Africa. That kind of complacency has left many African nations at the mercy of ruthless and dubious investors who do not have sound business ethics. This situation broods a one-way relationship that only benefits the few foreign investors rather than fostering a holistic development. Skilled personnel and basic inventions can be achieved through adopting LFs as a key initiative in STEM education. African governments can also adopt deliberate policies that promote industrial development. Once a conducive environment is set, issues of infrastructure and surplus investments can fall in place.

Major developments have happened in the four phases of industrial revolution. Unfortunately most of the developments took place when many manufacturers were packing up their bags from Africa in preference for new found homes, particularly China. The boom of China's manufacturing sector happened in the eye of deliberate policy shift. The exodus of industries out of majority African nations coincided with changes in the African political front, where indigenization policies were being mulled. Global economic recession worsened the situation.

The current level of industrial revolution, industry 4.0, is anchored on integrated technologies that include Internet of Things (IoT), Cyber Physical Systems (CPS), and Cloud Computing (CC) [10]-[12]. Cyber-physical systems (CPS) are physical and engineered systems, whose operations are monitored, coordinated, controlled and integrated by a computing and communication core [13]. CPS can be considered to be a confluence of embedded systems, real-time systems, distributed sensor systems and controls. CPS-enabled smart factories have a network of intelligent objects linking products and assets with information from the internet, as well as capturing context information. Many factors contribute to the progression of manufacturing trends through to the current phase (industry 4.0) and beyond. Some of them include shorter product life cycles, increasing product variation (mass customization), volatile markets, cost reduction pressures, scarce resources, cleaner production, lack of skilled workforce and aging community [14]. Cyber Physical Systems (CPS) and Internet of Things (IoT) technologies such as RFID, wired and wireless sensor networks, and embedded systems enable the digitization and virtualization of shared resources and capabilities in the services, manufacturing and supply chain management for access through the cloud resource pool. These technologies extend the internet into the real world, embracing everyday objects. Cloud Computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [15]. Individuals and corporate end users access the cloud through internet and access spans over different enterprises and platforms. Cloud services are based on technologies such as HTTP, HTML, XML, JavaScript, or other protocols. CC makes it possible to deliver enterprise information systems (EISs) where each party can contribute to the establishment of the advanced system, while delivering superior integration capabilities with any party's legacy systems and web-based intranets applications.

Super economies are benefiting from industry 4.0. Businesses have become smarter and more effective. However, this also means more disruption. Status quo is threatened. Companies must be agile and innovative in order to disrupt, instead of being disrupted. Figure 1 summarizes the four (industrial revolutions)

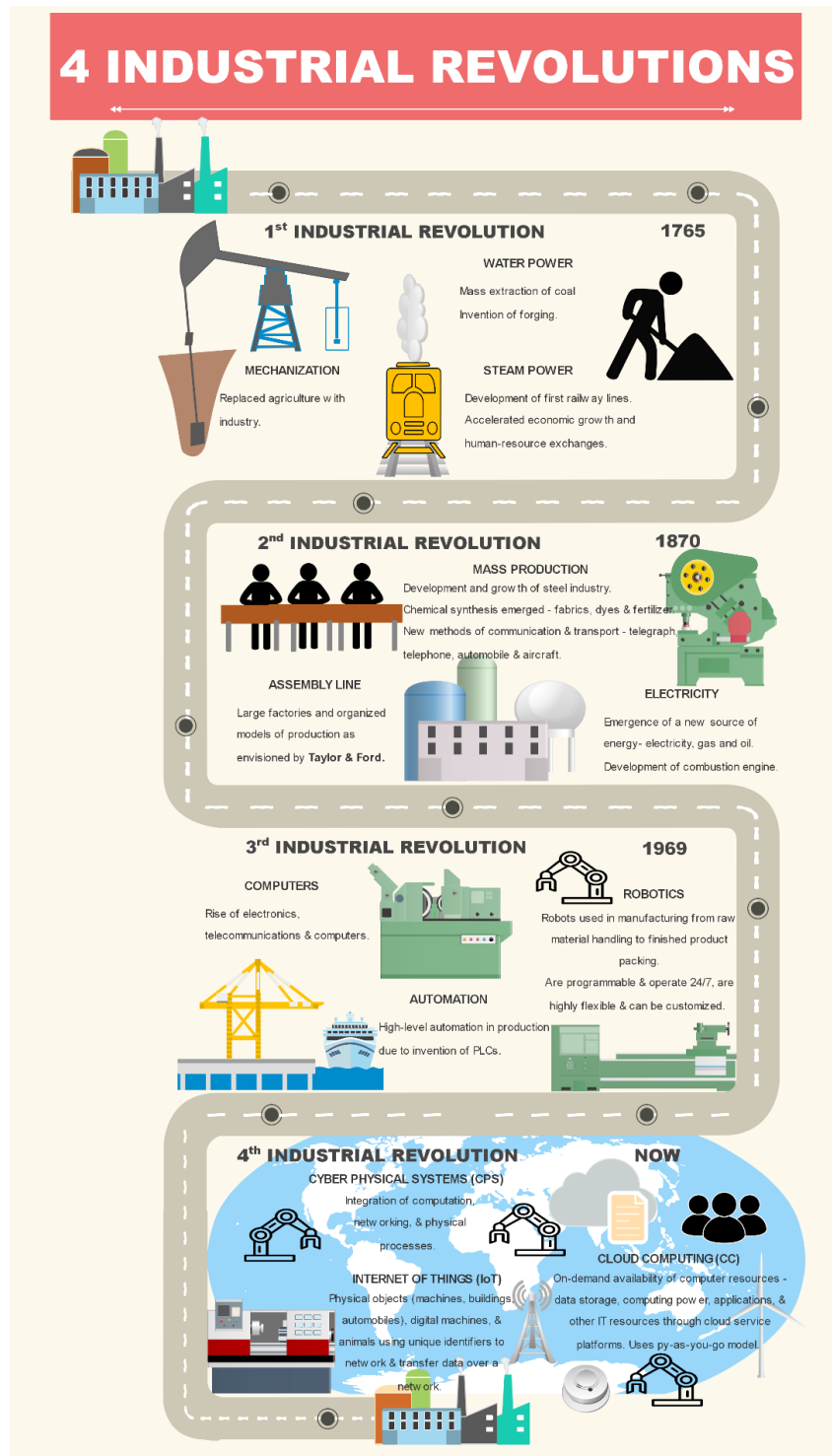


Fig. 1. The four (4) industrial revolutions.

### 3.2. Learning Factories in Engineering Education

Engineering education curriculum is centred on solving societal problems by using proven science to design products and systems. Because of the ever-growing complexity of the modern world, design is gaining more attention [16]-[18]. University campuses and other training institutions are phasing out traditional machine shops, combining the traditional equipment with digital design and manufacturing tools to establish creative communities [19]. Various initiatives have been pioneered to promote creativity

and innovation among student and professional communities. Such efforts range from boot camps to winter school programs. They promote rapid catching up with fast-changing technology, in collaborative, unique and inspiring environments. Unlike the formal education curricula which contributed to official assessments, these activities are extra curricula and administered to multi-disciplinary groups who are self-motivated to go an extra mile. The approach generates a significant multiplier effect where more interested individuals collaborate.

A learning factory (LF) is an idealized replica of the real world value chain industry that supports formal and informal learning through interdisciplinary hands-on engineering design projects with strong links and interactions with industry [10], [20], [21]. The LF concept was pioneered by a group of universities from the United States in 1995, led by Penn State University [22], [23]. Later on the European government and other states adopted the LF initiative to enhance education of engineers. LFs bring the real world into engineering education. Engineering graduates are exposed to the real life product life cycle – conception, design, prototyping, manufacturing and distribution. LF facilities consist of modern manufacturing facilities – CAD/CAM, CNC and manual machine centers, 3D printing, welding, and metrology.

Following the successful patenting and rollout of the LF concept, many other hybrid concepts were launched as efforts to allow students to develop real world competences in engineering. These are generally classified as “learning spaces” [24], [25], because they help learners to carry out research, identify and solve problems, collaborate with others in managing situations, ponder and evaluate their actions. Over the past two decades, terms such as Hacker Spaces, Maker Space and FabLab emerged. These later versions seem to have gained more popularity than the original “Learning Factory”. However, the concept still remain the same. Hacker and maker spaces (HMSs) are open-access workshops devoted to creative and technical work. They are a significant movement supporting informal learning through tinkering and hacking [26]. Makers interact with a growing global community of hackerspaces, makerspaces, fab-labs, and other collaborative spaces to share ideas and resources, promoted by an open-source culture. Makerspaces and Fab-Labs are more formalised and have a defined model which is easy to replicate. HMSs help in reorienting education institutions to foster a mindset of creativity and innovation. They promote learning by doing and project-based learning. These workspaces and their cloud platforms support learning and doing in a way that redefines traditional education and traditional manufacturing [27]. Smart tools, digital fabrication, and computational technology combine with the Internet to share ideas, solutions to problems and projects that the community members can easily make following instructions provided. The maker movement is a launch pad for a future where people become agents of change who pioneer the future they perceive with few constraints.

Fab-Lab is short for “fabrication lab.” Activities in Fab-Labs include digital design, 3D printing, laser cutting, CNC machining and various physical construction, using tools, crafts, and modern technology. The non-generic use of the term Fab-Lab refers to spaces and organizations who participate in a network run by the Fab-Foundation led by Neil Gershenfeld and Sherry Lassiter of the MIT Center for Bits and Atoms [28]. In 2012, there were nearly 100 Fab-Labs, at the beginning of 2016, there were 618 and in September of the same year already 711 Fab-Labs [28], [29]. The Fab-Lab network continues to grow due to its positive impacts on learning, fostering creativity and innovation. Fab-Lab community is driven by openness and constitutes of fabricators, artists, scientists, engineers, educators, students, amateurs, and professionals. There are currently over 1,000 Fab-Labs, located in more than 100 countries across the world, and the numbers continue to grow. The Fab-Foundation provides a template and budget for setting up a Fab-Lab. The Fab-Labs are being adopted by universities, primary and secondary schools, and many innovation centers. They provide a better model which promotes agile development and testing of new ideas compared to traditional workshop facilities that were defined by subjects or disciplines they catered for.

Educational makerspace communities support academic, extracurricular and personal design activities under the watch of schools, university faculties, staff, and students. Makerspaces are more useful in promoting engineering design because they shorten the time taken to launch new ideas into physical designs. They support iteration of ideas until better solutions are achieved. The culture of the maker movement promotes hands-on learning, openness to new ideas, diversity within problem-solving teams, sharing of techniques and results, teamwork, and multi-disciplinary approach. People use makerspaces for socializing and learning. Individuals with diverse backgrounds and skills come together, self-organize according to their needs and take decisions collectively on issues that appear throughout a project's life [30]. Through activities such as workshops, software and hardware development, prototyping of new products and processes or improvement of existing ones; the overall aim is to facilitate collective discovery and experimentation, enabling the community to participate actively by peer to peer learning and horizontal knowledge exchange [31].

### **3.3. Promoting Industrial Development**

Industrial development needs a deliberate approach, rather than to leave the situation to go out of hand. Africa must actively promote industrial development through targeted infrastructure, skills development, financing models, promoting partnerships between public and private sector (**3Ps**), and preparing for a digital future. There are many examples to benchmark with – Japan, China, Brazil, Korea, Taiwan, Thailand, Malaysia, Singapore and India. The cited nations illustrate the essential role of the state in providing a fundamental framework for regulating the political and economic environments [32].

Noteworthy to say, direct duplication of policy framework and initiatives from other nations may not always produce similar desired results. The initiatives given below for promoting industrial development are mere guidelines. Every nation has unique scenario which calls for adapting the solutions to suite the prevailing conditions.

**Policies on innovation** have pushed low ranked nations to attain higher rankings on key innovation indices. The dynamic market forces prevailing in the modern digital economy require serious innovation. African governments can rescue the situation by crafting favorable policies that support innovation in learning and research institutions as well as private sectors. Typical interventions could target financial support through banks, national credit institutions or venture capital. Innovative companies must be accorded the right kind of support needed to speedily move products from the laboratories to the market. The current industry 4.0 trends require companies to have short time-to-market. As discussed in previous sections, LFs are ideal for developing local industrial capacity to be able to create technologies suited to local conditions, as well as the global economies. These efforts should be preceded by deliberate technological acquisition, technology transfer, and adaptation to local environments.

**Policies on structural transformation** can bring overall sustainable development. Africa has relied on low level value addition based industries such as agriculture, mining, and wildlife for too long. New dimensions may seek to create a balance between the environment, development and equity distribution. There is need to shift resources (financial, natural and human resources) from traditional low value addition industries towards high value addition sectors. Industry 4.0 brought up many service sector based opportunities which Africa can also tap into. Modern industries are connectivity and data driven. A plethora of service oriented operations run on the backbone of cloud computing (CC) and internet of things (IoT). Industrial based high value addition activities involve setting up refineries to further process extracted minerals, building upstream industries to manufacture jewelry, ornaments, and fabrics from wildlife byproducts. These initiatives require emphasis on competence based education and ownership of the development process. Africa's workforce is envisaged to double by 2020. Calculated policy moves determine the quality of the future workforce and the nature of industrial activity in Africa.



**Promoting job growth** through relevant regulations in targeted sectors is important. The African continent has unique advantages due to favorable climatic conditions that sustain wildlife, forestry and crop production. Bilateral trade policies and agreements may be mooted for specific advantageous sectors. These could be in line of incentives for certain exports of an African origin, such as leather products, ornaments, jewelry, and agricultural produce. Botswana, for instance, has abundant beef which are exported to certain markets duty-free. Lesotho and Ethiopia are among other 40 African countries that benefited from the African Growth and Opportunity Act (AGOA) of 2000, which gives duty-free access to about 6 400 products to US markets. Another deliberate initiative to promote job growth is by enacting unique policies for certain industry sectors. For instance, waiving tax obligations for a certain number of years for newly formed businesses in particular sectors. Recently there has been a hype of talk about ease of doing business across most parts of African economies. Governments can cut unnecessary regulations and procedures in opening up businesses and other compliance matters. The export markets are usually marred by unnecessary red tape, which stifles efforts of exporters. Rwanda is one emerging African jewel due to significant improvements in terms of systems and procedures across the economic divide. This incentivizes new industry players to invest in setting up manufacturing facilities, create more jobs, boost national productivity and achieve economies of scale. Competitively priced goods are more preferred in the global markets, regardless of their origin.

**Public-Private Partnerships (3Ps)** boost industrial relations and create a balance of technology, skills and labor options. Public institutions are built with public tax funds and should be accessible for industrial development. Some African governments have invested in education and research infrastructure which are accessible to learners only. Fostering a collaborative environment through university-industry linkages, institutional support, policy alignment, directing investment into research, innovation and knowledge infrastructure can catapult industrial development across Africa. Establishing LFs in universities and other training institutions makes the public sector attractive when setting up **3Ps**. There should be mutually beneficial partnerships, as opposed to the public sector extending its begging bowl. The private sector is there to bring reality into the engineering education system through sponsored real-world problems. Also, the notion that public resources are for free does not help the situation. There should be no free meal in **3Ps**. Funds paid to access resources from either side should go into sustaining the systems and facilities. However, rent-seeking behavior and profiteering must be abolished if ever meaningful and lasting relations should be cultivated. **3Ps** are there to build capacity in science and technology, innovation systems, technopreneurship.

**Productivity improvement and global trade** has more success potential compared to localized targets. Many African initiated policies have targeted import substitution and capacity building for local firms to meet domestic demand. Such efforts are short-lived and unsustainable. No nation is completely self-reliant. As long as there is need to import some products, such as fuel and advanced machinery, global based trade focus turns out to be more sustainable. There is huge growth potential in global trade, hence more foreign currency earnings. Domestic markets are usually small to absorb all the produce. Lack of competitiveness can also lead to complacency in domestic industries. An in-depth analysis of the industrial revolutions has shown that most of the industries in Africa were set up in the past centuries. Efforts to increase capacity utilization in many of these obsolete industries has not borne any fruits. Rather, Africa must focus on initiatives to increase productivity and quality through advanced machinery, large capacity building, modern systems of production, and operations management. Global trade focus guarantees industrialization success through a ready global market, capital formation, and sustainable balance of trade. Domestic industries will not necessarily compete among themselves but will complement each other in boosting the national productivity and export volumes. Efforts to support a unified industrial sector in

terms of transport and logistics, and export corridors will be well coordinated. This has led to the development of Special Economic Zones (SEZs) in some economic sectors.

**Political stability** is relevant to achieving sustainable industrial development. Bad politics chases away capital. Most African nations are regarded as having high political risk. Investors, both domestic and foreign, shun environments which are risky. Investment thrives in nations which respect property rights, human rights, and upholds the rule of law. Nations with high political instability turn out to be corrupt, have unnecessary red tape, and labor unrest. Political instability breeds lawlessness and chaos. Reports and investigations of state capture have been witnessed in certain African countries, South Africa, in particular. A trend of coups also seem to be cropping up in Africa. In November 2017, a long serving Zimbabwe's president (Robert Gabriel Mugabe) was unseated through the intervention of the army.

#### 4. Conclusion

Engineering education is fundamental to social economic development and industrialization. However as discussed in the chapter, Africa must adopt modern initiatives such as Learning Factories. This will help African training institutions to switch from teaching knowledge to teaching competences. The redefined "learning spaces" shorten the time taken to launch new ideas into physical designs. They support iteration of ideas until better solutions are achieved. LFs promote hands-on learning, openness to new ideas, diversity within problem-solving teams, sharing of techniques and results, teamwork, and multi-disciplinary approach. Nations that support competence based engineering education are better industrialized and have higher GDP contribution from the manufacturing sector compared to the majority of Africa. Current production systems are very dynamic as evidenced by the detailed review of the four industrial revolutions. The current phase, industry 4.0, transforms speedily compared to former revolutions which were stable. Africa can better achieve industrialization by matching current industrial trends and through ownership of the transformation process.

#### Conflict of Interest

The author declares no conflict of interest.

#### Author Contributions

The author carried out all the analysis, reviews and recommendations solely.

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