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Application of Blockchain-based Technology in Chemistry Education Students' Data Management

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Abstract

Blockchain-based technology is a moderately novel research area. The purpose of this paper is to explore the application of this technology in chemistry education students' data management. The authors established a rationale for such application, discussed various areas of the application and pointed out the emerging possibilities for the application in the contemporary chemistry education departments. Also, the advantages and possible shortcomings of its application, as well as other issues relevant to the application were discussed. Consequently, the paper provides in-depth knowledge and understanding of the application of blockchain-based technology in chemistry education students' data management. The conclusion and implication drawn is that there is an urgent need for full integration of Information and Communication Technology (ICT) structure in the department of chemistry education so as to enable the application of blockchain technology for students' data management.

Keywords: *Application, Blockchain-based Technology, Chemistry Education Students' Data Management*

1. Introduction

Blockchain-based technology entails the delegation of data and information to users by denying a third party access to the data and information. It seizes delicate data from the possession of third party authorities and gives it back to the hands of its users (Crosby *et al.*, 2016). According to Crosby *et al.*, (2016), a blockchain technology is basically a distributed database of records shared among participating parties. Each record in database is verified by consensus of a majority of the participating system. The authors further explained that once entered, information can never be erased and that blockchain technology contains a verifiable record of every single transaction ever made. Moreover, blockchain technology has been used effectively over the years in the financial and non-financial sectors, including the education sector. The present researchers envision putting proof of existence of all educational documents, students' data private securities in blockchain. As observed by Grech and Camilleri (2017,) the core features of blockchain-based technology are ease of sharing and visibility. Hence the unavailability of any of these features in the present systems is often a dominant driver for the adoption of blockchain-based technology. They become particularly critical in transactions in which more than one organisation is making blockchain entries. Thus, everything in education including taking possession of a student's learning qualifications, legitimizing one's informal learning accomplishments, speeding up of a student's knowledge transfer as well as reorganization the job application process all more easily and more securely can be done through the adoption of blockchain-based technology.

As observed by Major and Omenu (2016), to effectively run the affairs of higher educational institutions in Nigeria, the challenges of the 21st century have placed a bigger

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onus on the administrators of these institutions to formulate and implement efficient data management policies and procedures to function as self-sustaining institutions just as business concerns and remain significant through viable competition in this present age. The authors further added that, in carrying out its core roles of teaching, learning, research and development of community, higher educational institutions create and use various forms of data. So far, some of the important data produced and used in chemistry education departments include personal and financial data. Personal data are initial application forms, results, periodic assessments, transfer and promotion, among others. There has been an argument on the subject of management of personnel data as being likely to pose problems because of their bulkiness, longevity, sensitivity and occupying of valuable space in offices.

On the other hand, financial data include all transactions held in reserve in relation to financial considerations. These include budget allocation, budget requests, statement of expenditure, shipment receipts, invoices, requisitions, purchase orders, and receipts of monies received or expended. Data management has become a basic aspect of the organizational life of chemistry education departments. Appropriate effectiveness of chemistry education departments would necessitate the generation and transaction of information in the form of data for teaching, learning, research and general administration in attaining set goals (Major & Omenu, 2016).

Students' data in chemistry education departments are very sensitive and vital, thus, it is a great cause of worry that core data for teaching, learning, research and general administrative framework may become very problematic and time consuming to retrieve and use even if at all they exist. There is always a mix-up of recorded information in files which even get missing. Improper labeling and storage of files in designated cabinets makes accessibility and usage difficult (Major & Omenu, 2016). Data management, forms management, and reports management can help reduce the rapid reproduction of unnecessary reports, documents, and copies, and at the same time improve the efficacy of those reports and documents that do need to be created (Akor & Udensi, 2013). In view of the forgoing, a computer-based information system is usually necessary in chemistry education department for the following purposes: superior processing speed, improved accuracy and enhanced dependability and reduction in cost. The overall speedup is significantly higher than the manual work. The management system boosts the functionalities of the routine works of the department in a number of ways. The computerization minimizes with ease the working time of users. The department staffs get information in any way they desire. Data retrieval is also easy and fast. This also reduces the burden on the department by restricting the users from entering invalid data. The maintenance of data has been made quite simple such as searching for data and data maintenance. The error rate will be reduced dramatically with the adoption of blockchain-based technology in managing of students' data in chemistry education department (Thuseethan, 2015).

However, the adoption of Information and Communication Technology (ICT) in data management has gained a lot of grounds in educational institutions in that; it has reduced the intricacy of work done by departmental staff and made students data to be more secured in the departmental database. Nonetheless, the ease of accessibility of these data by students has remained a bit problematic. Confidentiality is also a major problem encountered by students in the divulgement of personal data to a requesting authority through the involvement of a third party. Hence, confidentiality policy is most time broken when students request for their data to be given to them or a requesting authority which can be another department in the institution or another institution or an employer. On the contrary, the evolution of blockchain technology has made it possible for information to be shared without the involvement of a third party.

Blockchain-based technology is a concept in ICT family. In recent time, blockchain technology has been applied in various fields such as cryptocurrencies in the financial

area, which includes Bitcoin, Ethereum, and Zcash (Zerocash), *etc.*, (Chen *et al.*, 2018). As a result of its immutability, transparency, and trustworthiness for all transactions executed in a blockchain network, this innovative technology has many prospective applications in the management of data in chemistry education department (Underwood, 2016). At the preliminary stages of its emergence, blockchain technology was not able to lure a lot of attention. However, as Bitcoin continues to run safely and steadily over the years, the society has since become aware of the enormous possibilities of this underlying technological innovation and its application to many other fields over and beyond cryptocurrency (Collins, 2016). The first blockchain was conceptualized by a person (or group of people) known as Satoshi Nakamoto in 2008. It was implemented the following year by Nakomoto as a core component of the cryptocurrency bitcoin, where it serves as the public ledger for all transactions on the network.

The development of blockchain applications could be divided into three stages; Blockchain 1.0, Blockchain 2.0 and Blockchain 3.0. Blockchain 1.0 simply implies the disposition of cryptocurrencies as a peer-to-peer cash payment system. On the other hand, Blockchain 2.0 connotes the widespread applications of blockchain other than simple cash transactions, including stocks, bonds, loans, smart property and smart contacts. Whereas, Blockchain 3.0 entails the development of blockchain applications further than currency, finance, and markets, such as in the areas of government, health, science, literacy, culture, and art (Swan 2015). Blockchain technology has a point-to-point transaction feature and the activities of a third party are irrelevant; and hence not needed. This simply implies that all transactions do not require the participation of third parties. Circulation of digital currency based on blockchain technology is fixed. Specifically, in Bitcoin, the currency base is fixed at 21 million caps; therefore, a specific mining algorithm is used to generate digital currency and is confined to a pre-defined formula. Thus, there will be no inflation problem, collapse *etc*. In Blockchain 2.0 and Blockchain 3.0 applications, the combination of other activities such as government activities, educational activities, and financial activities can make these non-financial activities have the property of currency (Chen *et al.*, 2018). Blockchain technology has become a hot topic for more and more countries, institutions, enterprises, and researchers. One of the crucial features of blockchain technology is how many nodes in a distributed blockchain network maintain consensus and the Bitcoin blockchain network adopts a hash-based Proof-of-Work (PoW) distributed consensus algorithm (Nakamoto, 2008).

Blockchain technology is also known as distributed ledger technology. It permits participants to secure the settlement of transactions, achieve the transaction, and transfer of assets at a low-cost (Tschorsch & Scheuermann 2016). A sample flow of cryptocurrency blockchain transaction can be seen as follows. User A initiates a transaction to User B via a peer-to-peer blockchain network. A cryptographic proof of identity (a pair of public key and private) is used to the network to identify user A and user B uniquely. The transaction will then be broadcasted to the memory pool of the blockchain network waiting for transaction verification & validation. The new block is generated through a process known as reaching consensus; which is the procurement of a certain number of approved nodes. After reaching consensus, new "block" on the entire blockchain network is formed, and each node updates its respective copy of the blockchain ledger. This block contains all the transactions that occurred during this time. It is "linked" to the original block in the network through the digital signature (Yli-Huumo *et al.*, 2016). The consensus stage is achieved through the adoption of a consensus algorithm (Chen *et al.*, 2018). Blockchain is not only a new type of internet infrastructure based on distributed applications but also a new type of supply chain network. Essentially, blockchain is a distributed network of computers (nodes) used to maintain the source of information sharing. Each node maintains the security and accuracy of the information by keeping a complete set of ledgers of past transactions. When a new block is being created by a miner, who is the first one to validate all the transactions in the block and solve the

mathematical problem by generating a digital signature for the block which meets a pre-defined rule using the hash function. The newly created block will be broadcasting to the whole blockchain network, allowing all nodes to maintain the same complete ledger (Tschorsch & Scheuermann, 2016). Accordingly, this paper is fixated on considering the emerging possibilities of using blockchain-based technology for students' data management in the department of chemistry education.

2. Chemistry Education Students' Data Management Through Blockchain-Based Technology

On a general note, ICT have become one of the essential building blocks of the contemporary society. Many institutions now regard the mastering of the basic skills and concepts of ICT as an unavoidable part of the core of education. Based on this, a variety of novel models of education are surfacing in response to the new opportunities that are becoming available by integrating ICT and in particular blockchain-based technologies, into the educational institutions for learning and proper management of students' data. The efficient incorporation of such applications however, depends on lecturer's acquaintance and ability with the IT learning and management environment. Science lecturers and higher technical officers in chemistry education departments, for instance, need to know exactly how blockchain-based technology is used as students' data management tool. Studies that related to the use of ICT skills in chemistry education in particular and in science in general establish that ICT-based environments play a significant role in education (Dori, Rodrigues & Schanze, 2013). While this appears to be correct as a general evaluation, the future is influenced by innovations, fast-moving, and in many ways unpredictable. This paper is about the application of blockchain-based technology in chemistry education students' data management with the overall aim of increasing the effectiveness of students' data management.

Students' data are information of students which the school poses as records for proper identification of the students, monitoring of academic achievements of the students, compiling of analytical reports and storage for other purposes. Records are information received and kept, regardless of the form or medium received and maintained by an agency, institution, organization or individual in pursuit of its legal obligations or in the transaction of business (Enemute, 2005; Sapere-Obi, 2014). A record can also be seen as information, in any format, which must be retained as evidence of actions or decisions for operational or legal purposes (Heriot-Watt University, 2013). Records equip policy makers and educational managers with the information essential in making plans and decisions as well as taking actions that will facilitate the achievement of educational goals and objectives. Academic transcripts of students/graduates often demanded by employees and other higher institutions can only be made available through accurate data and efficient data management.

The academic reports of students can be used by lecturers and school administrators to perform follow-up on students' progress and identify those in need of remedial classes. Proper data management could help universities to manage their information, efficiently fulfill their mandate, protect them from litigations, preserve their corporate memory, and foster accountability and good governance (Sapere-Obi, 2014). Accurate and up-to-date data are required to ensure equity, fair-play and justice both in the award of graduation prizes to chemistry students and in the promotion, retirement and replacement of chemistry education department staff (Ifedili & Agbaire, 2011). Akor and Udensi (2013) pointed out that, data management plays a significant role in various aspects including, inter alia, risk management process, strategic planning process, bettering performance and improving service delivery, promoting good governance, supporting democratic accountability, fulfilling legal requirements, combating corruption, promoting and protecting human rights and ensuring sound financial management.

Chemistry education students' data management plays a very vital role in the efficient and effective management of the department of chemistry education. It is the core activity in the administration of the department of chemistry education because it documents the planning and implementation of suitable administrative duties which allow proper monitoring of work. There will be variation in the nature and extent of the data depending upon the purpose, setting and context of the services. However, it is important that the staff of the chemistry department becomes familiar with the blockchain-based technology for managing students data (Egwunyenga, 2009). This is because Blockchain-based technology provides a machinery to verify that data of students has existed at a specific time (Grech & Camilleri, 2017). Thus, even after the students' graduation from the department, their data can be accessed when necessary.

In organizations such as the Universities, paper is seen as the material for data in administrative documentations (Igwoku, 2008). Also, Thuseethan (2015) noted that, most of the departments' organization and management of activities is being done manually. Thus, according to the situation of current analysis, chemistry education department face difficulties in managing the routine works that have been done by them. Some of which include; data security and reliability, data Validations, time consumption in getting the details of any of the student and employee, book *etc.*, high cost activities, difficulty in producing analytical reports and filling data entry forms, requisition of bulky paper work (registers) and entry mistake. These, forthwith, have become setbacks to the accuracy of results obtained. Hence, with educational institutions being the general centers for data generation and by extension records keeping, the department of chemistry education has a lot to do with data and cannot function well without a good data management framework (Ifedili & Agbaire, 2011).

One of the major problems faced by chemistry education departments is the problem of monitoring the academic achievements of individual student as well as show that all students are meeting the set standard for learning. The ability of a chemistry education department to ease this burden is affected by the department's access to students' information which has to be accurate and relevant (Onuiri *et al.*, 2015). However, the main purpose of data management programs in chemistry education departments is to monitor data of all types and formats to ensure that such pass efficiently through creation, use, storage and disposal or permanent retention at minimum cost. Thus, effective data management systems in higher educational institutions should provide functional policies, procedures and necessary information required for right functioning. These could lead to efficiency as available information recourses are synergized for the competitive advantage of such institutions in the emerging global order. By implication, the importance attached to students' data has placed a demand on higher educational institutions to put in place comprehensive data management programs, mapping all data for easy administrative purposes. This call for higher-level technology staff (Major & Omenu, 2016). To this end, it is necessary to utilize Egwunyenga's (2009) earlier recommended that professionally trained staff be employed from time to time and that existing staff be sent for essential training through in-service ICT-related training programmes. This will enable effective implementation of bIockchain-based technology for students' data management in the department of chemistry education.

3. Further Applications of Blockchain-Based Technology in Chemistry Education

Presently, blockchain technology has been introduced into education in some institutions of higher learning, and most of them use it to support academic degree management and summative evaluation for learning outcomes (Sharples & Domingue 2016). Blockchain technology can formulate the whole transcript. In the formal learning perspective, this includes learning contents and outcomes as well as students'

achievements and academic certificates. Subsequently, in the informal learning perspective, information about research experience, skills, online learning experience as well as individual interests are included. These data can be safely stored and accessed on a blockchain network in appropriate ways (Chen *et al.*, 2018). Some institutions that have used the blockchain technology to manage students data include; The University of Nicosia, Sony Global Education and Holberton School (Chen *et al.*, 2018; Hoy, 2017; Sharples & Domingue, 2016).

Furthermore, blockchain technology contributes to reducing degree fraud. In the past, there were numerous cases of degree fraud. Nevertheless, it can be avoided by employing blockchain in granting and managing student's degree at present. The data matched with users' ID and stored in blockchain are checked, validated, and maintained by the miners from all over the world. Blockchain distributed ledger is immutable and trustworthy. Thus, the reliability and authority are both guaranteed, which will significantly reduce degree fraud. Also, blockchain can be used as a "capacity-currency transformation bank." Specifically, blockchain learning ledger records detailed information about the users' learning experience and follows the development of their knowledge and skills. All of them can be transformed into a sort of digital currency and stored on a blockchain network according to a series of comprehensive standards. Students will gain rewards through their efforts on studies, which is called "learning is earning" (Sharples & Domingue 2016). For both learners and lecturers, blockchain technology has a great potential for broader application prospects on formative evaluation, learning activities design and implementation, and keeping track of the whole learning processes.

4. The Emerging Possibilities in Chemistry Education Departments

In blockchain technology, the central authority is replaced with a more robust decentralised network by public key infrastructure (PKI). This decentralised structure augments the longevity of the network because duplicates of the blocks, on which the signatures are stored, are so numerous. Beyond removing the dependence upon any certificate authority or trusted third-party, blockchains provide autonomous time stamping, which produces substantial security benefits. A reliable timestamp is clearly important in cases where credentials expire, but it is also critical for a practical reason - the issuer must be able to rotate issuing keys on a regular basis, both as part of security best practices, but more critically in response to a key leak. To determine that a record was issued by a specific issuer when the issuing key was valid requires knowledge of an independent timestamp (Grech & Camilleri, 2017). Contrasting many PKI systems, signatures on a blockchain are also independent of file-format: the same software can be used to sign any kind of file, irrespective of the (proprietary) standards with which it was created (Thompson, 2017). Thus, in a chemistry education department, blockchain will be of importance in the following areas;

4.1. Issuance of Certificates

When blockchain technology is used in the issuance of certificates, there is an opportunity to not just verify credentials without an intermediary, but to enrich and add value to the already existent digital certification ecosystem: Mozilla Open Badge is already being used to provide digital certifications to students in some prominent institutions of learning. The objective of notarizing certificates on a blockchain is therefore to transform a digital certificate that a student generally receives privately into an automatically verifiable piece of information that can be consulted by third parties through an immutable proof system, on a public blockchain (Grech & Camilleri, 2017). Currently, access to a public platform almost unavoidably requires a student to share or divulge 'sensible' metadata, which tends to include private information. Students will be able to approach academic institutes and employers while maintaining a discreet level of

confidentiality: in principle, only the information that the students would mark as public during the proof generation process would be accessible to third parties (Grech & Camilleri, 2017).

Preferably, applications would be built over an open source architecture that can warranty data continuity of lifelong learning achievements and no lock-in with one particular solution. The accountability and consistency of the information available on the platform and the blockchain, will be of great advantage to the chemistry education department, other departments, other academic institutions and companies. Students could also use the public metadata to seek similar profiles, thereby, fostering the creation of new models of social inclusion and entrepreneurship without a centralized authority vouching for the validity of the information. To this end, blockchain technology can be applied to students' data management in chemistry education department in many innovative ways beyond just certificate management and academic achievements' assessment. For both students and lecturers, blockchain technology has a great potential for broader application prospects on formative evaluation, learning activities design and implementation, and keeping track of the whole learning processes. There abound opportunities for software organisations that can facilitate and simplify the process of accessing the blockchain for students and badge issuers (institutes, companies, schools *etc.*,) (Aglietti, 2017).

4.2. Smart Contract

A Smart Contract is fundamentally a computer protocol running on the Ethereum blockchain network which feigns a real contract (such as economic transactions, employment, *etc.*,) (Kosba *et al.*, 2016). It can expedite contract negotiation, simplify terms of contract, execute the contract, and verify contract success state. It marks the unique and precise identity of parties in a transaction (contract subjects) through a digital way and stipulates the rights and obligations of both sides (contract terms) by code. The smart contract not only reduces "third party costs" in traditional transactions but also dramatically guarantees the transaction's security and trustworthiness. The smart contract greatly increases executive power and fairness compared to the traditional one. Therefore, if lecturers and students carry out instructional and learning activities based on a smart contract, some of the issues like missing scripts, omission of name or registration number, among others, in chemistry education departments would be solved (Chen *et al.*, 2018).

4.3. Motivation

From the perspective of students, there are still some negative subjective or objective factors impeding good learning outcomes, such as the lack of motivation, and financial pressure. Due to the trait of currency property, blockchain can be used to motivate students of the department of chemistry education by implementing "learning is earning" (Sharples & Domingue, 2016). The lecturers can give real-time awards to students through some simple clicks. Students will get a certain number of digital currencies according to smart contract as rewards. This kind of money can be stored in the education wallet, used as tuition, even exchanged with real currencies (Chen *et al.*, 2018).

4.4. Assessment of Students' Learning Achievements

Assessment is also a problematic issue in the department of chemistry education. Formative assessment has been advocated for a long time, and yet it is still not suitable because it is not easy to track every detail of teaching and learning. Applying blockchain technology and smart contract can deal with this challenge in chemistry education department. Notably, the reliability, immutability and traceability of blockchain imply that the data recorded on blockchain are more specific, authentic and anti-theft. Blockchain technology can alleviate the problem of free-riding in collaborative learning which often impedes fair evaluation. Each student submits his/her work to the learning

platform through his/her unique account, the smart contract running on it will review student's performance, and the results will be recorded into blocks. All behaviours during collaboration will be saved into blocks as evidence for evaluation as well. Moreover, public blockchain has the attribute of decentralization. It means that the distributed ledger ensures the consistency of most nodes. Thus, as nodes in blockchain network, students' opinions would be taken into consideration when assessing them. In this context, blockchain ensures the fairness of the evaluation (Chen *et al.*, 2018).

4.5. Learning Activities Design, Implementation and Tracking

It is sometimes difficult to carry out educational evaluation due to the sophisticated and artistic nature of teaching/learning instructions. The customary method based on students' response tends to be one-sided, lacking subjectivity and is hardly helpful for lecturers' improvement. A new assessment system can be constructed based on blockchain network and smart contract. First, lecturers need to submit preplanned instructional activities as a smart contract to the department. During the teaching process, all teaching activities will be recorded in the blockchain network. The smart contract will verify the consistency of the teaching design and practice, which is going to be an important instruction evaluation indicator. Furthermore, a smart contract between lecturers and departments, as well as the one between lecturers and students can be verified and supplemented with each other. Lecturers who meet the standards will get digital currency as a reward. It serves as both an appreciation and encouragement for lecturers' teaching skills. From the perspective of student development, supervisor or academic advisor is directly responsible for the supervision of the student's program. They have the responsibilities of assisting the student in planning study programs and staying informed of student's research activities and progress. However, in practice, these issues are not checked and supervised, so it will be controversial to distinguish the responsibilities if something negative happens in the future.

This situation will be changed if smart contract and blockchain technology is used in this area. All details should be monitored by smart contract platform and recorded into blockchain ledger. Such as how many times has the supervisor/lecturer discussed with students in the past semester? How many times has the supervisor reviewed the thesis both in draft and final form? Have they provided appropriate guidance to the students in course selection and research design? The traceability and immutability feature of blockchain technology have made it possible for both the students and supervisors' behaviours to be be recorded in the blockchain ledger. This innovative technological application is fantastic and best as it can protect the interests of both the lecturers and student (Chen *et al.*, 2018).

4.6. Construction of Balance in Measuring of Learning Outcome

Generally, blockchain can be used to create a balance to measure learning process and outcomes. It is a reliable and an equal proof of value for everyone. Tentatively, blockchain can solve the problems of information asymmetry and trust among strangers because of its decentralization and immutability features. It ensures genuineness because the information and value are published and maintained collectively. It provides a dependable way for talent investment. The user with more education on digital currencies possesses a greater chance of winning the appreciation and investment. Blockchain ledger tracks everything you've ever learned. Employers can use this information to offer you a job that best suits your skills. On the other hand, the user who wants an excellent employee can also resort to the blockchain ledger. It will greatly decrease the risk of investment bias and failure. In a word, the interest of both parties is maximized with blockchain technology (Chen *et al.*, 2018).

5. Advantages of Blockchain-Based Technology Application in Students' Data Managements in Chemistry Education Department

Some advantages of using blockchain-based technology in students' data management in the department of chemistry education are described as follows:

Efficiency: All data are automatically run through pre-set procedures. Therefore, blockchain technology can not only considerably reduce the cost of labor but also improve efficiency. Therefore, there will no need having many office attendants in the chemistry education department, hence, a huge cost reduction in manpower investment. For the digital currency of Blockchain 1.0, the automation of distributed ledger is mainly the automation of settlement. Blockchain technology could speed up the clearing and settlement of certain financial transactions by reducing the number of arbitrators involved, and by making the reconciliation process even faster and more efficient (Wang et al. 2016).

5.1 Reliability: The decentralized nature of a blockchain network changes the databases of the entire transaction records from closed and centralized ledgers maintained by only a few accredited institutions to open distributed ledgers maintained by tens of thousands of nodes. The failure of a single node does not affect the operation of the whole network. This avoids the single point of failure and ensures the high reliability of the applications which built on the blockchain technology (Chen *et al.*, 2018).

5.2 Security: Blockchain network uses the one-way hash function which is a mathematical function that takes a variable-length input string and converts it into a fixed-length binary sequence. The output bears no apparent relationship to the input. The process is hard to reverse because, given just the output, the input is impossible to determine (Yli-Huumo *et al.*, 2016), hence, students' data in the department will be more secured.

5.3 Trust: Blockchain network makes the trust decentralized too. Unlike the centralized trust we take for granted, such as central governments issuing currencies and commercial banks, or the central school issuing certificates, blockchain network acts as new trust bearers with decentralized ledgers. These ledgers are shared among a network of tamper-proofed nodes (Underwood 2016).

6. Possible Shortcomings

It is irrefutable that there will be latent downsides of applying blockchain technology in students' data management in chemistry education department. As a multifaceted system, some learning behaviours and learning upshots need to be reviewed by the lecturers subjectively such as essays and classroom presentations. It is quite hard to evaluate this kind of learning activities by the pre-programmed smart contract without human intervention.

If an educational blockchain system is adopted in chemistry education department, all students' educational data would be integrated into blockchain ledgers. The immutability feature of blockchain technology would act as a double-edged sword, removing the possibility of modifying educational record for legitimate reasons for some students.

Additionally, many technical issues or setbacks are not addressed for the blockchain to be applied in chemistry education department for student's data management. For example, the classic Proof of Work consensus mechanism wastes energy and has a poor performance in terms of number of transactions per second (Vukolić, 2015), which would cost an extra expense, and hinder its adoption in the department of chemistry education and schools in general.

7. How to Start

The application of blockchain-based technology for chemistry education students' data management in any institution can start by first organizing a workshop with the purpose to equip chemistry education lecturers, higher technical officers and departmental ICT staff with practical activities and logistical training to include blockchain-based technology into their chemistry education curriculum and management. During this workshop, participants will gain hands-on experience using technology such as iPads, laptops and a variety of interfaces and sensors packaged with computer-based activities for chemistry education and general science. Participants will gain familiarity with the general chemistry modules, learn about logistics related to implementation, and develop new activities for future use. Immediately after the workshop, the head of department, in collaboration with the management of the faculty of education and in conjunction with the institution's management, will implement the use of blockchain-based technology in the department.

8. Conclusion

This paper demonstrated that it is possible to apply blockchain-based technology in chemistry education students' data management. However, there is an urgent need for full integration of ICT structure in institutions' department of chemistry education so as to enable the application of blockchain for students' data management. As noted in the paper, blockchain-based technology has the potential to revolutionise chemistry education departments by facilitating the transition to and functioning of digital data management. Furthermore, future researchers should experiment the application of blockchain-based technology in chemistry education students' data management in order to establish empirical data in this research area.

References

[1] P. U. Akor and J. Udensi, "An Assessment of Record Management System in Establishment Division of Two Universities in Nigeria", Mediterranean J Soc Sci., vol. 4, no. 12, **(2013)**, pp. 87-96**.**

[2] G. Chen, X. Bing, M. Lu and N. Chen, "Exploring blockchain technology and its potential applications for education", Smart Learning Environments, vol. 5, no. 1, **(2018)**, pp. 1-10.

[3] R. Collins, "Blockchain: A New Architecture for Digital Content", EContent, vol. 39, no. 8, **(2016)**, pp. 22-23.

[4] M. P. Crosby, S. V. Pattanayak and V. Kalyanaraman, "Blockchain Technology: Beyond Bitcoin", Applied Innovation, vol. 2, **(2016)**, pp. 6-10.

[5] Y. J. Dori, S. Rodrigues and S. Schanze, "How to Promote Chemistry Learning Through the use of Ict. In: Eilks I., Hofstein A. (eds) Teaching Chemistry - A Studybook", Sense Publishers, Rotterdam, **(2013)**.

[6] E. J. Egwunyenga, "Record Keeping in Universities: Associated Problems and Management Options in South West Geo-Political Zone of Nigeria", Int J Edu Sci, vol. 1, no. 2, **(2009)**, pp. 109-113.

[7] B. I. Enemute, "Management of records in Nigerian universities: Problems and prospects", The Electronic Library, vol. 23, no. 3, **(2005)**, pp. 345-355.

[8] A. Grech and A. F. Camilleri, "Blockchain in Education", Inamorato dos Santos, A. (ed.) EUR 28778 EN; doi:10.2760/60649, **(2017)**.

[9] Heriot-Watt University, "Student Records Management Policy", Version 4, **(2013)**.

[10] M. B. Hoy, "An Introduction to the Blockchain and its Implications for Libraries and Medicine", Med. Ref. Serv. Q., vol. 36, no. 3, **(2017)**, pp. 273-279, https://doi.org/10.1080/02763869.2017.1332261.

[11] C. J. Ifedili and J. J. Agbaire, "Management of Educational Records in Nigerian Universities for Better Results", Rev Eu Stu., vol. 3, no. 2, **(2011)**, pp. 52-57.

[12] E. A. Onuiri, I. Oludele, C. Oshilagun and O. Yadi, "Biometric Student Record Management System", Int. J. Com. Sci. Info. Sec", vol. 13, no. 4, **(2015)**, pp. 50-62.

[13] M. Sharples and J. Domingue, "The Blockchain and Kudos: A Distributed System for Educational Record, Reputation and Reward. Adaptive and adaptable learning", Springer, Cham, **(2016)**, pp. 490-496, https://doi.org/10.1007/978-3-319-45153-4_48.

[14] F. Tschorsch and B. Scheuermann, "Bitcoin and Beyond: A Technical Survey on Decentralized Digital Currencies", IEEE Commun. Surv. Tutorials, vol. 18 no 3, **(2016)**, pp. 2084-2123, https://doi.org/10.1109/COMST.2016.2535718.

[15] S. Underwood, "Blockchain beyond Bitcoin, Commun", ACM, https://doi.org/10.1145/2994581, vol. 59, no. 11, **(2016)**, pp. 15-17.
[16] S. Thompson, "The Preservation of Digital Signatures on the Blockchain", UBC iSchool Student Journal. 3. Available at: https://ojs.library.ubc.ca/index.php/seealso/article/view/188841/186526 retrieved on April 14th, **(2017)**.
[17] M. Vukolić, "The Quest for Scalable Blockchain Fabric: Proof-of-Work vs. BFT Replication", Open problems in network security. Springer Cham, **(2015)**, pp. 112-125, https://doi.org/10.1007/978-3-319-39028-4_9.
[18] M. Vukolić, "The Quest for Scalable Blockchain Fabric: Proof-of-Work vs. BFT Replication", Open problems in network security. Springer Cham, **(2015)**, pp. 112-125, https://doi.org/10.1007/978-3-319-39028-4_9.
[19] H. K. Wang and D. Chen, "A Maturity Model for Blockchain Adoption", Financ. Innov., vol. 2, no. 1, **(2016)**, https://doi.org/10.1186/s40854-016-0031-z.
[20] J. D. Yli-Huumo, S. Ko, S. Choi, K. Park and K. Smolander, "Where is Current Research on Blockchain Technology?-A Systematic Review", PLoS One, vol. 11, no. 10, **(2016)** e0163477 https://doi.org/10.1371/journal.pone.0163477.
[21] M. Fabunmi, "Perspective in Educational Planning", Udun Prints and pack, Agbowo, Ibadan, Nigeria **(2004)**.
[22] I. F. Igwoku, "An Analysis of Record Management Strategies in Western Nigeria", M.Ed. Dissertation, Unpublished. Abraka: Delta-State University, **(2008)**.
[23] N. B. Major and F. Omenu, "Records Management in Higher Educational Institutions in Bayelsa State: Implications for School Administration", WSN 26, **(2016)**, pp. 11-20.
[24] E. C. Sapere-Obi, "The Impact of Records Management on Administration in Tertiary Institutions in Bayelsa State", M. ED Thesis, Lagos: National Open University of Nigeria, **(2014)**.
[25] M. Swan, "Blockchain: Blueprint for a New Economy", 1st edn. O'Reilly Media: Sebastopol, CA. **(2015)**.
[26] A. A. Kosba, E. Miller, Z. Shi and W C. Papamanthou, "The Blockchain Model of Cryptography and Privacy- reserving Smart Contracts", IEEE Symposium on Security and Privacy (SP), Hawk, **(2016)**, pp. 839-858, https://doi.org/10.1109/SP.2016.55.
[27] A. Aglietti, "Growbit @ International Open Recognition Day", Available at https://tail.aqquadro.it/growbit-international-open-recognition-day-a39281072a6c, retrieved on April 14th, **(2018)**.
[28] S. Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System", Available at https://bitcoin.org/bitcoin.pdf, Retrieved on April 14th, **(2018)**.
[29] E. Piscini, J. Guastella, A. Rozman and T. Nassim, "Blockchain: Democratized Trust. Distributed Ledgers and the Future of Value", Deloitte University Press. Available at: https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/technology/deloitte-uk-tech-trends-2016-blockchain.pdf retrieved on April 14th, **(2018)**.
[30] S. Thuseethan, Department Management System for Departments of Sri Lankan Universities. Available at https://arxiv.org/abs/1501.00526v1, retrieved on April 6th, **(2018)**.

