Black Africans' Contributions to Global Industrial Revolutions

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Abstract

This article evaluates the contributions that have been made by Black Africans (in Africa and the diaspora) to the different industrial revolutions. The methodology used in this research was mainly qualitative. The findings confirm that Black Africans had achieved technological advances before the arrival of Western and Eastern slave traders and colonialism in Africa, and had made substantial contributions to the pre-industrial revolution and the first industrial revolution. Even though slavery and colonisation halted further technological innovation and advancements, there is strong evidence to suggest that Black Africans are currently contributing to the Fourth Industrial Revolution. Impressive innovations are coming from Africa. African leaders must support Africans' technological innovations through funding, proper training, and availing raw materials for them to contribute to the Fourth Industrial Revolution.

Introduction

The purpose of this article is to critically evaluate the contributions made by Black Africans to the different industrial revolutions of the past and to explore what Black Africans can contribute to the Fourth Industrial Revolution (4IR). From the onset, the concept 'Black Africans or African people' refers to Black Africans and their dependents with African ancestry in the diaspora. It documents examples of technological contributions made by living and non-living people with African ancestry to demonstrate that Black African people can play a leading role in the current 4IR and future industrial revolutions, irrespective of where they live in the world. The specific intention of this article is to motivate current and future generations of Black Africans by showing them how our ancestors dominated the technological advancements and innovations in what is called the pre-industrial revolution by Western countries; and how Black Africans lost their dominant position in the global technological advancements because of the slave trade, colonisation, and the religious brainwashing that came with these. The article starts with a conceptual and historic overview of the different industrial revolutions and what the 4IR truly entails. It proceeds with a discussion of how Black Africans contributed to technological and scientific innovations of the past industrial revolutions. The article concludes with suggestions for what Black Africans can do to benefit from the 4IR and contribute to its technological innovations. The conceptual and historical development of different industrial revolutions and their effects on the African continent are discussed in the next section.

Conceptual and Historic Overview of Past and Present Industrial Revolutions

The Fourth Industrial Revolution (4IR) has dominated the media, political and economic circles, and academia in Africa and around the globe since the beginning of the 21st century (Maharajh, 2018: 1). Although used earlier by French writers, the term 'industrial revolution' was first popularised by the English economic historian Arnold Toynbee (1852–1883) to describe Britain's economic development from 1760 to 1840. 'Industrial revolution' initially meant 'complete change in the relationship between employers and employees brought about by mechanical inventions in the late 18th and early 19th century' (Fowler & Fowler, 1965: 621). In modern history, the term has been more broadly applied by the media, researchers, politicians, and even ordinary people on the streets to describe the different industrial revolutions dominated by industry and machine manufacturing that followed the UK's First Industrial Revolution (1IR) (Maharajh, 2018: 1). The first part of this article provides a brief discussion of the different industrial revolutions and the disruptions associated and identified with them in the literature; the second part discusses Black Africans' contributions to the different industrial revolutions.

The Journey from the Pre-Industrial Revolution to the Fourth Industrial Revolution (4IR)

The Pre-Industrial Revolution period entailed 'the transition from foraging (wild fruits gathering and wild animal hunting) to farming and animal domestication, which started about 10 000 years ago' (Schwab, 2016: 11). This period ended in the 18th century (1760 to 1840) when the steam engine was developed and used to mechanise, which began the mass Industrial Revolution, first in the UK and later in other Western industrialised countries. The pre-industrialisation period was dominated by the agrarian revolution, which was made possible by the combined efforts of human labourers and animals. Black African slaves were the main source of labour used in the production of products such as sugar and cotton in the European countries and their colonies (Williams, 1988). People and animal labour were also the main source of transportation and communication (Schwab, 2016: 11). The 1IR, which is discussed below, was the next step in the evolution process of the agrarian revolution of the Pre-Industrial Revolution.

The First Industrial Revolution (1IR)

Historical literature shows that the First Industrial Revolution (1IR), 'began in Britain in the 18th century (1760 to 1840) and then from there spread to other parts of the world' (Encyclopaedia Britannica, 2019: 1). The 1IR was epitomised by the development of the steam engine (Harvey, 2017: 2). The steam engine ushered in the mechanical production of

things that were traditionally done by humans and animals in the 1IR (Xing and Marwala, 2019: 2). 'Steam engines use hot steam from boiling water to drive a piston (or pistons) back and forth' (Ślusarczyk, 2018: 232). The steam engine enabled industry owners to mechanise mass manufacturing and build locomotives powered by steam engines to transport people and products to different places great distances apart (Xing and Marwala, 2019: 2). Because of the steam engine, machinery was able to function much faster, with rotary movements and without human power (SAHO, 2017: 1). Noticeably, coal became a key factor in the success of industrialisation. It was used to produce the steam power on which industry depended (SAHO, 2017: 1).

The Second Industrial Revolution (2IR)

The world entered the 2IR with the discovery and use of electricity in factories in the latter part of the 19th century and the early part of the 20th century (Ślusarczyk, 2018: 232). The discovery of electricity made it possible to produce electricity-powered machines/tools, which made mass production much faster than it was in the 1IR (Harvey, 2017: 2; Xing and Marwala, 2019: 1). Because of electric motors, car manufacturers such as Henry Ford increased efficiency on a large scale (i.e. mass production and assembly lines in automobile manufacturing industries as a way to boost productivity) (Schwab, 2016: 11). Because of the discovery of electricity, it was possible to manufacture items that use engines to function, such as aeroplanes, telephones, cars, and radio, most of which could be manufactured through mass manufacturing/production. Electricity led to the further automation of many tasks previously performed by steam engines in the 1IR (Nalubega and Uwizeyimana, 2019).

"There is no doubt that the 4IR differs from the other industrial revolutions that came before it. Unlike its predecessors, the 4IR is based on three 'megatrends', namely physical, digital, and biological (Xing and Marwala, 2019: 1), which are deeply interrelated. In fact, the various technologies of these megatrends benefit from each other and improve based on the discoveries and progress each makes (Schwab, 2016: 17)."

The Third Industrial Revolution (3IR): Electronic/ Programmable Tools

The 3IR slowly began to emerge in the late 1950s and early 1960s. John Bardeen and Walter Brattain's discovery of the transistor in November 1947 catalysed the 3IR. This discovery led to the electronic age that gave the world computers and the internet (Xing and Marwala, 2019: 1). In addition to the development of semiconductors and mainframe computing (the 1960s), other technological inventions of this era included personal computing (1970s and 80s) and the internet (1990s) (Schwab, 2016: 11). Therefore, it is often said that the 3IR (characterised by electronics, the internet, and the use of information technology) further automated mass production (Ślusarczyk, 2018: 232).

The Fourth Industrial Revolution (4IR): Robotics and Artificial Intelligence (AI) (2000 onwards)

There is no doubt that the 4IR differs from the other industrial revolutions that came before it. Unlike its predecessors, the 4IR is based on three 'megatrends', namely physical, digital, and biological (Xing and Marwala, 2019: 1), which are deeply interrelated. In fact, the various technologies of these megatrends benefit from each other and improve based on the discoveries and progress each makes (Schwab, 2016: 17). Thus, the 4IR refers to a new phase that focuses heavily on 'interconnectivity, automation, machine learning, and real-time data' from the physical, digital, and biological fields of practices and disciplines (Marwala, 2007). Xing and Marwala (2019: 2) argue that several rapid changes in physical technologies (e.g. intelligent robots, autonomous drones, driverless cars, 3D printing, smart sensors, etc.); digital technologies (e.g. the internet of things [IoT], services, data and even people, etc.); and biological technologies (e.g. synthetic biology, individual genetic make-up, and bio-printing, etc.) will inevitably and profoundly affect the way we work, learn, and live. These technologies have already become crucial for economic competitiveness and

social development. The link between physical and cyber networks is expected to allow continuous and uninterrupted real-time information flow for robots to do the work and perform tasks that were done by humans in the past (Nalubega and Uwizeyimana, 2019). Machines and robots powered by AI are therefore the hallmarks of the 4IR (Xing and Marwala, 2019: 1). The 4IR is about connectivity between the industrial IoT and Big Data and will require secure and reliable infrastructure to allow for machine learning. The connectivity between the industrial IoT and Big Data enables machine learning to take place, and the emergence of AI machines and robots that can perform sophisticated tasks better, faster, more efficiently, and more effectively than humans (Ślusarczyk, 2018: 232). The following sections focus on Black Africans' contributions to technological innovations that constitute the different industrial revolutions. The following are just a few of the many examples of historical records of Black Africans' technological innovation contributions to different industrial revolutions in almost all fields including, but not limited to: medicine, philosophy, astronomy, mathematics, physics, civil engineering, and other fields.

Contributions of Technological Innovations by Black Africans to Different Industrial Revolutions

> 'I have great respect for the past. If you don't know where you've come from, you don't know where you're going. I have respect for the past, but I'm a person of the moment. I'm here, and I do my best to be completely centred at the place I'm at, then I go forward to the next place' (Angelou, 2011).

This opening statement by American poet Maya Angelou (1928–2014) teaches us that the knowledge of where one comes from is an important starting point for one's discovery of what one can do or can become in the future. This statement seems to be true if one looks at the historical records about the indigenous Black Africans in Africa.

Black Africans' Contributions to the Pre-Industrial Revolution

The literature suggests that the Pre-Industrial Revolution era, in both Africa and the rest of the world, was characterised by manual and animal labour. There is evidence to suggest that most African societies had developed technologies in almost all the fields many millennia before what is known as the Pre-Industrial Revolution, long before the arrival of Western colonisers in Africa. While most African countries import everything small and big from Western and Eastern countries, historical records show that Black African ancestors were self-sufficient in almost everything. The oldest stone tools in the world have been found in eastern Africa: 'evidence for tool production by our hominin ancestors has been found across Sub-Saharan Africa' (Maropeng 2021: 1). A review of historical records shows that Africa has the world's oldest record of human technological achievements, long before the arrival of colonialism.

Advancements in Medicine, Surgery, Caesarean Sections, and Mathematics before the Arrival of the Slave Trade and Colonialism

According to Opoku-Mensah (2019: 1), Andreas Vesalius (the 16th century Dutch anatomist and physician), has often been considered to be the father of modern human anatomy because of his influential book, De Humani Corporis Fabrica Libri Septem. However, this is not entirely true, because a study of some of the greatest contributions of Sub-Saharan Africa to human development suggests that the field of anatomy first evolved in Egypt (3,100 B.C.). According to Brazier (2018: 1), 'Ancient Egypt was a civilization that lasted from 3,300 to 525 B.C.E.' Historical records show that the process of gaining knowledge about human anatomy and the cranium began with the ancient Egyptians, whose embalmers were required to gain anatomical knowledge to perform mummification rituals (Opoku-Mensah, 2019: 1). The Egyptians developed the process of embalming before anyone else could imagine that embalming was possible around 3,200 B.C. The reason that the Egyptians embalmed bodies was because they believed religious resurrection could only occur for bodies which were preserved intact (Raymond, 2020: 1). Modern embalming methods originate from Egyptian embalming technology and practices (Raymond, 2020: 1).

A review of historical records also shows that the first school solely dedicated to medicine dates back to ancient Egypt's first dynasty ((c. 2,925–c. 2,775 BCE) (Liberato, 2019: 1). Physicians came from all over

the world to study at Egyptian schools that, when translated, were called The House of Life. Unlike the rest of Africa where knowledge was mostly passed from generation to generation through oral history, medical practices in Egypt were meticulously recorded by scribes on papyrus scrolls, such as the ones known as the Ebers Papyrus (named after the British trader Georg Ebers who claims to have purchased it from Egyptian tomb raiders or could have stolen it from an Egyptian tomb in 1873). The other record is what is referred to as the Edwin Smith Papyrus (also named after the man who may have purchased it or stolen it from an Egyptian dealer in 1862) (Sutherland, 2016). The Edwin Smith Papyrus is a medical text on surgical trauma, dating back to 1,600 B.C., and is considered to be the only medical papyrus of its time to reflect a systematic scientific approach to medicine (Brazier, 2018: 1). Another early medical dissertation is the Ebers Papyrus (an Egyptian medical papyrus of herbal knowledge dating to circa 1,550 B.C.), which contains over 700 remedies and magical formulas and several incantations which are aimed at repelling demons that cause diseases (Brazier, 2018: 1). It is believed that the authors of the Ebers Papyrus likely penned them around 1,500 B.C.E.; however, the document may contain material dating back to 3,400 B.C.E that was copied and included for the preservation of knowledge (Brazier, 2018: 1).

The two papyruses are among the oldest preserved medical documents in existence. The Ebers Papyrus 'provides evidence of some sound scientific procedures', some of which are still practised today (Brazier, 2018: 1). A closer look at the Ebers Papyrus shows that ancient Egyptian doctors had specialised knowledge of dentistry, pharmacology, gynaecology, autopsy, embalming, and general healing. The largest contribution the ancient Egyptians made to medicine may be that they realised that the pulse related to the heartbeat and that the bronchial tubes were related to the lungs (Brazier, 2018: 2). The first known physician was the high priest and Vizier, Imhotep, who lived from 2,667 B.C. to 2,648 B.C. The polymath Black man Imhotep is the true father of medicine in world history. This genius African doctor is believed to have diagnosed and treated over 200 diseases that included (but were not limited to) the abdomen, eyes, rectum, bladder, and many more. He also practised surgery as well as dentistry. Because of his abilities to treat and heal many diseases he was initially considered to be a demi-god. He was elevated to full God status in 525 A.D. and is the only human being ever to be given this status (Brazier, 2018: 1). The fact that an ordinary person was given a status which was known to be exclusively reserved for the Creator alone in ancient Egypt suggests that Imhotep was a genius and a successful doctor in his time.

Ancient Africa's contribution to scientific knowledge was not limited to Egypt. It is said that European travellers in the Great Lakes region of Africa during the 19th century also reported cases of surgery in these kingdoms (Doyle, 2006: 37). Medical historians, such as Jack Davies, argued in 1959 that Bunyoro's traditional healers could have been the most highly skilled in pre-colonial Sub-Saharan Africa. The Bunyoro's traditional healers possessed a remarkable level of medical knowledge (Davies, 1959: 47). According to Doyle (2006: 32), Caesarean sections and other abdominal and thoracic surgery operations were performed regularly in the Great Lakes region of Africa. These ancient surgeons used antiseptics, anaesthetics, and cautery iron to avoid haemorrhage and sepsis.

In addition, around 400 B.C., West Africans began smelting iron. Societies in East Africa—in what are now known as Tanzania, Rwanda, and Uganda—had achieved significant advances in metallurgy and tool-making between 1,500 and 2,000 years ago. These advances in scientific knowledge and tool-making were more significant than those of Europe, which astonished Europeans when they learned about it (Opoku-Mensah, 2018: 2). In fact, ancient East African furnaces could reach 1,800°C, 200 to 400°C warmer than those used by the Romans at the time (Opoku-Mensah, 2018: 2).

As Lovejoy (n.d.: 14) puts it in the analysis of African Contributions to Science, Technology and Development, scientific discovery in almost every field such as Mathematics can be found in the 35,000-year-old textbooks on mathematics in Egypt. These were housed in the Library of Alexandria founded in 295 B.C., which is now considered the largest library in the classical world. Another example is the Sankoré University in Mali (1312 C.E. to 1337 C.E.), which was capable of housing 25,000 students and had one of the largest libraries in the world containing between 400,000 and 700,000 manuscripts. There is a consensus among many scholars such as Strouhal

(1989: 241) that ancient Egyptian mathematicians had an impeccable understanding of the principles underlying the Pythagorean theorem. The ancient Egyptians knew, for example, that 'a triangle had a right angle opposite the hypotenuse when its sides were in a 3 - 4 - 5 ratio' (Katz and Imhausen, 2007: 31). They were also able 'to estimate the area of a circle by subtracting one-ninth from its diameter and squaring the result' (Strouhal, 1989: 241; Katz and Imhausen, 2007: 31), as follows:

$$\text{Area} \approx [(8/9)D]^2 = (256/81)r^2 \approx 3.16r^2,$$

[Sources—Strouhal, 1989: 241; Katz and Imhausen, 2007: 31]

According to Strouhal (1989: 241) and Katz and Imhausen (2007: 31), the above area formula is the closest approximation of the modern mathematic formula πr2. In addition, Kemp (1991) states that 'the golden ratio seems to be reflected in many Egyptian constructions, including the pyramids' (Kemp, 1991). In fact, according to Bianchi (2004: 230), the engraved plans of Meroitic King Amanikhabali's pyramids show that Nubians had a sophisticated understanding of mathematics and an appreciation of the harmonic ratios (HR). They also provided other sacred ratios with incredible details of time and space (i.e. duration, length and size of the days, months, and years) in what is known as sacred geometry. The engraved plans of the HR are indicative of much to be revealed about Nubian mathematics. Lovejoy (n.d.: 14) avers that the application of technology to the natural environment by ancient Africans has been a vital part of the history of Africa and the development of the African diaspora throughout the world, especially in the Americas. When Black Africans migrated, whether they did so as slaves or as willing travellers, they took with them knowledge of agricultural techniques and skills that they were able to employ in other countries to develop the natural environment into farmland (Blackburn, 2011).

The history of science and technology in Africa since then has, however, received relatively little attention compared to other regions of the world, despite notable Black Africans' developments in mathematics, metallurgy, architecture, and other fields in the Pre-Industrial Revolution era.

Black Africans' Technological Innovation Contributions to the First Industrial Revolution (1IR)

The 1IR period (1750–1840) is believed to have led to the Berlin Conference, which kickstarted the 'Scramble for Africa' from 1884 to 1885 (Mjamba, 2014). The Berlin Conference signalled the start of a long period of colonialism, which was between 1804 and the 1950s, even though some countries such as Namibia, Zimbabwe, and South Africa attained independence between 1980 and 1994. By the time of the 1IR in Britain in the 18th century (Encyclopaedia Britannica, 2019: 1), Britain, Spain, Portugal, France, Germany, and other Western countries were already aware of the existence of the abundant natural resources in Africa (and other colonised parts of the world) (Austin, 2021). Colonialism helped to achieve several objectives, namely, to extend markets, keep the enslaved people in their home environments, and access much-needed raw material for free from colonised countries (Austin, 2021). Instead of establishing commercial partnerships with the Black African kingdoms, they colonised them so that they could acquire free raw materials and free human labour (Kessler, 2006: 1).

It is therefore not surprising that Britain, the country in which the 1IR started, also had many colonies under its control in different parts of the world. This is confirmed by Hudson (2011: 1) who stated that the Industrial Revolution began to transform Britain to such an extent in the 19th century that by the time of the Great Exhibition in 1851, the country became known as the 'workshop of the world'. 'The Great Exhibition of the Works of Industry of All Nations (also called the Great Exhibition or the Crystal Palace Exhibition)', which took place in Hyde Park, London, from 1 May 1851 to 15 October 1851 was an international exhibition (The Gazette, n.d.: 1). It is therefore not surprising that World War I (1914–1918) and World War II (1939–1945) were fought between Western powers to wrestle colonies from each other. As Crowder (1985: 1) argues, the most important legacies of WWI were the reordering of the map of Africa by creating artificial borders which characterise Africa today. It is also during this time in 1914 that Germany lost control of its colonial empire to the Allies (Handerson, 1942: 124).

It is important to note that no colonial power developed manufacturing industries in their colonies. Manufacturing in colonial countries was

discouraged to avoid competition for raw materials with manufacturing industries back in Europe. Therefore, Black Africans lost everything from wealth and skills to belief systems, and become impoverished during the colonial era. King Leopold II of Belgium's speech, which shows the real intention of the Christian missionary journey in Africa, was exposed to the world by Mr Moukouani Muikwani Bukoko, a Congolese man born in 1915. In 1935, while working for the missionaries in the Congo, Mr Bukoko bought an old Bible from a Belgian priest who forgot King Leopold II's speech in the second-hand Bible he sold (Nobles and Okoro, n.d: 1).

In an extract of the Letter from King Leopold II of Belgium to Colonial Missionaries, 1883, King Leopold II of Belgium describes the objectives of colonialism and western religious missionaries as follows:

- Your principal objective in our mission in the Congo is never to teach the niggers to know God, this they know already. Your essential role is to facilitate the task of administrators and industrials, which means you will go to interpret the gospel in the way it will be the best to protect your interests in that part of the world.
- Your mission in Africa is 'to keep watch on disinteresting our savages from the richness that is plenty [in their underground].' You must use any possible means 'to avoid that they get interested in it, and make you murderous competition and dream one day to overthrow you.'
- Your mission in Africa is to use the gospel to make the Negro and their off-spring believe they can find comfort in poverty and misery. To achieve this objective, 'you must find texts ordering, and encouraging your followers to love poverty, like; 'Happier are the poor because they will inherit the heaven' and, 'It's very difficult for the rich to enter the kingdom of God.' To 'make sure that niggers never become rich. Sing every day that the rich can't enter heaven.'
- Use the Gospel to make them powerless and helpless and ensure that their posterity is also as powerless as their parents. 'You have to detach from them and make them disrespect everything, which gives them the courage to affront us. Your action will be directed essentially to the younger ones, for they won't revolt when the recommendation of the priest is contradictory to their parents' teachings. To ensure perpetual subjugation and total control of the Negros, 'You must singularly insist on their total submission and obedience, avoid developing the spirit in the schools, teach students to read and not to reason' (Nobles and Okoro, n.d: 1).
- Trick the Negro into believing that pain and suffering are good for them. To do so, you must; 'Recite every day – 'Happy are those who are weeping because the kingdom of God is for them."
- Teach them that they are born with sins and that you, the Whiteman have come to rescue them from their sinful nature. To do so, you must; 'Institute a confessional system, which allows you to be good detectives denouncing any black that has a different consciousness contrary to that of the decision-maker.'
- Corrupt the niggers' minds by teaching them to forget their heroes, culture, belief systems and to adore only ours (King Leopold II of Belgium, cited in Nobles and Okoro, n.d: 1).

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Colonialism has achieved its intended objectives to a significant extent. Without industrial development in colonial countries, Black Africans are only consumers of western and eastern produced goods and services. Without the education that trains people to become rational thinkers and innovators, most people attending African schools and universities are only trained to repair the goods and equipment designed and manufactured in Western and Asian industries. With all the colonisers' and religious efforts to discourage Black Africans from

following in the footsteps of our ancestors, who took the leading role in the pre-colonial era, colonialism eliminated Black Africans' abilities to develop in many social, economic, technical, intellectual ways. Most training received by Black Africans empowers them to be better users and consumers of Western and Asian electronic products. This explains why few African countries have developed industries, research and development, and manufacturing.

In his analysis of 'Why has Africa failed to industrialize?', Tefirenyika (2016: 2) explains that the African continent is 'less industrialised today than it was four decades ago.' Consequently, 'the contribution of Africa's manufacturing sector to the continent's gross domestic product declined from 12% in 1980 to 11% in 2013, where it has remained stagnant over the past few years' (Tefirenyika, 2016: 2). Africa accounted for more than 3% of global manufacturing output in the early 1970s. However, this percentage has since fallen from 3% in 1970 to less than 2% in 2013 and it is likely to remain small throughout the coming decades (Tefirenyika, 2016: 2). This problem emanates from the colonial era. Innovation and manufacturing became impossible through many decades of the slave trade, when the African continent lost many of its artisans to slave traders and colonialism because the few remaining Black African artisans could no longer gain access to the necessary raw material (such as copper, zinc, and gold) that their ancestors used to manufacture ornaments and household goods before the arrival of Western people in Africa. Hence, it was impossible for the skills possessed by our ancestors to evolve and develop in the same way technological evolution took place in Western countries.

Black Africans' contributions to, and benefits from, technological innovations in the 1IR and 2IR

The above discussion shows that Black Africans were not able to contribute to the First Industrial Revolution, which started between the 18th and 19th centuries. Black Africans' contribution to the First Industrial Revolution was in terms of them being turned into slaves and in terms of having their raw material stolen by their colonial masters. There is no evidence of Black Africans' technological contribution or benefits from the Second Industrial Revolution. It has been argued above that the 2IR was characterised by the discovery of electricity-powered machines/tools and took place in the latter part of the 19th century and the early part of the 1950s (20th century). The contribution of Black Africans to the development of electricity-powered machines was limited. Evidence suggests that the African continent did not benefit from the discovery of electricity. For example, almost 17% of the world's citizens still have no access to electricity, and many people still do not have access to other basic infrastructure such as cell phones and the internet (Schwab, 2016). The World Bank (2021: 1) estimates that '660 million will still lack access in 2030, most of them in Sub-Saharan Africa.'

Black Africans' contributions to the 3IR

The 3IR slowly began to emerge in the late 1950s and early 1960s. The 3IR (characterised by electronics, the internet, and the use of information technology such as computers) further automated mass production. It can be argued that Africa, and Sub-Saharan African countries in particular, have not been able to replicate what developed countries such as the UK and USA have done to achieve the same results. This is because of limited availability of, or lack of access to, infrastructures such as computers, smartphones, and electricity. High levels of illiteracy or poor education are also some of the main problems facing citizens in almost all Sub-Saharan African countries, especially those living in rural areas (Uwizeyimana, 2015: 150). To date, Africa remains the part of the world with the least access to the internet and electronic facilities such as computers and smartphones. Few, if any, of these electronic tools are manufactured in Africa. Most of them are manufactured by Asian and Western developed countries. Africa's 43% internet penetration on 09 December 2020 was far below the world average of 64.2% (Statista, 2020: 1). The success of the 4IR will depend on widespread and uninterrupted access to the Internet where anything and everything is linked.

Can Black Africans contribute to the 4IR?

As indicated above, Africa was one of the leading continents before the arrival of slave traders and colonialists. However, because of the slave trade and colonialism, Africa contributed little and has missed out on many of the inventions/innovations of the 1IR, 2IR, and 3IR. Black Africans cannot afford to fail to maximise the benefits of the 4IR. Examples showing that Black Africans are capable of making significant

contributions to the 4IR abound in the literature. For example, Nsengimana (2018: 2) cites the examples of young Black African university students from Senegal who won a global innovation contest run by Ericsson. These students created a Virtual Reality (VR) headset that allows scientists, especially students, to complete science laboratory experiments through VR without the need of constructing a laboratory or buying equipment. Heinrich-Böll Stiftung (2018: 3) mentions examples highlighted in the 2018 edition of the Innovation Prize for Africa, where the African Innovation Foundation (AIF) recognised ten major examples of innovations by Africans. Among these innovations were 'two molecular tests for the rapid, accurate and effective detection and load quantification of tuberculosis and hepatitis C' (Morocco) and an eNose sensor for tea processing (Uganda) which supplements current tea-processing procedures using low-power sensor devices to determine optimum levels of tea fermentation. They also included Mobile Shiriki Network, a smart solar kiosk powered by strong solar panels and equipped with large-capacity batteries invented by Rwandan students, and Waxy II technology, invented by Tanzanians (Heinrich-Böll Stiftung, 2018: 3). In addition, on 16 November 2017, CNN broadcasted a programme titled 'African innovations that could change the world' and listed several innovations that it said were 'truly African' in the sense that, unlike innovations in Western countries that seek to replace human labour to increase profit, these Black Africans' innovations make the work of human professionals (labourers) more effective, efficient, economic, and faster. These 4IR innovations range from VR, 3D printing technology, and AI to cars (CNN, 2017: 2). They also include the Biomedical Smart Jacket (Uganda) that helps medical doctors improve the diagnosis of pneumonia in a faster and more accurate way than human beings. The Biomedical Smart Jacket analyses the chest and then sends medical reports and pictures via Bluetooth to a computer. They also include robot traffic wardens, which were invented by a team of Congolese engineers, based at the Kinshasa Higher Institute of Technology. The robot traffic wardens are used to control traffic jams across Kinshasa (Nsehe, 2014: 2). They also include the M-Pesa app for mobile banking, which was invented in Kenya in 2007 and is now used by 30 million users in 10 countries (Nsehe, 2014: 2).

There are currently many Black African innovations to be listed in the limited space of this article, but one cannot forget Dr Philip Emeagwali (born 23 August 1954, Nigeria), who invented the world's fastest computer 'based on bees'. According to CNN (2017: 2), Dr Emeagwali discovered the efficiency of the way bees construct and work with honeycombs. In 1989, he used 65,000 processors to invent the world's fastest computer, which performs computations at 3.1 billion calculations per second. His invention is used in weather forecasting and in predicting global warming (Famous Black Inventors, 2019: 1). This Nigerian-born scientist and inventor is known for first using a Connection Machine supercomputer to help analyse petroleum fields (CNN, 2017: 2).

Conclusion and Recommendations

The objective of this article was to analyse the different types of industrial revolutions and to discuss how Black Africans contributed to them. The analysis in this article shows that Black Africans contributed heavily to the Pre-Industrial Revolution period in the sense that they led technological innovations from medicine to engineering, manufacturing and other disciplines. However, Africa was entirely under colonialism by the time of the 1IR, and the technological development of the 1IR did not spread to the African continent. The slave trade and colonialism killed all technological developments and extinguished all efforts that characterised the African continent before the arrival of slave traders and colonisers. The world graduated from the 1IR to the 2IR, because of the discovery of electricity to power the machines and tools, which led to increased mass productions in Western manufacturing industries. Once again, Black Africans did not benefit from the discovery of electricity in the 2IR because of colonisation. As indicated in this article, about 1.3 billion of the world's 1.7 billion who lack access to electricity globally are in sub-Saharan Africa. Because of the lack of access to electricity (and other general infrastructures), many Black Africans have not been able to benefit from the 3IR, which was characterised by automation of tasks made possible by electronic/programmable tools such as computers and the internet.

However, unlike the 2IR and the 3IR, and despite the colonial exploitative economic systems that have decimated manufacturing efforts and have turned Africa into a permanent supply of Western industrial raw material needs, there is evidence that Black Africans can contribute to the 4IR technological

innovations. As we embark on the 4IR, it will be important for Black Africans to keep in mind that anyone who consumes the products and services they do not manufacture will become the market for those who provide them. The 4IR presents the chance for Black Africans to regain the technological innovation leadership they once held in the pre-colonial era. The 4IR is different from the 1IR, 2IR, and 3IR because it uses advanced technologies that do not follow the natural evolution of its predecessors. For example, the 4IR uses sensors and AI technologies, which can be invented by anyone, anytime, and anywhere on the globe. The article presented a few examples of 4IR technological innovations which have been accomplished by Black Africans from different corners of the African continent. These include ground-breaking technological breakthroughs in almost every area of life (science, technology, medicine, farming, financial service, security, etc.).

The fact that the 4IR technological innovations can happen anywhere in the world provides ample opportunities for Black Africans to contribute to its development. However, to benefit from and contribute to the 4IR technological advancements, African leaders should encourage, nurture, and support Black African investors and innovators. Instead of spending government budgets on purchasing technologies and robots made in Western and Asian countries, they could invest in infrastructure development, providing better education, and financial support to Black African inventors and innovators. The success of Black Africans in the 4IR technological innovations, research, development, and manufacturing will depend on the abilities of African education systems and institutions to produce graduates with the necessary critical thinking, technological innovation, and manufacturing capacity, instead of producing consumers of Western manufactured goods. All of these are necessary to create a conducive environment for Black Africans to engage actively in innovation and the manufacturing of the software and hardware that drive the 4IR. Angelou's aforementioned statement that '[i]f you don't know where you've come from, you don't know where you're going' is especially pertinent for Black Africans at this moment in time. The article presented many examples to demonstrate that Black Africans occupied a leading position in technological innovations in the past and that they can become great inventors and innovators in the current 4IR and future industrial revolutions.

References

Angelou, M. (2011). 'Maya Angelou's 2011 'Arizona Republic' interview.' Azcentral [online]. Available at: https://www.azcentral.com/story/entertainment/books/2014/05/28/maya-angelou-arizona-republic-interview/9682587/

Austin, G. (2021). 'African Economic Development and Colonial Legacies.' International Development Policy [online]. Available at. https://journals.openedition.org/poldev/

Bianchi, R.S. (2004). Daily Life of the Nubians. London: Greenwood Publishing Group.

Blackburn, R. (2011). 'Enslavement and Industrialisation.' BBC History [online]. Available at: http://www.bbc.co.uk/history/british/abolition/industrialisation_article_01.shtml

Brazier, Y. (2018). 'What was ancient Egyptian medicine like?' Ancient Egypt Online [online]. Available at: https://www.ancient-egypt-online.com/ancient-egyptian-medicine.html

CNN. (2017). 'African Innovations That Could Change the World.' CNN [online]. Available at: https://edition.cnn.com/2017/11/16/africa/gallery/africa-innovations-that-could-change-the-world/index.html

Crowder, M. (1985). 'The First World War and its consequences in Africa.' UNESCO [online]. Available at: https://en.unesco.org/courier/news-views-online/first-world-war-and-its-consequences-africa

Davies, J. N. P. (1959). 'The Development of Scientific Medicine in the African Kingdom of Bunyoro-Kitara.' Medical History, 3(1): 47-57. https://doi.org/10.1017/S0025727300024248

Doyle, S. (2006). Crisis & Decline in Bunyoro: Population & Environment in Western Uganda 1860-1955. London: James Currey Publishers.

Encyclopaedia Britannica. (2019a). 'Industrial Revolution.' Encyclopaedia Britannica [online]. Available at: https://www.britannica.com/event/Industrial-Revolution

Famous Black Inventors. (2019). 'Dr Philip Emeagwali: Inventor of the World's Fastest Computer.' Famous Black Inventors [online]. Available at: https://www.black-inventor.com/dr-philip-emeagwali

Fowler, H.W. and Fowler, F.G. (1965). The Concise Oxford Dictionary of Current English. Oxford: The Clarendon Press.

Handerson, W.O. (1942). 'The conquest of the German colonies, 1914-18.' New Series, 27(106): 124-139. https://doi.org/10.1111/j.1468-229X.1942.tb00829.x

Harvey, R. (2017). 'The 'Fourth Industrial Revolution': Potential and Risks for Africa.' The Conversation [online]. Available at: https://theconversation.com/the-fourth-industrial-revolution-potential-and-risks-for-africa-75313

Heinrich-Böll Stiftung. (2018). 'Perspectives #03/2018: Through the Looking Glass - Images of African Futures.' Heinrich-Böll Stiftung [online]. Available at: https://za.boell.org/2018/10/29/perspectives-032018-through-looking-glass-images-african-futures

Hudson, P. (2011). 'The Workshop of the World.' BBC History [online]. Available at: http://www.bbc.co.uk/history/british/victorians/workshop_of_the_world_01.shtml

Katz, V.J. and Imhausen, A. (2007). The Mathematics of Egypt, Mesopotamia, China, India, and Islam: A Sourcebook. Princeton: Princeton University Press. https://doi.org/10.1515/9780691235394

Kemp, B.J. (1991). Ancient Egypt: Anatomy of A Civilization. London: Psychology Press.

Kessler, I.R. (2006). 'What Went Right in Tanzania: How Nation Building and Political Culture Have Produced Forty-Four Years of Peace.' Honours Thesis: Walsh School of Foreign Service of Georgetown University.

King Jr., M.L. (1963). 'I Have a Dream' speech by Martin Luther King. Jr HD (subtitled). YouTube [online]. Available at: https://www.youtube.com/watch?v=vP4iY1TtS3s

Liberato, L. (2019). 'History of Ancient Egypt.' Wikipedia [online]. Available at: https://en.wikipedia.org/wiki/History_of_ancient_Egypt

Lovejoy, P.E. (n.d.). 'Lovejoy African Contributions to science.' UNESCO [online]. Available at: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/CLT/pdf/P_Lovejoy_African_Contributions_Eng_01.pdf

Maharajh, R. (2018). 'Africa and the Fourth Industrial Revolution: The Need for "Creative Destruction" Beyond Technological Change.' Heinrich-Böll Stiftung [online]. Available at: https://za.boell.org/2018/12/04/ Africa-and-fourth-industrial-revolution-need-creative-destruction-beyond-technological

Maropeng. (2021). Stone tools. Maropeng [online]. Available at: https://www.maropeng.co.za/content/page/stone_tools

Marwala, T. (2007). Computational Intelligence for Modelling Complex Systems. Delhi: Research India Publications.

Mjamba, K.O. (2014). 'Scramble for Africa: Berlin Conference of 1884-85 kicked off.' This is Africa [online]. Available at: https://thisisafrica.me/scramble-for-africa-berlin-conference/

Nalubega, T. and Uwizeyimana, D.E. (2019). 'Implications of the Fourth Industrial Revolution for Public Sector Monitoring and Evaluation in Africa.' Africa's Public Service Delivery & Performance Review, 7(1): a318.
https://doi.org/10.4102/apsdpr.v7i1.318

Nobles, V. and Okoro, C. (n.d). 'Letter from King Leopold II of Belgium to Colonial Missionaries, 18831.' AllAfrica [online]. Available at: http://allafrica.com/stories/200510060035.html

Nsehe, M. (2014). '7 Innovative Products from Africa You Should Know.' Forbes [online]. Available at: https://www.forbes.com/sites/mfonobongnsehe/2014/02/13/seven-innovative-products-from-africa-you-should-know/#7b2d398a7f1c

Nsengimana, J.P. (2018). 'How Africa Wins the 4th Industrial Revolution.' Forbes [online]. Available at: https://www.forbes.com/sites/startupnationcentral/2018/10/10/how-africa-wins-the-4th-industrial-revolution/?sh=40d48c0d2f37

Opoku-Mensah, A. (2019). 'Historical Perspectives on African Scientific Heritage.' LinkedIn [online]. Available at: https://www.linkedin.com/pulse/historical-perspectives-african-scientific-heritage-aida-opoku-mensah

Raymond, C. (2020). 'Origins of Embalming.' VeryWellHealth [online]. Available at: https://www.verywellhealth.com/what-is-embalming-1132124

South African History Online (SAHO). (2017). 'Grade 8 - Term 1: The Industrial Revolution in Britain and Southern Africa from 1860.' South African History Online (SAHO) [online]. Available at: https://www.sahistory.org.za/article/grade-8-term-1-industrial-revolution-britain-and-southern-africa-1860-0

Schwab, K. (2016). 'The Fourth Industrial Revolution.' World Economic Forum [online]. Available at: https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab

Ślusarczyk, B. (2018). 'Industry 4.0 - Are We Ready?' Polish Journal of Management Studies, 1(17): 232-248.
https://doi.org/10.17512/pjms.2018.17.1.19

Statista. (2020). 'Internet penetration rate in Africa as of December 2020, compared to the global average.' Statista [online]. Available at: https://www.statista.com/statistics/1176654/internet-penetration-rate-africa-compared-to-global-average/

Strouhal, E. (1989). Life in Ancient Egypt. Norman, Oklahoma: University of Oklahoma Press.

Sutherland, A. (2016). 'The Ebers Papyrus - Most Famous Plant Medicine 'Encyclopaedia' Of Ancient Egypt.' Ancient Pages [online]. Available at: http://www.ancientpages.com/2016/02/03/the-ebers-papyrus-most-famous-plant-medicine-encyclopedia-of-ancient-egypt/

The World Bank. (2021). 'Report: Universal Access to Sustainable Energy Will Remain Elusive Without Addressing Inequalities.' World Bank [online]. Available at: https://www.worldbank.org/en/news/press-release/2021/06/07/report-universal-access-to-sustainable-energy-will-remain-elusive-without-addressing-inequalities

Tefirenyika, M. (2016). 'Why has Africa failed to industrialize?' UN [online]. Available at: https://www.un.org/africarenewal/magazine/august-2016/why-has-africa-failed-industrialize
https://doi.org/10.18356/285fde1f-en

The Gazette. (n.d.). 'The Great Exhibition of 1851.' The Gazette [online]. Available at: https://www.thegazette.co.uk/all-notices/content/100717

Uwizeyimana, D.E. (2015). 'Mobile Phones as Means for Extending e-Governance in Rural Areas of Sub-Saharan Africa.' African Journal of Public Affairs. 8(4): 150-170.

WEF. (2017). 'Energy Access Africa.' World Economic Forum [online]. Available at: https://www.weforum.org/projects/energy-access-africa

Williams, E. (1988). Capitalism and Slavery. New York: Russell & Russell.

Xing, B. and Marwala, T. (2019). Implications of the Fourth Industrial Age on Higher Education. Johannesburg: University of Johannesburg.
https://doi.org/10.25073/0866-773X/87