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An Integration of Blockchain Technology in Teacher Education in Nigeria for the Production of Effective Science Teacher in the 21st century

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Abstract

With the growing demand for science education and the need for highly qualified science teachers, improving teacher training and certification processes has become increasingly urgent. This article explores the potential integration and application of blockchain technology to improve quality science teacher education. Key challenges in science teacher education and a conceptual framework for leveraging blockchain technology to address these challenges are also presented. Blockchain technology provides a decentralized, transparent, and immutable platform that can revolutionize the way we train and certify science teachers. The proposed framework integrates features such as secure certification, continuous professional development tracking, and decentralized collaboration among educators. The article also discusses the potential benefits and limitations of implementing blockchain technology for science teacher education. In conclusion, the article highlights the transformative potential of blockchain technology to ensure quality science teacher training in Nigeria.

Keywords: *Teacher Education, Blockchain Technology, Teacher Training and Certification, Leveraging Blockchain Technology*

Introduction

As the world rapidly moves towards a digital age, it is essential for teacher educational systems in Nigeria to keep up with the changing times. The training process of Nigerian science education teacher is no exception. In order to equip future educators with the necessary skills and knowledge, it is crucial to integrate the concepts of Blockchain Technology into process of production of quality and effective science teacher educator.

Furthermore, the production of quality science teachers is crucial for fostering scientific literacy, promoting critical thinking skills, and nurturing the next generation of innovators and problem solvers, (Hameed, et'al 2019). However, the current teacher training and certification process faces several challenges that hinder the production of highly skilled science educators. These challenges include issues such as fragmented credentialing systems, limited opportunities for continuous professional development, and a lack of collaboration and knowledge sharing among teacher educators.

In addition, National Commission for Colleges of Education (2012), opined that teacher is the kingpin of quality in education. Since education has become the primary tool for the overall development of society, Teacher Education must occupy a position of pre-eminence in the planning and organization of the modern society. This in turns demands that the Nigerian people and government make both Teaching and Teacher Education a very attractive professional pursuit. Integrating Blockchain Technology in the process will go a long way in appraising teacher education programme in Nigeria.

Likewise, Haleema et'al (2022), asserts that one of the fundamental components of the United Nations' sustainable development 2030 agenda is quality education. Haleema et'al (2022) opined that the agenda aims for inclusive, equitable education, utilizing digital technologies like blockchain and smart devices to empower student teachers and ensure active participation in learning processes.

Osuji, (2009), teacher education refers to professional education of teachers towards attainment of attitudes, skills and knowledge considered desirable so as to make them efficient and effective in their work in accordance with the need of a society at any point in time. According to Anisiuba, (2020), blockchain is a Distributed Ledger Technology (DLT), which helps the user to keep records of any digital transactions, and makes the history of any digital asset unalterable and transparent.

To this end, Integration of Blockchain Technology in the process of production of science teacher will be of great value. One of the main advantage of integrating blockchain technology in education is the enhancement of transparency and efficiency.

Nigerian Certificate in Education (NCE) as a Teacher Education System

The Nigerian Certificate in Education is a specialized certificate awarded to individuals who have successfully completed a three to four-year teacher training program at a Teacher Training College or College of Education approved by the National Commission for Colleges of Education (NCCE). This program is designed to equip individuals with the necessary knowledge, skills, and competencies required to teach at the primary and secondary school levels in Nigeria, (NCCE, 2012).

One of the key benefits of obtaining an NCE is that it is a recognized qualification by both the government and non-governmental organizations in Nigeria. This certification serves as a prerequisite for individuals who wish to teach in public and private schools in Nigeria. This recognition also makes it easier for NCE holders to secure employment opportunities in the education sector, which is highly competitive in Nigeria, (NCCE, 2012).

The NCE program covers a wide range of subjects, including Education and General Studies, Secondary Education (Arts and Social Sciences), Secondary Education (Sciences), Secondary Education (Languages) and Secondary Education (Vocational and Technical Education). This diverse curriculum ensures that NCE holders have a well-rounded education, making them versatile and adaptable to different teaching environments. This also allows individuals to specialize in a particular subject area and become experts in their field, making them valuable assets to educational institutions (NCCE, 2012).

Furthermore, the NCE program is a stepping stone for individuals who aspire to further their education and obtain a Bachelor's Degree in Education. NCE holders can gain direct entry into the second year of a Bachelor's Degree in Education program, saving them time and money. This opportunity to progress in their education also allows NCE holders to advance in their careers and take on leadership roles in schools and other educational institutions.

The NCE program offers academic benefits and practical teaching experience, preparing individuals for real-life scenarios, developing effective strategies, and fostering confidence in a diverse, evolving education landscape.

Teacher Education System in Nigeria and the Emerging Technologies

Naturally, every human being is a teacher. Teaching occurs when a formal or informal activity transforms someone's experience from unknown to known. (Mormah and Bassey, 2021). Despite being informal, the traditional African teaching method relied on everyday experiences with tangible and intangible resources from the environment, such as artifacts, crafts, festivals, folklore, natural resources, arts, and idioms, to support teaching and learning. This method is still used today to preserve and transfer our cultural heritage, (Mormah and Bassey, 2021). Jibril (2008), opined that teacher education is any type of instruction that is planned, designed, organized, and implemented with the intention of developing individuals who will teach, mostly but not just in primary and post-primary schooling.

The relationship between teaching and education has changed in the modern day because some people are qualified to teach and have the associated rights and obligations. These individuals are known as teachers. As a result, this person needs to complete a procedure known as Teacher Education, as well as unique and specialized training through approved platforms and programs. (Mormah and Bassey, 2021).

In keeping with the foregoing, the Federal Government of Nigeria currently values teaching profession greatly, as shown by the National Policy on Education, which states the following objective of teacher preparation programs: to produce highly motivated, diligent, and effective classroom instructors for all levels of the educational system; to give teachers the professional and intellectual preparation necessary for their roles; and to develop their ability to adapt to changing circumstances. (Federal Republic of Nigeria, 2013).

Teacher education is not a "island" unto itself, (Etim, 2006); Its goal is to use emerging technologies and worldwide best practices to bring it into line with the competitive modern global community. (Etim, 2006). In line with the above, UNESCO (2008) reported that, ICT plays different, but complementary role, with new technologies, requiring new teacher's roles, new pedagogies and new approaches to the process of teacher education process. According to the Nigeria National Policy on Education cited by Federal Republic of Nigeria (2013), all teachers in educational institutions shall be professionally trained. Teacher education programmes shall be structured to equip teachers for the effective performance of their duties and Information and Communication Technology (ICT) training shall be incorporated into all teacher training programmes.

In a trying to support the above assertions, the paper maintains that there is need for appraisal of teacher education system and the implementation of Blockchain Technology. Consequent upon, teacher educational institutions, should anticipate new technological developments in the process of production of effective and qualitative science teachers.

A Review of Blockchain Technology and its Application

The idea of blockchain was initially proposed and introduced in 2008 through the application of Bitcoin and cryptocurrency, (Nakamoto, 2008). In recent years, a wide range of sectors, including academia, have shown a considerable interest in blockchain technology, (Ghazawneh, 2019). Although the application blockchain is mostly known and attributed to cryptocurrency (Beck et al., 2016), Blockchain technology is becoming more widely employed outside of cryptocurrency in a range of sectors and applications. (Zheng et al., 2018), including banking (Tapscott and Tapscott, 2016), insurance (Underwood, 2016; Lorenz et al., 2018), health care (Swan, 2015; Ekblaw et al., 2016), public service (Akins et al., 2014), security service (Noyes, 2016), and education (Sharples and Domingue, 2016).

A blockchain is a collection of blocks that contains transaction data for a particular amount of time (Nakamoto, 2008; Beck et al., 2018). By revealing every transaction, this system lowers transaction ambiguity, insecurity, and uncertainty while providing a single truth to all network participants. (Beck et al., 2016; Naerland et al., 2017; Catalini and Gans, 2018). Blockchain technology operates on a decentralized database of transactions uniformly distributed among decentralized nodes. (Glaser, 2017). It is a consensus-based

data structure, based on cryptography that ensures database consistency and forbids changes once transactions are approved. (Underwood, 2016; Beck et al., 2018).
Typically, there are public and private blockchains (Buterin, 2014; Peters and Panayi, 2016; Zheng et al., 2018). Nodes can receive data from a private blockchain and submit new transactions only after the data have been pre-registered by a central authority, nodes can read data from a public blockchain and propose new transactions. (Beck et al., 2018). Permissioned or permissionless transaction validation is possible in a blockchain. In a permissioned blockchain, only authorized nodes are able to read, submit, and validate transactions. In a permissionless blockchain, any nodes are able to do these tasks. (Peters and Panayi, 2016).
Blockchain technology first appeared in 2008 and has since developed through three stages: Blockchain 1.0, Blockchain 2.0, Blockchain 3.0. (Gatteschi et al., 2018), and Blockchain 4.0 (Iyer, 2021). To ease the simple digital financial and cryptocurrency transactions, the first stage, was designed and utilized. The second stage was introduced for properties and smart contracts, (Alshareef, 2022). These smart contracts would impose precise rules and criteria that must be followed before it is registered in the blockchain,. The registration process can be done without the interference of a third party. The third stage involves the development of many applications of blockchains in numerous sectors, including but not limited to government, education, health, and science, (Alshareef, 2022). Meanwhile, the application of blockchain in the education sector is still in its infancy. Only a few educational institutions use blockchain technology to validate and share academic certifications and/or learning outcomes of students (Chen et al., 2018). Therefore, blockchain technology has so much more to offer and has the potential to transform the education sector

Mechanisms used by Blockchain for Data Storage and Security

According to Identity Management Institute (2007), several mechanisms are used to secure the data on a blockchain:

1. **Cryptographic hashing**: Blocks in blockchain has a hash of the data in the block as well as the cryptographic algorithm from the previous block. As a result, blocks become chained and dependent on one another's integrity. A block's hash will change if any attempts are made to change its contents, which will be picked up by the network and denied.
2. **Distributed ledger**: A blockchain consist of networked computers, that store a copy of the ledger. This mechanism makes failure nearly impossible, and it would be exceedingly challenging for an attacker to modify the data on all copies of the ledger same time.
3. **Smart contracts**: Blockchains allow the use of smart contracts, these contracts are executed based on the agreement details between multiple entities. These automated

contracts can be used to enforce the terms of a contract, making them more secure and less prone to fraud or errors.

4. **Proof-of-work**: The process of adding a new block to the chain requires the completion of a difficult mathematical puzzle, known as proof-of-work. This requires significant computing power and energy, which makes it expensive and time-consuming for an attacker to try to add false blocks to the chain.
5. **Proof-of-stake**: Proof-of-Stake (PoS) is a cryptocurrency consensus mechanism used to confirm transactions and create new blocks through randomly selected validators. Data security is ensured through consensus mechanisms based on participants' economic stake and commitment. The combination of economic incentives and decentralized validation mechanisms positions Proof of Stake as a robust and efficient framework for securing blockchain data.
6. **Consensus mechanisms**: To add a block to the blockchain, the change must be approved by the majority of the network nodes. This helps ensure that the blockchain data is correct and that any changes to the data will be detected and rejected. The combination of cryptographic hashing, proof-of-work, and consensus mechanisms makes it extremely difficult for an attacker to alter the data on a blockchain. This is why blockchains are often considered to be secure and reliable.

Leveraging Blockchain Technology in Teacher Education and Production of Effective Science Education Teacher.

Blockchain decentralizes data storage across multiple sites, preventing tampering with instructor and student information. It ensures accurate student records, monitoring development, and promoting transparency and accountability in the education system.

Nagar (2023), outlined the following to buttress how Blockchain Technology can be applied to improve teacher education system and production of quality science teacher:

1. **Keeping of Students Academic and Extra-curricular Records:** Students data and records are very important, these include attendance, scores, grades, personal information, curriculum choices, transcripts and certificates. The blockchain securely stores everything, so there is no need to store records in documents or files. Integration of blockchain technology in teacher education system will make robust outcomes.
2. **Curating Lessons:** Blockchain aids in organizing and curating lessons using smart contracts. Educational applications use smart contracts to automatically encrypt lectures, assign tasks, and verify accuracy. Students receive credits, and teachers earn cryptocurrency payments.
3. **Allocation of Degrees and Certificates:** This information is stored in the student’s records, so it takes up more space. Everything is accessible on the blockchain with blockchain technology. So the organizations don’t have to deal with the candidates for the transcripts/certificates. This makes verification much easier.

4. **Access to ultra-Modern Learning:** The days of students sticking to their education plans are gone. The education system is evolving with the times. Traditional education models cannot offer free and advanced modern learning. Blockchain-based education give access and allows learners to learn about the topics and subjects that are trending.
5. **Watchful Learning:** Our lives are built on decision-making; whether it is at work, at home, or for entertainment. Logical learning is the key to this because it helps individuals to make better decisions. This can be used to solve complex Multiple Choice Questions or advanced questions related to science and technology. This increases brain power and memory.
6. **Payment of Fees:** Secured platforms facilitate safe student fees payment and scholarships transaction using cryptocurrencies or card information, maintaining transparency on the blockchain network.
7. **Convenient Learning:** Blockchain technology enhances learning by providing easy access to information, enabling immersive virtual environments with 3D graphics, enhancing students' understanding of subjects through immersive, immersive learning experiences.
8. **Feedback and Evaluation:** Blockchain technology can enhance teaching by enabling anonymous feedback from students, recorded on the blockchain, thereby providing teachers with valuable insights for self-improvement and improved teaching quality.

Benefits of Blockchain Technology in the Teacher Education and Production of Quality Science Education Teacher.

Blockchain in Teacher Education Industry has many benefits. Nagar (2023), looked at the following as ways which Teacher Education can benefit from Blockchain Technology and production of quality science teacher:

1. **Data Security Improvements:** Blockchain, a decentralized platform, significantly reduces data breaches in the education sector by preventing unauthorized access to sensitive data and ensuring secure storage of student records.
2. **Verification of Credentials:** Validating school credentials currently requires that you contact multiple institutions. This can be tedious and costly. The data's accessibility, immutability and speed can make the verification process easier and more efficient with blockchain.
3. **Transparency:** Blockchain enhances transparency in education by storing grades and data on a decentralized platform, fostering trust and confidence among students.
4. **Improved Access to Education:** Blockchain technology can enhance education access for disadvantaged communities by verifying credentials of those without official documentation or those affected by conflict or natural disasters.
5. **Education Programs can be Customized:** Blockchain technology can be used to customize teacher educational programs to meet individual student needs, record

student progress and track learning history. This allows for personalized learning plans that are tailored to student's strengths and challenges.

Challenges of Integrating Blockchain in Teacher Education System

According to Saga (2024), implementing blockchain technology in the education business presents numerous problems and obstacles for educational institutions. Saga (2024), further opined that these challenges must be carefully addressed and solved to achieve successful integration and outlined them as follows:

1. **Data Privacy:** One of the primary concerns when implementing blockchain in education is ensuring the privacy and security of student data. Because blockchain is inherently transparent and unchangeable, additional safeguards must be implemented to secure sensitive information and ensure compliance with data protection laws.
2. **Scalability:** Scaling blockchain technology to suit the demands of large educational institutions can be a difficult challenge. As the volume of data and transactions grows, it's critical to guarantee that the blockchain network can handle the strain without sacrificing performance and efficiency.
3. **Interoperability:** Integrating blockchain into existing teacher educational systems and platforms might be difficult due to interoperability difficulties. Ensuring easy data exchange and compatibility between various blockchain systems and educational software is critical for a successful transition.
4. **Resistance to Change:** Implementing blockchain technology necessitates a fundamental cultural transformation in educational institutions. Many stakeholders may be reluctant to change, either because they do not comprehend it or because they are afraid of disturbance. Overcoming this reluctance and cultivating an open mindset to innovation is critical for successful adoption.
5. **Costs and Resources:** Adopting blockchain in education necessitates financial investments as well as committing resources for development, implementation, and continuing support. To make educated judgments, educational institutions must carefully weigh the costs and benefits of integrating blockchain technology.
6. **Risk of error:** According to Mara-Florina, (2020), since the data encrypted on a blockchain network is immutable and unalterable, any error made on any block cannot be overwritten and it requires the creation of a new block.

Conclusion

In conclusion, the integration of blockchain technology in the production of quantity science education teacher in Nigeria has the potential to bring about significant improvements in the teacher education sector. It will promote transparency, data security, efficiency and it would in addition, equip future science teacher educators with the necessary knowledge, skills, practical experience and promote critical thinking skills.

With blockchain-based digital credentials, students will have a verifiable record of their academic achievements, making it easier for them to apply for jobs or further studies. This will cut down on the tedious and time-consuming process of manual record keeping and verification.

Moreover, it will also save costs for schools, as they will no longer need to spend on printing and issuing physical certificates. It would also bridge the digital divide and prepare science teacher students for the digital economy. Therefore, it is crucial for the government and educational institutions in Nigeria to embrace this technology and explore its vast potential in improving the quality of education in the country. With proper implementation and regulation, the integration of crypto and blockchain technology can bring about a much-needed transformation in the Nigerian education system.

Way Forward

The following are recommended as a way forward to integrating blockchain technology in teacher education in Nigeria:

1. Blockchain's inherent features, such as immutability, transparency, and security, must be harnessed by public and private schools for improving processes of science teacher production that rely on trust, verification, and collaboration.
2. Government and private organization should carry out further research, experimentation, and innovation in leveraging blockchain technology to enhance science education and empower educators.

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