Effects of Emerging Technologies on African Development: A Narrative Review on Selected African Countries

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10.46303/ ressat.2023.19

How to cite
Badaru, K. A. & Mphahlele, R. S. (2023). Effects of emerging technologies on African development: A narrative review on selected African Countries. *Research in Social Sciences and Technology*, *8*(3), 36-51.
https://doi.org/10.46303/ressat.2023.19

ABSTRACT

The rapid onset of the COVID-19 pandemic, also known as the SARS-CoV-2 outbreak, has brought to light how important technology may be to the socio-economic development of a nation, particularly in Africa. The study conducted a narrative review of pertinent literature to critically assess the effects of two types of emerging digital technologies: Artificial Intelligence (AI) and nanotechnologies in Africa. The results show that emerging technology-related research, development, and deployment are happening throughout Africa. Nanotechnology and AI have had a substantial impact in many spheres of African economies. The study, however, acknowledges in its conclusion that not all African nations have derived the same benefits from emerging technologies, including the digitalisation processes. There are still large disparities in the accessibility of technology and digital skills in several rural and underdeveloped areas in Africa. Thus, recommendations on how to close these gaps are provided for all African countries to profit more consistently from the emerging technologies and the digitalisation processes.

KEYWORDS

African countries; digitalisation process; e-learning; emerging technologies; nanotechnologies.

INTRODUCTION

A combination of technophobia and a lack of real enthusiasm in embracing technology in several African countries characterised the time before the COVID-19 outbreak erupted. In Uganda, for instance, prior to the COVID-19 outbreak, teachers were prohibited from bringing laptops, smartphones, and tablets into the classroom (Kyamazima, 2022). It was thought that digital devices would cause students to become distracted and lose focus while working on their academic assignments. The reluctance of seasoned teachers to use the digital technology installed in their various schools and classrooms in Uganda is an example of technophobia, which is the fear of the adoption of technology (Kyamazima, 2022). Due to the coronavirus lockdown which underscored the importance of the fourth industrial revolution (4IR) for developmental purposes, it appeared that technophobia had been conquered in the African education sector, particularly in Uganda.

The sudden emergence of the COVID-19 pandemic has highlighted the crucial role that technology may play in the socioeconomic growth of a country, particularly in Africa. During the COVID-19 shutdown periods, technological breakthroughs were implemented in several different economic areas around the world, including those related to education, health, defense, and security. The COVID-19 lockdown periods have brought attention to how important digitalisation and e-learning are in both developed and underdeveloped nations. The advent of digital technologies has allowed for the operation of educational institutions, research institutions, and commercial enterprises without needing to engage physically. Using available digital technology, changes have also been witnessed in how professors, teachers, researchers, and businesses operate. Digitalisation became a survival tactic for all economic sectors because of the shutdown of educational institutions as a containment mechanism to reduce the pandemic's impact and spread (Said *et al.*, 2020).

Additionally, even in the post-COVID-19 era online service provision acceptance and use, remote employment, and e-learning appear to be the new normal (Said *et al.*, 2020). Simply put, digitalisation, the replacement of face-to-face (F2F) interactions by digital ones, has gained more momentum (Rosak-Szyrocka *et al.*, 2022, p. 59782). The argument is that the replacement of face-to-face encounters cannot be accomplished without the use of digital technology enabling online interactions in all spheres of human society, given the straightforward definition of digitalisation. According to Tunmibi *et al*. (2015), who developed a thorough conceptualisation of e-learning, it "involves a wide range of content and instruction methods and has come to signify a new model of education involving revised curriculum, infrastructure, teacher professional development, textbooks, and examinations to give students access to technology and "21st-century skills" like creative problem solving" (p. 54). The implementation of the e-learning system, which took the role of the traditional classroom instruction during the global COVID-19 lockdown, depends heavily on technology. Since the epidemic drove every sector of every nation, including higher education institutions (HEIs), to convert from conventional face-to-face interactions to online learning platforms for instructional purposes,

the pandemic has undoubtedly been regarded as a paradigm-shifting event (Badaru & Adu, 2022).

As a general technological term, e-learning encompasses a wide range of ICT-enabled applications and processes, including computer/web-based learning, virtual or online classrooms, digital collaboration, and networking (Badaru & Adu, 2022). In order to share resources, coordinate work processes, and determine "who does what, when, how, and why," communications between educators and students are formed through e-learning platforms (Badaru & Adu, 2022, p. 70).The e-learning platforms, which include learning management systems (LMSs), Google, Amazon, YouTube, Facebook, Microsoft Teams, Zoom, and many others, have shed light on the potential benefits of ICTs and the broader digital field for the education sector. Education has a crucial role in a country's development, acting as a catalyst for social change, a builder of human capital, and a facilitator of the knowledge transfer between generations and cultures.

Once more, we make the case that education is a driving force behind the fourth industrial revolution (4IR), also known as the digital transformation, which has had an impact on the growth of every sector in contemporary countries. China and the United States of America have led the 4IR since 2008 during the globalisation era, and since 2014 during the digital globalisation age (see Figure 1). The transformation of social and political structures as well as the digitalisation of the economy and industry are all part of this revolution, according to Alyoshina (2020). Global, regional, national, and local economies, enterprises, educational systems, communities, and politics are all being affected by the fundamental process of digitalisation (Alyoshina, 2020). The 4IR has brought with it a plethora of new or emerging technologies that are quickly enhancing the competitiveness of industrial enterprises whose operations currently rely on fundamental ideas like digital interconnection, autonomisation, self-control of systems, and big data analysis (Ralph *et al.*, 2020).

Emerging technologies have been described as radically novel and relatively fast-growing technologies whose deployment and utility may incur disruptive effects in all sectors of the economy or societies (Razakamaharavo, 2021). Attempts at defining emerging technologies in the extant literature have focused on the potential socio-economic impact which emerging technologies are capable of exerting on the economy and society, the uncertainty associated with the emergence process, as well as the characteristics of novelty and growth (Rotolo *et al.*, 2015). While some of these emerging technologies have been developed and deployed, others are still being researched and tested in Africa. From the perspective of education, emerging technologies are defined as "those technologies which are likely to have a large impact on teaching, learning, or creative inquiry on college and university campuses within the next five years" (Bozalek *et al.*, 2013, p. 421). These technologies are applied in a teaching and learning context for an individualised, flexible, and differentiated approach, with a focus on learning needs and pedagogy which are more learner-centred than a teacher-centred, 'one-size-fits-all' method (Bozalek *et al.*, 2013). In addition, characteristics of emerging technologies are

described as follows: "they may or may not be new technologies; they change rapidly so are always in a state of coming into being; they go through cycles of hyped expectations; they are in a continuous state of being understood and researched, and they have potential for transforming social practices" (Bozalek *et al.*, 2013, p. 422).

Technology has both beneficial and harmful effects, as will be explained later. Regarding the detrimental effects of emerging technologies on the continent of Africa particularly, digitalisation renders nations (developed and developing) susceptible to cybercrimes, cyber espionage, and the sabotage of vital infrastructure (Allen, 2021). Allen (2021) emphasises that emerging technologies might be exploited as instruments of oppression, division, and conflict, which is another negative effect or harmful role of these technologies. This is supported by Razakamaharavo (2021), who provided an example of how AI technologies were applied to the prosecution, surveillance, and monitoring of particular groups during elections and/or in routine policing. A notable example is the employment of AI technology by the Chinese government to keep tabs on the Uyghur population (Razakamaharavo, 2021).

The absence of a legal framework to govern artificial intelligence (AI) and other emerging technologies in Africa makes it seem as though innovators are free to introduce their technological innovations to the continent without worrying about how their applications will be governed by existing legal frameworks. There is also a lack of digital infrastructure and a lack of consumer protection or national security measures (Mueller-Kaler, 2020).

Twitter purportedly removed several of former President Buhari's posts, causing the Nigerian administration to have problems with the microblogging service. In response, the Federal Government of Nigeria (FGN) prohibited Twitter from operating in Nigeria. The Twitter prohibition persisted for months before the microblogging service consented to further requirements, including obtaining a local license and registering its business with the Corporate Affairs Commission (CAC) of Nigeria. Another significant issue raised by Murray (2018) is the continent's regrettably expensive internet bills and subpar coverage and speeds. In addition, Africans' limited proficiency in other languages as well as educators' and instructors' lack of digital literacy or pedagogical expertise are problems (Murray, 2018).

Last but not least, there is the propensity for emerging technologies to be used to spread false information, misinformation, or rumours among the populace; such deep fake disinformation has the power to sow unrest or exacerbate already-existing crises, and governance may be in danger of failing if prompt action is not taken.

Against this background, the following questions would be addressed in the study:

(1) What impact have new technologies had on the development of selected African countries?

(2) How can emerging technologies aid African development efforts?

METHOD AND MATERIALS

This section of the study deals with the research design, search approach, inclusion and exclusion criteria, and data analysis method.

Research Design

The researchers conducted a narrative review of extant literature on the emerging technologies and the impact they have had on the development of selected African countries. A narrative review is a method for conducting a literature review that identifies and summarises common themes from a body of knowledge about a certain subject or relevant research issues (Ferrari, 2015). The method of conducting a literature review was chosen because it enables a thorough and in-depth analysis and consolidation of the current literature to meet our research concerns (Record-Lemon & Buchanan, 2017).

Search Strategy and Selection Criteria

The narrative literature review approach was adopted to critically analyse empirical studies published in scientific journals and relevant databases. These were contextually searched from the Google Scholar, EBSCOHost, ResearchGate, and others. The process of data collection was guided by prioritising and conducting a search for articles which were considered relevant and categorised into three descriptors: highly relevant, relevant, and not so relevant. To achieve the study's aim, the researchers further employed the Boolean Operator (Jahan *et al*., 2016) as the strategy to search for relevant literature, using terms like digital technologies, emerging technologies, e-learning platforms, digitalisation process in Africa, African development, African countries, and emerging technologies. The researchers also set out the criteria for inclusion and exclusion of articles. The researchers searched for English-language publications that address how emerging technologies are affecting Africa's development. The researchers were cognisant of the fact that there are anglophone and francophone countries in Africa and scholarly publications might be in both English and French. The researchers rejected non-English articles and those that were not focused on emerging technologies or were published outside of African nations. Even though 159 articles were initially reviewed, only 68 articles were relevant and included in the first draft of this study. Articles that did not meet the criteria were categorised as not so relevant and discarded. Twenty-five articles were found to be highly relevant and included in the final draft. Rumrill and Fitzgerald (2001) argue that the narrative literature review methodology has drawbacks, including the inability of studies conducted using this method to be replicated or reproduced. However, it is a superb technique for research synthesis from the extant literature (Ferrari, 2015).

Data Analysis

The linked literature on the findings was organised by the study using the thematic analysis method (Watson, 2020). Data on the impacts of emerging technologies on the sectoral development of economies, security, and governance, as well as educational development in a few African nations, were organised and debated around the themes that emerged from the literature analysis. It is important to highlight that because the study was never an empirical study involving human participants, no ethical approval was ever needed for it.

FINDINGS AND DISCUSSION

The findings and discussion revolve around the emerging themes based on the study's research questions and the literature search conducted to address them. The themes include the effects of emerging technologies on the economy, governance and security architectures, and education in certain African countries such as Nigeria, Uganda, South Africa, Ghana, Cameroun, and Rwanda.

In this review, the researchers focused on two categories of emerging technologies: digital technologies: Artificial Intelligence (AI) and nanotechnologies, as well as their impact on African development. As indicated by Razakamaharavo (2021), the emerging technologies include those which have merged the virtual and the real world (mixed reality) such as Augmented Reality (AR) and Virtual Reality (VR); Artificial Intelligence (AI); and Blockchains, to mention a few. There is an ongoing engagement in technological research and development as well as deployment across Africa. For example, Nigeria and Ethiopia are two countries on the continent that have established prosperous and growing AI hubs. In addition, an AI hub has been built in Ghana by one of the four big tech companies, Google (Alphabet). As shown in Figure 1 below, Facebook, Amazon, and Tencent are the other three giant tech firms advancing global digitalisation during the current 4th Industrial Revolution. In Kampala, the AI centre known as 'the UN Global Pulse lab' was built by the United Nations Organisation (UNO).

Figure 1

The 4th Industrial Revolution (2000-2010s)

Era/Stage of Globalization	Main Products	Leading Nations	Innovations	Giant Tech Companies of the Era
Globalization 4.0 (2008+)	Digital Goods/Services	United States of America	Robotization	Google (Alphabet)
Digital Globalization (2014+)	Data, Information	China	Artificial Intelligence	Facebook
			Autonomous Vehicles	Amazon
			Internet of Things (IoT)	Tencent

Source: Adapted from Alyoshina (2020)

Another example of the deployment of emerging technology in Africa is the use of drones for improving healthcare service delivery in Rwanda. This African country deploys drone technology for blood delivery in remote areas of the country, thereby helping in protecting

healthcare workers against certain risks associated with their jobs. Artificial Intelligence has helped enable remote service delivery, increased automation of offices, and improved institutions of learning, homes, and manufacturing companies, as well as streamlined the analysis of mass data at unbelievable speeds (United Nations, 2021).

A world without AI technologies, such as the internet and software applications, can be better imagined than experienced in this 21st century age. Combating the ravaging COVID-19 pandemic would not be possible without the effective integration of technological systems with biological, digital, and physical elements to produce effective vaccines. The Association for the Advancement of AI has defined AI as "the scientific understanding of the mechanisms underlying thought and intelligent behaviour and their embodiment in machines" (Alyoshina, 2020, p. 26). Artificial Intelligence is a collection of software technologies programmed for a computer system or robot to carry out equal to or far better than normal human computational effort in accuracy, capacity, and speed. AI technologies have helped to solve problems associated with recognising and generating objects which include texts, images, sounds, events, and many other stimuli (Alyoshina, 2020). For instance, many hospitals are now using AI technologies for the analysis of images (e.g., echocardiography) and prediction by using object recognition software applications; while some house helps have been trained to recognise voice signatures of their house owners for security reasons, such that they can only respond to instructions from the right persons when asked to open doors and/or switch off lights (United Nations, 2021). This is the way AI technologies are being utilised and applied.

The specific subareas of AI include large-scale machine learning, deep learning, natural language processing, collaborative systems, computer vision (image analytics), algorithmic game theory and computational social choice, soft robotics (robotic process automation), evolutionary computation, and neuroevolutionary systems (United Nations, 2021). Artificial Intelligence technological tools, such as android phones, the internet, search engines, software applications, and other gadgets for home and office use, are today found everywhere in our cities and campuses across Africa. Educational institutions across the globe took advantage of AI technologies during the COVID-19 lockdown for teaching, learning, and research activities (Fahimirad & Kotamjani, 2018). Nanotechnology is a fast-growing, powerful, and emerging medical technology and the control over it has become a source of competition among developed nations. Saad and Elmahjubi (2018) aver that applications of nanotechnology have diverse impacts on all spheres of life in modern societies. This type of technology includes nanomedicine, nanomagnetics, nanomechanics, nanophononics, nanoelectronics, and nanoelectronics. Although its strongest impact has been made in the field of medicine and healthcare services.

The Organisation for Economic Cooperation and Development (OECD) defines nanotechnology as "the understanding of processes and phenomena and the application of science and technology to organisms, organic and inorganic materials, as well as parts, products, and models thereof, at the nanometre-scale (but not exclusively below 100 nanometres) in one

or more dimensions, where the onset of size-dependent phenomena usually enables novel applications" (as cited in United Nations, 2021, p. 9). Nanotechnology is regarded as being pervasive, and as an enabler and key driver of the next industrial revolution (United Nations, 2021). This assertion may not be far from the truth because it is almost impossible not to find nanotechnological elements in modern-day products, such as washing machines, cosmetics, detergents, medicines, electronics, food packaging, mobile phones, and computers (United Nations, 2021). While the United States is the biggest contributor to investments in research and development (R&D), as well as in the number of patents filed and registered with the United States Patent and Trademark Office (USPTO) and the European Patent Office (EPO); a few other developing nations like Saudi Arabia, China, and Iran are on the list of top R&D performing nations in terms of nanotechnology.

Of course, there are a small number of African countries like Tunisia, South Africa, and Egypt that are also steadily investing in the nanotechnology industry. For instance, South Africa has successfully filed 87 patent applications for inventions in nanotechnology with the USPTO in 2001; and just seven (7) patent applications have been filed in 2017 with the EPO. Egypt also filed 40 patent applications with the USPTO. According to research on the effects of nanotechnology on Nigerian society by Ejeta *et al*. (2017), there are opportunities for nanotechnology to address critical global development priorities, such as in water purification systems, energy systems, medicine, pharmaceuticals, food production, and nutrition, as well as ICTs. Nanotechnology is also advantageous because it "produces with little labour and land use, low cost, and modest requirements for material and energy" (p. 138). Figure 2's data sheds more light on how Africa continues to lag behind other regions that engage heavily in nanotechnology R&D and produce ground-breaking nanotechnological products. Korea, Japan, and Germany are the other major contributors after the United States (United Nations, 2021).

Figure 2

Patent applications by African countries (sum of 2001-2017)
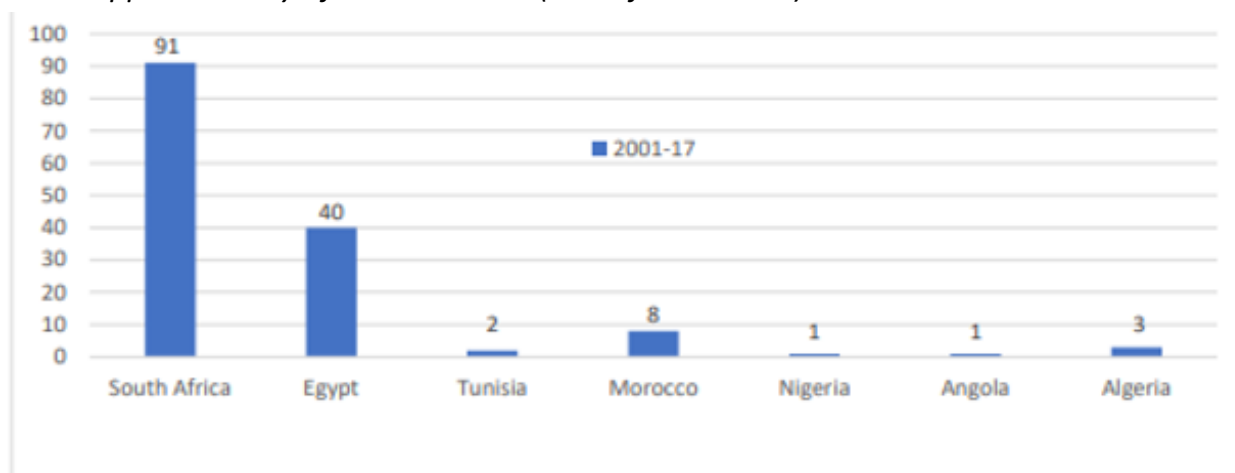
Source: Statnano Database (as cited in United Nations, 2021)

Emerging technologies have the potential for both positive and negative impacts on Africa's development. That is the unfortunate thing about development in the globe, it comes with some challenges or negative impacts. So, this is the case with emerging technologies in Africa.

Economic Effects of Emerging Technologies

Emerging technologies have a significant impact on certain fields or socio-economic systems by altering the composition of actors involved, the institutions they belong to, the ways in which they interact, and the processes involved in the creation of new knowledge (Rotolo *et al*., 2015). Emerging technologies have economic impact**s** on agriculture, education, security, manufacturing, transport systems, human capital, banking systems, and Small and Medium Enterprises (SMEs). Agricultural productivity and modernisation have received a boost with the application of emerging technologies through the provision of more reliable and tailored information to farmers at the right time; for instance, higher quality satellite data as well as new analysis techniques, such as using learning machines, to advise farmers on inputs and insurance policies suitable for the continent's highly differentiated microclimates (Murray, 2018). In Tanzania, Olam, a private company, has used a mobile phone-based system to effectively send farming instructions and other information to more than 30,000 small-holder coffee farmers (Murray, 2018). South Africa and Burkina Faso have adopted commercial Genetically Modified (GM) crops using genetic engineering technology to increase yields of maize, cotton, and soybeans. Murray (2018) posits that emerging technologies have the potential to enhance Africa's modernisation in terms of agriculture, increase farm outputs, and reduce prices of food, thereby reducing risks of food insecurity and climate change disasters. The economic potential of emerging technologies is believed to be great as 1.7 million jobs have been created through mobile technologies, contributing $144 billion or an estimated 8.5 percent of GDP to the economy of Africa (Allen, 2021).

The emerging technologies have facilitated e-hailing (intermediate business) in the transport sector, providing public transport services through electronic applications across the cities of Africa. There are popular e-hailing transport companies such as Uber, Bolts, Yokoo rides, and inDriver in South Africa; SafeBoda in Uganda; SafeMotos in Rwanda; Bolt, GIGM, inDriver, and Bolt in Nigeria. E-hailing transport services via apps have brought innovations and economic contributions in terms of employment generation in African countries. Similarly, e-payment platforms are innovations brought into the banking sector by various emerging technologies in Africa, similar to what others have in other countries outside of the continent. The popularity of mobile and online banking has grown even among rural dwellers in Africa. With mobile phones and/or computer system units connected to the internet, people and governments in Africa can initiate and execute banking transactions like sending and receiving payments from customers, payments of employees' salaries, payment of taxes, and even open new bank accounts (Murray, 2018). In addition, emerging technologies have bolstered prospects of ecommerce through the

proliferation of online trading stores and online service sales. In Nigeria, there is the famous Jumia shopping site accessible to other African online customers in the rest of the world.

Emerging Technologies' Effects on Governance and Security

African governments are now adopting emerging technologies for the governance and security of their citizens. Emerging technologies such as AI play dynamic roles in elections in some African countries. For example, Nigeria's Independent National Electoral Commission (INEC) has introduced a Bimodal Voter Accreditation System (BVAS) machine for reading Permanent Voter Cards (PVCs) and for facial authentication of voters by using their captured fingerprints to establish their eligibility for voting during any election. The BVAS machine also serves as a replacement for the Z-pad for uploading results from each of the polling units directly to the INEC election results viewing portal (IReV) in real-time on election day. The INEC headquarters has deployed BVAS machines as the Voter Enrolment Devices (VEDs) for the nationwide continuous voter registration exercise. Thus, its usage has eliminated the use of incident forms for voter accreditation during any election at state or national levels. These election devices were deployed for use during the governorship elections in Anambra state on the 6th of November 2021, in Ekiti on the 18th of June 2022, and in Osun on the 16th of July 2022. The general perception of the BVAS technology is that it has helped improved Nigeria's election credibility by reducing rigging to the barest minimum during the conduct of the 2023 general elections.

E-governance has significantly improved Africa's public service delivery through constant engagement with emerging technologies. For context, e-governance service delivery involves the application of emerging technologies to enhance the access and delivery of public services to the citizenry and corporate bodies across all government departments and agencies (Dugbazah *et al.*, 2022). Emerging technologies have enabled African governments to provide e-services, e-commerce programmes, and access to other vital information services from ministries, departments, and agencies (MDAs) through the internet. Through various digital platforms, the government's participation in activities, such as voting, banking, collection of taxes, e-visa, passport application, and applications for marriage, birth, and death certificates, has been boosted and made cost-effective, unlike the inefficient paper-based filing systems (Dugbazah *et al.*, 2022). The e-governance system has helped African governments in their reforms of public services by reducing corruption, promoting transparency, and fostering efficiency and inclusion. According to Dugbazah *et al*. (2022), a lot of progress has been made toward e-governance service delivery adoption in no less than thirty countries in Africa, such as Rwanda, Togo, Nigeria, Lesotho, South Africa, Cameroun, Ghana, and many others.

In terms of security and defence, emerging technologies, such as biometric technologies, have been beneficial and useful in the banking and health sectors for identification, border control, crime prevention, and predictive policing (Razakamaharavo, 2021). African governments have deployed these technologies for the verification of persons at their borders, and airports, and for online customer data capturing by banks and hospitals. Drones have also

become incorporated into the arsenals of state and non-state actors on the continent (Allen, 2021). The national police and military institutions in some of these African countries have been armed with AI-powered surveillance technologies, such as drones for security surveillance and crime prevention. For instance, the Lagos State Neighbourhood Safety Agency in July 2022 reportedly deployed 233 technological devices, which included surveillance drones, body cameras, binoculars, smartphones, and internet facilities to its divisional offices across the state (Adegoke & Pedro, 2022).

There is no gainsaying the fact that African countries, like other developed nations of the world, need modern technologies for the security and protection of lives and property in their respective territories. As posited by Razakamaharavo (2021), Zimbabwe, South Africa, Uganda, Ghana, and Kenya are the leading African countries in the massive deployment of facial recognition technologies (e.g., Closed-Circuit Television- CCTV) for security surveillance. Rwanda was the first country in the world to offer commercial drone service delivery in 2016, partnered with the United States-based company Zipline, for life-saving medical supplies to the remote parts of the country (Allen, 2021). Nigeria was also the first African country in 2016 to publicly announce its use of drones in the fight against terrorism in the northern region (Allen, 2021). A South African company has, since the 1970s, been manufacturing drones and it recently declared an intention to build drone swarms for the transfer of technology and portable production with its partner countries (Allen, 2021).

Emerging Technologies' Effects on Education

E-learning platforms through tablets, computers, or smartphones with a stable supply of power and internet connectivity provides access to educational resources and information of international standards even at relatively low costs. Emerging technologies in Africa have facilitated digital learning via Google search engines, YouTube videos, Wikipedia resources, and interactive software apps like Facebook and Twitter for scripted lesson plans and personalised learning (Murray, 2018). The viability of some digital platforms, such as WhatsApp, Zoom App, Telegram channel, and the LMSs, has been used and found to be effective for teaching and learning during the COVID-19 lockdown periods, not only in Africa but also in other parts of the world (Badaru & Adu, 2022). In Nigeria, all the examination bodies, like the Joint Admissions and Matriculation Board, the West African Examination Council (WEAC), the National Examination Council (NECO), and others, have all introduced online platforms or portals for the registration of candidates and results checking. This is another innovative impact of emerging technologies on the country's educational system. Only JAMB has successfully adopted computer-based testing (CBT) for its annual Unified Tertiary Matriculation Examination (UTME). The use of technologies in the conduct of examinations might have been conceived to cut down the costs of the administration of the examinations and incidences of examination malpractice on the one hand, while on the other hand the online systems for the conduct of exams are not completely shielded from malpractices and other hitches. These are the same reasons why most higher education institutions in Nigeria have introduced the CBT system in the conduct of their post-

UTME; all these online or digital innovations in the education sector have been made possible by the availability of emerging or new technologies.

The National Teachers' Colleges' remote learning programme was developed in conjunction with the Belgian development agency, Enabel, and the Ugandan Ministry of Education (NTCs). The collaboration resulted in the creation of the TTE Sandbox internet portal, which at least allowed for the continuation of teacher training and education in Uganda during the COVID-19 shutdown (Kyamazina, 2022). The TTE Sandbox started off as a collection of communication tools to help NTCs with distance learning. But as time went on, it proved to be a useful tool that accelerated Uganda's return to normal educational activity. The teacher-trainees' minds were developed using the TTE Sandbox so that they could use technology as a productive teaching tool in classrooms. The Ugandan school teachers were also trained on how to use digital tools such as screencasting, podcasting, video conferencing, eBooks, or padlets for teaching and learning activities. The strategy was also rolled out to prevent the Ugandan education sector from becoming extinct or crippled after the prolonged period of school closure (Kyamazina, 2022).

CONCLUSION

African nations, which include Nigeria, South Africa, Ghana, Uganda, Rwanda, and others, have benefited from digitalisation, e-learning, and emerging technologies by having better access to education, higher chances for employment, better access to high quality healthcare, higher agricultural productivity, and more innovative business practices. These African countries have also benefited from the development of new sectors and business models made possible by emerging technologies such as blockchains and AI. Digitalisation helps to advance economic development by opening new business prospects, enabling more efficient operations, and connecting African businesses to the global market. E-learning platforms have helped Africa by eliminating the barriers of cost and distance, enhancing access to education for people living in rural and undeveloped areas. This has helped Africa's literacy rates increase and the continent's educational gap close. Emerging technology has tremendously helped in the provision of accessible healthcare. Telemedicine and mobile apps have been implemented to improve access to the healthcare system. Africa's farmers now have access to real-time meteorological information, market prices, and other data-driven insights thanks to the digitalisation of agriculture, which also helps to decrease waste and increase crop yields. Finally, digitalisation and emerging technologies have tremendously increased innovation in Africa, enabling local entrepreneurs to develop whole new products and services that meet regional needs. Economic expansion and the emergence of new job opportunities have both been facilitated by technological improvements. Nevertheless, it is critical to acknowledge that not all African nations have benefited equally from digitalisation, e-learning, and emerging technologies. There are still significant gaps in the availability of technology and digital skills, particularly in rural and

impoverished areas. It will be crucial to close these gaps for all African nations to benefit from the digitalisation processes.

Recommendations

Nigeria, South Africa, Uganda, Ghana, and other African nations must now establish a legal framework that is acknowledged on a worldwide scale to regulate the use and operation of emerging technologies. Stakeholders in the education and technology sectors must be involved in the process, leading to the making of final decisions in this regard to allay concerns about the abuse of such legislation. Legislative frameworks that safeguard consumer rights and privacy should encourage the development and acceptance of cutting-edge technologies. This will promote the beneficial use of digital technologies for all Africans and help to increase public confidence in them. As efforts are made to promote capacity building and cooperation in the research and development of goods in the AI and nanotechnology industries, it is important that African nations enhance their investments in the sector.

The digital infrastructure of the continent, which includes access to devices, electricity, and internet connectivity, should be improved. This requires investment from both the public and commercial sectors. The usage of and access to digital technologies will, therefore, increase. Similarly, public agencies, academic institutions, and businesses should broaden their digital skills-teaching initiatives, particularly in rural and impoverished regions. With more individuals having the skills and knowledge required to take advantage of digital technology the region will be able to guarantee required skills for teaching and learning. The development of cutting-edge digital solutions that meet regional demands should be a joint effort between the public and private sectors. The economy could grow as a result, and more employment could be produced. Governments, educational institutions, and businesses should increase their R&D spending to promote innovations in new technology.

To make significant progress in this area, tertiary institutions with departments of mathematics, engineering, science, technology, telecommunications, physics, chemistry, and other subjects must encourage and support their students in using their final-year projects as a vehicle to produce tangible goods and file for patents on inventions in the science and technology sector. For African nations to reap the full benefits of new technologies and close the gap between the continent and the rest of the globe, regional and sub-regional levels of international cooperation and partnership are crucial. Taking care of neighbourhood problems can encourage economic growth and create new job opportunities. Authorities, academic institutions, and commercial stakeholders should promote cooperation and knowledge exchanges to build a strong digital ecosystem in Africa. Consequently, it might be simpler to share best practices and ensure that local needs are considered when building digital solutions. By implementing these suggestions, Africa may receive greater advantages from digitalisation, e-learning, and emerging technologies, and contribute to the continent's economic development.

REFERENCES

Adegoke, A., & Pedro, I. (2022). Agency deploys 233 body cameras, others in Lagos to enhance effective community policing. *Newsdiary*, https://newsdiaryonline.com/agency-deploys-233-body-cameras-others-in-lagos-to-enhance-effective-community-policing

Allen, N. (2021, March 11). *The promises and perils of Africa's digital revolution*. Brookings, https://www.brookings.edu/techstream/the-promises-and-perils-of-africas-digital-revolution/

Alyoshina, I. (2020). Artificial Intelligence in an Age of Digital Globalization. *Proceedings of the International Conference on Technology & Entrepreneurship in Digital Society*, 26–30. https://doi.org/10.17747/TEDS-2019-26-30

Badaru, K. A., & Adu, E. O. (2022). Platformisation of Education: An Analysis of South African Universities' Learning Management Systems. *Research in Social Sciences and Technology*, *7*(2), 66-86. https://doi.org/10.46303/ressat.2022.10

Bozalek, V., Ng'ambi, D., & Gachago, D. (2013). Transforming teaching with emerging technologies: Implications for higher education institutions. *South African Journal of Higher Education*, *27*(2), 419-436. https://journals.co.za/doi/pdf/10.10520/EJC144269

Dugbazah, J., Glover, B., Mbuli, B., & Kungade, C. (2022). Improving Africa's service delivery through E-Governance. *African Union Development Agency*, https://www.nepad.org/blog/improving-africas-service-delivery-through-e-governance

Ejeta, K. O., Dolor, G. A., Ndubuka, G. I., Nkuma-Udah, K. I., Azeez, T. O., & Odugwu, O. (2017). Impact of nanotechnology in Nigeria: a short survey. *International Journal of Biosensors & Bioelectronics*, *2*(5), 136-139. https://www.researchgate.net/publication/322312644

Fahimirad, M., & Kotamjani, S. S. (2018). A review on application of artificial intelligence in and learning in educational contexts. *International Journal of Learning and Development*, *8*(4),106-118. https://doi.org/10.5296/ijld.v8i4.14057

Ferrari, R. (2015). Writing narrative style literature reviews. *Medical Writing*, *24*(4), 230-235. https://doi.org/10.1179/2047480615z.000000000329

Jahan, N., Naveed, S., Zeshan, M., & Tahir, M. A. (2016). How to conduct a systematic review: A narrative literature review. *Cureus, 8*(11), 1-8. https://doi.org/10.7759/cureus.864

Kyamazima, D. (2022). 'Technophobia' in Uganda Education Sector Overcome Thanks to Corona Lockdown. https://open.enabel.be/en/UGA/2197/1965/u/technophobia-in-ugandan-education-sector-overcome-thanks-to-corona-lockdown.html

Mueller-Kaler, J. (2020). *Can AI and emerging tech boost African development?* https://www.atlanticcouncil.org/content-series/smart-partnerships/can-ai-and-emerging-tech-boost-african-development/

Murray, S. (2018). New technologies create opportunities. In R.S. Newfarmer, J. Page, & F. Tarp (eds.). *Industries Without Smokestacks Industrialization in Africa Reconsidered*, Oxford: Oxford University Press, pp. 27-47. https://library.oapen.org/bitstream/handle/20.500.12657/25128/9780198821885

Ralph, B. J., Pacher, C., & Woschank, M. (2020). Conceptualization of the Lecture 'Digitalization and Digital Transformation in Metal Forming' based on Implications from Contemporary Teaching and Learning Theories. In *Proceedings of the 2nd African International Conference on Industrial Engineering and Operations Management,* October 20-22, 2020, Harare, Zimbabwe (pp. 703-712). http://www.ieomsociety.org/harare2020/papers/215.pdf

Razakamaharavo, V.T. (2021, August). Implications of emerging technologies on peace and security in Africa. *Accord*, https://www.accord.org.za/conflict-trends/implications-of-emerging-technologies-on-peace-and-security-in-africa/

Record-Lemon, R. M., & Buchanan, M. J. (2017). Trauma-informed practices in schools: A narrative literature review. *Canadian Journal of Counselling and Psychotherapy*, *51*(4), 286-305. https://journalhosting.ucalgary.ca/index.php/rcc/article/view/61156

Rosak-Szyrocka, J., Żywiołek, J., Zaborski, A., Chowdhury, S., & Hu, Y. C. (2022). Digitalization of higher education around the Globe during covid-19. *IEEE Access*, 10, 59782-59791. https://doi.org/10.1109/ACCESS.2022.3178711

Rotolo, D., Hicks, D., & Martin, B. R. (2015). What is an emerging technology? *Research policy*, *44*(10), 1827-1843. https://core.ac.uk/download/30612882.pdf

Rumrill Jr, P. D., & Fitzgerald, S. M. (2001). Using narrative literature reviews to build a scientific knowledge base. *Work,* 16(2), 165-170. https://content.iospress.com/openurl?genre=article&issn=1051-9815&volume=16&issue=2&spage=165

Saad, S. A., & Elmahjubi, A. (2018). Nanotechnology: Concepts, Importance and the Current State of Scientific Research. *Proceedings of First Conference for Engineering Sciences and Technology: Vol. 2*, 552–562. https://doi.org/10.21467/proceedings.4.22

Said, B., Hajar, E., & Amine, S. (2020). The Covid19 outbreak: a catalyst for digitization in African countries. *Journal of the Egyptian Public Health Association*, *95*(1), 1-2. https://doi.org/10.1186/s42506-020-00047-w

Tunmibi, S., Aregbesola, A., Adejobi, P., & Ibrahim, O. (2015). Impact of E-Learning and Digitalization in Primary and Secondary Schools. *Journal of education and practice*, *6*(17),53-58. https://www.uneca.org/sites/default/files/TCND/AFSTIF2021/Emerging-technologies-for-Sustainable-VK1.pdf

United Nations. Economic Commission for Africa; United Nations. Economic and Social Council;

United Nations. Economic Commission for Africa; United Nations. Economic and Social Council. (2021). Harnessing emerging technologies: the cases of artificial intelligence and nanotechnology. UN. ECA African Science, Technology and Innovation Forum (3rd session: 2021, Feb. 25-26: Brazzaville, Congo). Addis Ababa: UN. ECA. https://hdl.handle.net/10855/48302

Watson, E. (2020). Education: The Potential Impact of Social Media and Hashtag Ideology on the Classroom. *Research in Social Sciences and Technology*, *5*(2), 40-56. https://doi.org/10.46303/ressat.05.02.3