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Cloud Computing Services and Its Effect on E-Learning in the Post-Covid-19 Pandemic Era: *A Review*

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Abstract
The COVID-19 pandemic has disrupted global activities and posed a major challenge to education systems around the world. This has led to the closure of educational institutions around the world, demonstrating that education systems are always under pressure to meet the changing needs of society. These closures have enabled students and teachers around the world to adopt technological innovations in teaching and learning. Countries around the world with better infrastructure have continued academic activities without hindrance while other countries such as developing and underdeveloped countries have suspended or partially continued academic activities due to inadequate infrastructure to conduct academic activities on a large scale. This article aims to raise awareness among education stakeholders about the need to rethink the adoption of electronic learning (e-learning) supported by cloud computing services. Clouds in providing education in the post-COVID-19 era. Cloud computing services have facilitated teaching and learning during the COVID-19 pandemic as they allow teachers and students to interact and collaborate on learning activities. Students access learning materials, interact with each other, learn at their own pace, complete assignments, and submit assignments easily to teachers. Therefore, education stakeholders need to rethink the adoption of this innovation in education delivery by putting in place appropriate mechanisms such as organization and planning, training and retraining appropriate teachers and students, investing appropriately in technology infrastructure, and bridging the gap in the digital divide between students. This becomes important because there is no guarantee that another pandemic or disaster will not occur in the future.

Keywords: COVID-19 Pandemic, Cloud Computing, E-learning, Adoption

Introduction
The COVID-19 pandemic has significantly affected almost every system in the world, thereby disrupting and resetting every activity, including the regular education system. Pendergast & O'Brien (2023) reported that up to 91% of students worldwide, or 1. 6 billion children and adolescents, had to close schools, leading to three-quarters of absences. Number of classroom lessons, amounting to about 131 million students in March 2020 to September 2021 in most countries. This was done to

reduce the number of infections and led to a rapid change in traditional teaching and learning methods, forcing teachers and students to switch to online teaching. The situation caused by COVID-19 has prompted schools, colleges, and other educational institutions to adopt cloud computing to provide electronic learning (e-learning) services to students.

One of the key benefits of using cloud computing technology is its ability to provide an online interactive platform where teachers can communicate and interact with their students through technology-based learning (Nasri, 2019). In most African countries, students and teachers are forced to use virtual teaching and learning methods but encounter some difficulties. Therefore, the COVID-19 pandemic has led to a paradigm shift from normal to new normal in the education sector in terms of thinking, understanding, teaching and learning. The successes recorded in most countries through the implementation of online programs have created opportunities for schools to continue accessing online support (Mbhiza, 2021; Eickelmann & Gerick, 2020; Huber & Helm, 2020). Universities have had to embark on retraining their lecturers to ensure effective and successful delivery of online teaching. In most countries, cloud computing is also used in teaching and learning along with electronic learning media. Based on this, African countries, including Nigeria, need to rethink cloud computing services and their impact on e-learning, as the world is rapidly moving towards transformation. New technology, especially in the field of education. Currently, global education systems are seriously applying e-learning, distance education, online assessment, artificial intelligence, cloud computing, gamification, and many other digital technology-based techniques in curriculum delivery. These adoptions took center stage during and after the COVID-19 pandemic.

Unfortunately, many developing and underdeveloped countries, including Nigeria, are yet to fully adopt these innovations in their education systems, causing their education systems to lag behind their peers around the world (Ridwan et al., 2019). While traditional face-to-face teaching and learning is good, the adoption of cloud-based e-learning in the Nigerian education system is much better as it puts the Nigerian education system on the global map. Unfortunately, even after COVID-19 disrupted the country's education system, Nigeria is yet to seriously rethink the area of adoption, full acceptance, and integration of e-learning-based cloud into its education system (Ogwu et al, 2023). The COVID-19 pandemic brings a new reality that never allows educators such as teachers to adopt new technology services but forces them to adopt those (Peytcheva-Forsyth & Aleksieva, 2020).

METHOD AND MATERIALS

This article aims to raise awareness among education stakeholders about the need to rethink the adoption of electronic learning (e-learning) supported by cloud computing services in Providing education in the post-COVID-19 era. This segment reveals the methods and techniques adopted for data retrieval to achieve the objective of this study. The researchers searched various online sources to extract articles related to this topic. No restrictions were placed on the geographical location of the study site's publications, both developed and

developing countries were included in the search. Publications from 2011 to 2023 were considered in this search, and the publication language chosen for the database search was English. A clever search query was created and journals and articles were retrieved using keywords including but not limited to E-Learning, Cloud, Cloud Computing, Cloud Education, Cloud computing in e-Learning, Cloud-based e-learning during the COVID-19 epidemic and its impact. The target online sources were the relevant websites, Sci-Direct, Research Gate, and Scopus. A literature search using the Google search engine was used and the previously listed information sources were searched using two popular web browsers: Google Chrome and Mozilla Firefox, by the researchers. Both titles and abstracts were extracted and collated.

DISCUSSION

COVID-19 has caused major disruptions in the education sector as well as other sectors, causing nearly all global activities to stop due to the spread of the virus. The education sector has been hit hard as teaching and learning have been suspended in most schools around the world. The virus spread through droplets is highly contagious and causes many deaths worldwide (WHO, 2020; Eze et al., 2021). As stated in the UNESCO report, 1.5 billion students in 195 countries were out of school globally due to school closures (UNESCO, 2020b). According to Cahapay (2020), the first case recorded outside of China occurred on 13 January 2020, while the first case of COVID-19 in Nigeria was recorded on 27 February 2020 (Ehanire, 2020). The spread of the disease has forced governments around the world to enact laws leading to a complete or partial shutdown of activities besides physical contact with people, which ultimately leads to social distancing. This has led to some schools in Nigeria adopting technology in education. Online learning and assessment have been adopted by many countries around the world as the new normal, making the existing digital divide visible to all. Countries with better technology have continued teaching and learning through online learning platforms supported by cloud computing services. Unlike in developing countries, where online learning faces many challenges such as not having a computer and internet access at home, not being able to use a mobile phone due to poor network coverage, and lack of funds to buy data, etc.

E-Learning

Electronic learning (e-learning) has been characterized by Lawless (2023) as the conveyance of learning and preparing through computerized assets. It is given through electronic gadgets such as computers, tablets, and indeed cellular phones that are associated with the web. This makes it simple for clients to memorize anytime, anyplace, with few, if any, limitations. It has changed instruction in both schools and businesses, making it less demanding for students and representatives to memorize at their possess pace in an environment that suits them. It can moreover be seen as a user-friendly media that permits information to be shared and gotten to through mechanical gadgets such as portable phones, and portable workstations (Sharma et al,

2014). Electronic learning was not intended to supplant conventional instructing and learning strategies but to progress quality and advance execution within the instruction division. It speeds up the dispersion and cultivating of web-based aptitudes, mindfulness, thoughts, and learning capabilities. A blend of computer program applications, the web, and other web-based stages has made instruction open (Agrawal, 2021). This has expanded the number of clients who can interface to an online-educational stage and associated with numerous clients who are not confined to as it were understudy or teachers (Ashtari and Eydgahi, 2017). E-learning applications and forms incorporate Web-based learning, computer-based learning, virtual instruction openings, and advanced collaboration, and its substance is conveyed through the web, sound or video tape, toady TV, and CD-ROM. It incorporates learning at an individual's pace, or instructor-led and incorporates media within the frame of content, pictures, liveliness, gushing video, and sound (Parte, 2017).

The Concept of Cloud Computing and Cloud Computing Services

Cloud computing according to Samyan and St. Flour (2021) is a set of servers or databases that provide information and services that can be accessed remotely over the internet. It uses the internet and central remote servers to maintain data and applications. The National Institute of Standards and Technology (NIST) sees cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable resources such as networks, servers, storage, applications, and services that can be rapidly provisioned and released with minimal management effort or service provider interaction (NIST, 2011). The costly nature of conventional processing infrastructure difficulty in management, increase in data size and online users, and inefficiency of past computing techniques in retrieving data anywhere and at any time gave rise to the need to archive data with an external storage infrastructure. Especially as the number of users of the internet, video conferencing, and other related technologies increased thereby making it difficult for user data to be taken care of by traditional computing. This gave birth to cloud computing, which has made it possible to manage the volume, variety, and availability of data in a more efficient and scalable manner (Agrawal, 2021). Cloud computing is, therefore, a huge multifaceted system that is made up of numerous end users, cloud service providers, physical hardware machines, internet latency, service brokers, bandwidth, scheduling algorithms, storage capabilities, etc. (Mansouri et al, 2020). It operates on the principle of the "Pay as You Go" (PAYG) model, where a user pays for the services they use as the infrastructure is made to serve on an on-demand basis to users.

Cloud Computing Services

Cloud computing provides services such as:

a). Infrastructure as a Service (IaaS): here, hardware resources such as storage, CPU, and memory are offered as services to customers. It provides users with networks, servers, data storage capacities, and other vital computer equipment resources to enable users to run their software and systems properly. In addition, IaaS enables users to access a wide range of online

platforms and applications without acquiring larger infrastructures. These resources are therefore rented instead of buying dedicated servers and networking equipment with money.

b). Software as a Service (SaaS): This model enables software applications to be offered as services on the internet instead of buying software application packages by individual users, thereby resolving the problems of licensed software which requires constant updating. In addition, provides flexibility and allows users to modify, test, and associate with various kinds of software and methods that would be difficult if the software is bought as well as provides smooth access to huge amounts of data collection. This model also gave birth to Communication as a Service, which assists services that can be provided to students, teachers, and administrators such as email, and makes available large virtual space where students can store large media image files. Furthermore, this model also gave birth to Desktop as a Service (Daas), which is a technology where learners get access to an environment that may be customized based on needs and goals. Here, hardware requirements are not much and allow reduced costs (El-Sofany et al, 2013).

c). Platform as a Service (PaaS): This model deals with the provision of facilities to support the entire application development lifecycle including design, implementation, debugging, testing, deployment, operation, and support of Web applications and services on the internet. PaaS enables its users to develop add-ons, and also develop standalone Web-based applications, reuse other services, and develop collaboratively in a team. The PaaS model can be self-managed, as a result, the developer who is also a user, can reduce material costs to manage the system resourcefully. Some frequently used PaaS models are EC2 (Amazon), Google Apps, and Force.com. Cloud computing empowers e-learning thereby making the learning process faster, more reliable, and easier to use, and enhancing more interactive features (Aquil et al, 2022; St. Flour, 2021).

d). Hardware as a Service (HaaS): This model provides hardware services

e). Database as a Service (DaaS): This model offers database and services that allows for management to evade the difficulty and running cost of a database.

Cloud-based E-learning

El-Sofany (2013), noted that cloud computing has several layers necessary for Cloud Education. These layers are the Physical hardware layer (such as server, storage devices, and internet access), Virtualization layer (such as online storage and application system), Education middleware layer (teaching and learning platforms), and Application layer (where the hosting service takes place). The Physical Infrastructure as a Service supports active hosting while the Platform as a Service provides the model and resources to create and run the cloud applications. Software as a Service is a service layers that offer features such as content, access to content, collaborative learning, and monitoring facilitating interaction among teachers, students, and educational institutions (Dahdouh et al, 2017). Suitable cloud services for educational settings are private cloud architecture – which can use the local network, and several Institutions can team up to deploy a hybrid cloud known as educational cloud – which

can use public networks to access the functions provided by both cloud models (Agrawal, 2021).

The Impact of Cloud Computing Services on E-Learning

The use of cloud computing in education has not only made a significant impact on education but also brought about new prospects in teaching and learning. Lifelong learning is been supported and made possible as a result of the incorporation of cloud computing in education by institutions, policymakers, and administrators (Alajimi et al, 2018). A large of cloud systems used by educational institutions to disseminate, communicate, and interact with learners and educators exist as a result of the reduced cost, access to resources, flexibility, reliability, etc. Cloud computing enables students and teachers to access, store, and share information, resources, and applications securely and efficiently. In addition, data can be accessed over a large network with improved security and privacy. It has brought opportunities for students to study from home and access school data with ease and at their convenience. The benefits of Cloud computing in education include reduced cost, access to resources, flexibility, provision of positive learning experience, etc. Some examples of cloud computing in education are cloud-based Learning Management Systems such as Canvas and Blackboard, online video conferencing platforms such as Zoom, and cloud-based storage solutions like Google Drive for sharing documents, among others.

The use of cloud computing in e-learning is highly advantageous as it assists educators use cloud scalability, flexibility, and security to sustain the standard of e-learning in areas of training, accessibility from any location, and at any time using any digital device. Flexible data storage and management techniques, in addition to rugged security features, have made cloud-based e-learning the most cherished type of hosting in the educational technology industry (Vynogradska, 2021). This is because it assists educators in uploading a large number of E-learning contents, and materials in various formats and types such as videos, presentations, questionnaires, texts, etc, hosting online classes, and interacting with distant learners at less expensive cost. One of the features of 21st-century education is accessibility, digestibility, on-point, and repeatability. These assist in replacing lectures that require a long period to deliver with a few minutes long video with practical exercises to support e-learning outcomes, delivered through software as a service (SaaS) e-learning platform (Vynogradska, 2021). The integration of e-learning through cloud technologies gives rise to a reduction of cost, helping users not to invest highly in technological equipment as simple digital devices such as phones, computers, tablets, etc can be used to access data using a good internet connection (Bora & Ahmed, 2013).

In the area of availability, cloud-driven e-learning provides higher service quality as a result of fast processing capacity and large amounts of data that can be stored (Kiran, 2014). Integration of cloud computing in e-learning makes it possible to monitor, store, and control data and it allows data to be shared, stored, and distributed on demand over larger accessible platforms (Dahdouh et al., 2017). Other benefits of cloud computing in E-learning are:

Strong virtual classroom environments – there are no limitations in the cloud, webinars, creating and uploading new training content, hiring experts to teach remotely instead of relocating them, running Massive Open Online Courses (MOOCs) for thousands of students, assisting them to pass their examinations remotely with video and screen recording are all possible in the cloud.

Ease of Development – producing new novel training materials or adding more features to cloud-based E-learning solutions is made faster and less expensive as cloud resources permit faster video/audio rendering and encoding, creation of Sharable Content Object Reference Model (SCORM) compliant objects in addition to shortening the time needed to prepare new online courses.

Secure data storage – cloud computing producers provide numerous security features and also encrypt all data in storage and transit.

Application of innovative technology – cloud computing platforms back the latest technology innovations such as Augmented and Virtual Reality, Machine Learning, and Artificial Intelligence, thereby allowing and strengthening pieces of training with virtual laboratories and machine learning-based personalization course contents.

Challenges of Cloud Computing-backed E-learning

Cloud-based e-learning has some challenges just like other technologies. Some of the challenges facing cloud-based e-learning are risks connected to data protection, security, and the retention of data integrity, which are very critical to institutions or schools having works with intellectual property, patents, etc. In addition, the transition from traditional delivery to an online system needs serious organization and planning, which is not so cheap (Almaiah, et al, 2020). The migration to a digital education system requires convenient e-learning infrastructure and appropriate deployment of cloud models to deliver the right service to students and teachers. Teachers, educators, and users need to be properly trained and given enough access and support. Lack of technological infrastructure and inadequate investment in technology serve as major challenges to cloud-based e-learning in most countries.

For African countries such as Nigeria, some of the challenges facing cloud computing as noted by Obodoeze et al, (2014) include security and privacy issues, High cost of broadband internet, high bandwidth costs, high cost of IT services, frequency of power outages and lack of enabling law or bill to protect cloud data, etc. The level of preparedness of institutions, lack of infrastructure, paucity of funds, and policy issues in educational sectors also posed considerable challenges. Other challenges militating against the success of technology innovation in Nigeria include inadequate technical know-how, infrastructure, accessibility issues in Nigerian universities, and the digital divide among Nigerian students. Better implementation framework must be put in place to address these challenges. Furthermore, students from low-income homes, those from rural areas, and students with special needs require distinctive attention (Fadip et al, 2021). The COVID-19 pandemic exposed the level

of unpreparedness of most education sectors to provide distance learning, weak educational infrastructure, inequality in access to the internet, and finally teachers' unwillingness to switch to distance learning (UNESCO, 2020).

CONCLUSION

The disruption in education, caused by the COVID-19 pandemic has led to a great transition to online teaching and learning in institutions of higher learning, thereby changing how students and lecturers relate to educational knowledge. The pandemic also forced all educational stakeholders to adapt to the new ways of teaching and learning. Cloud-based e-learning has made teaching and learning easier for both students and teachers as it quickens access to educational materials, easy interaction between students and teachers, at a reduced cost, etc.

Educational leaders therefore need to rethink content creation and content sharing and establish working communities to meet the demands of the new normal in education. Online teaching and learning in Nigeria can only be effective when the educational sector is properly funded, through proper investment in technological infrastructure, and proper training and retraining of lecturers on new technology applications. Since it is clear that the only solution to ensure that students are not deprived of learning at any point in time is the adoption of cloud-based e-learning, efforts should be intensified to adopt and integrate this technology into the education system in Nigeria.

RECOMMENDATIONS

There is no doubt that the COVID-19 pandemic altered the traditional way of teaching and learning, hence the need for urgent measures to be taken to assist the change. With the future of education in mind, it is therefore time to go for new methods of training and preparing teachers and educators to equip them with the requisite skills and competencies to keep pace with changes in the education sector. Existing skills should be reviewed and upgraded for both students and teachers to equip and prepare them for the future, bridging the gap of the current digital divide and creating avenues for collaboration and coordination between institutions of various categories to provide quality education to all students. This is important since there is no guarantee that another pandemic that will lead to global lockdown will not surface.

It is therefore imperative that government and the education practitioners rethink how to sustain and improve the digital learning that kept academic activities afloat during the COVID-19 pandemic. The government and the education sector should therefore put mechanisms in place in the area of proper training the teachers and educators in the use of technology for curriculum delivery, assessment, and practical activities in education. There is a need for the provision of adequate technological infrastructure nationwide to support cloud-based e-learning. Challenges of inequality in accessing the internet, and teachers' and student's unpreparedness to switch to learning through technology must be addressed. Technological infrastructure should be made available to all institutions both primary, secondary, and tertiary

to be prepared for the shift to the new normal. Furthermore, there is a need for the establishment of regulatory policies and frameworks to handle emergencies and ensure quality and equity in education.

The underprivileged must be empowered through the collaboration and support of organizations and institutions. Rethinking Cloud-based e-learning involves proper funding by the government, therefore, the government must be ready to step up their budgets towards education in the country, so as the boost the morale of teachers and educators towards online teaching and learning. There is also a need to expand broadband connectivity and properly invest in the necessary structures that will assist e-learning to thrive, and this can be achieved through the adoption and implementation of policies and programs in line with the targeted shift in education. The novel worldwide reality has called for a rational move towards to adoption of technological innovation in the education process rather than being old-fashioned. Therefore, a serious determination is needed by stakeholders to sustain this new norm. Efforts must be made to curtail the digital divide that exists among students.

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