ELEVATING HIGHER EDUCATION CHALLENGES USING BLOCK CHAIN TECHNOLOGY

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CONCEPT PAPER

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ABSTRACT

Block chain technology is a modern technology that is digital based and has a provision for storage of information of products that cannot later be hacked neither manipulated. Block chain technology is a technology that looks forward to bringing transformational features that will impact higher education. From the year 2009 when block chain technology was founded, its applications have had a wide range of applications including the education sector and food industry.

It is clear from its description that this technology will impact and transform the entire learning sector by enhancing quality and blending with emotional intelligence. The ability of block chain technology to hold and provide information on both employees and learners within the jurisdiction of higher learning is imperative, with benefits such as protection data, accountability and integrity of the University.

This Conference paper will consider using block chain technology as a tool for education safety and quality, and therefore it can transform higher education. Block Chain is the centre game and driving wheel to complete revolution in our Kenyan Universities. Effectiveness can be achieved with the help of a quick response code, which include the implementation of QR code on block chain technology. This will make it possible to track information about information delivery, quality assessment throughout their life of students. Additionally, clean data, attendance, and payment systems can be integrated into one block hence providing relevant and necessary information on teaching and comprehension to all. This will make learning more effective with rich, secure and transparent platform in using block chain technology to improve learning and teaching methods.

Key words: *Blockchain technology, pedagogy*, education; higher education

1. Introduction

Today, technologies are an integral part of the world economy and especially in our Kenyan country. According to McKinsey Global Institute analysis (2013), there 12 disruptive technologies that will significantly change the situation in the global market by 2030. Their potential economic impact is estimated to be between 14 and 33 trillion US dollars. These 12 high-potential technologies discussed in the Institute's analysis do not include Blockchain. Nonetheless, even though being out of the list, Blockchain has become a dark horse in the competition, given the fact it will influence most of the listed technologies, i.e. Cloud, Internet of Things, and Autonomous cars. Many sources which are dedicated to technology industry have started to share the opinion that Blockchain itself might become one of the most powerful technologies of tomorrow. (TechCrunch, 2015). Blockchain technology is a modern technology that is digital based and has a provision for storage of information of products that cannot later be hacked neither manipulated. It's a technology that looks forward to bringing transformational features that will impact food industries. Profit in education sector is under constant pressure to grow and to withstand market demands and strategies (Daily Nation Newspaper May, 2019). Learning skills is produced but not for an anonymous bulk market, in which price is the only way of product differentiation.

Given the fact of this system of price differentiation, the education sector is strongly costprice driven. Another factor that pressures prices is the circular surplus (and shortage) of supply and demand of pigs caused by farm termination and scaling of other farms. Therefore, prices in the pig sector follow a price cycle. In this study, we consider the contribution of blockchain in higher education regarding the use of IT infrastructure and computing solutions to monitor the multiple systems within a university, in an effort to promote, maintain or restore the educational system [5]. In the field of higher education, privacy and security breaches are purportedly increasing every year, especially with regard to academic diplomas and degrees. Blockchain technology has a role in ensuring their authenticity and keeping accurate records. The increasing digitization of higher education has further led to the acknowledgment of concerns related to secure storage, while blockchain technology allows decentralized open data, absence of frauds, safe storage of information, and reduction in transaction expenses related to academic data control Blockchain has been suggested as a way to solve critical challenges faced by higher education, such as recordkeeping of diplomas and by a student-centric approach.

2.1 Review and related work

Firstly, the technology became well-known in 2008 when it was conceptualized by either an individual or a group of founders of Bitcoin under the name of Satoshi Nakamoto in a research paper titled "Bitcoin: A Peer-to-Peer Electronic Cash System". Blockchain was used as a core component for Bitcoin cryptocurrency. There, the concept of technology was referred to as "block" and "chain". By year 2014, Blockchain had become a term which is referring to new

applications of the distributed database. (Kariappa, 2015). Finally, in 2017 it is discussed that Blockchain is a foundational technology. It has an ability to establish new foundations for both economic and social systems. However, while the influence of the technology is to be enormous, it might take years for Blockchain to be implemented into economic and social infrastructure systems. The adoption process will be smooth and steady, not rapid, because waves of technological and social changes still gain momentum. (Iansiti & Lakhani, 2017). From the year 2009 when block chain technology was founded, its applications have a wide range of applications including the farming industry (Ariyadech et al, 2016).

According to (Iansiti & Lakhani, 2017), Blockchain is not a disruptive technology, but foundational. Disruptive is a technology, which creates in a relatively short period of time a new market by provision of new values, which completely transform existing marketplace. A foundational technology is also establishing markets and business models, but the adaptation and development of them can take decades. Thus, the effect of Blockchain adaptation will be significant, and social, economic and political systems will be affected. Additionally, Ethereum's and other modifications of Blockchain have provided a new vision of this technology and made it interesting for many industries for example marketing, security and now in agriculture. Despite the similarities between implementations, there are some differences in a level of the Blockchain's innovations, starting with no innovation and finishing with entire new Blockchain systems being built. The leading tech companies are representing their solutions based on the technology and fintech companies are researching on possibilities of its implementation known as dApps (Fernández-Caramés et al,2019).

2.1.1 Blockchain in higher education

Higher education is looking forward to implementing block chain technology in their operations just like other business sectors. Because of the advanced levels of technology, there is a need to adjust to the operations within the food industry. Enforcing food safety by various food industries is a significant factor in terms of caring for consumers (Kamath & Reshma, 2016). Block chain technology has been implemented in various fields such as Agriculture, Health, Banking and Education (Singh, 2018). Block chain technology can as well be implemented in food industry as a tool for food safety. With the advanced levels of technology, it is important for various food industries to find ways of ensuring safety in the food products they are offering to consumers. (Angela ,2019), describes block chain technology to be a tool of improved operations across all the fields. Many cases have been in existence for the many years with the learners having limited information.

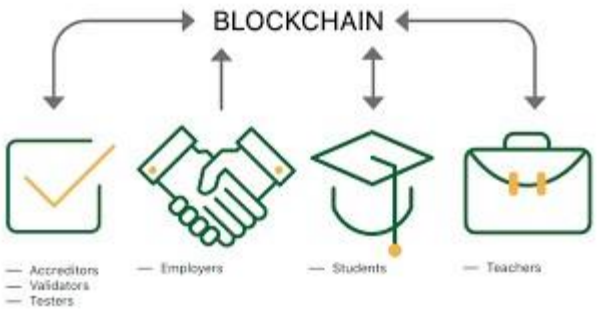

Figure 4: Education safety information system

Several technologies might have been implemented to help in the determination of learning safety but block chain technology stand out to be the best. The use of block chain technology has progressively been implemented in the U. S and Canada in food. Most developed countries have started adopting safety measures. Block chain is the most preferred and reliable method of food safety since it can store a large amount of data based on the food products without any form of manipulations (Mike, 2016). Block chain technology can be used to enhance food safety by involving all the participants such as farmers, vendors, and consumers in getting access to the information on food. Multinational food industries such as Unilever, Carrefour, and Dole food have attempted to implement block chain technology to improve the safety levels of foods.

2.1.2 Blockchain systems

Blockchain normally uses a spread ledger with a consensus system and public/private key cryptography. Current blockchain systems are categorized roughly into three types: public blockchain, private blockchain, and consortium blockchain (Buterin, 2015). In the public blockchain, all records are visible to the public and everyone could take part in the consensus process. Differently, only a group of pre-selected nodes would participate in the consensus process of a consortium blockchain. As for the private blockchain, only those nodes that come from one specific organization would be allowed to join the consensus process (Awwad, 2018). A private blockchain is regarded as a centralized network since it is fully controlled by one organization. The consortium blockchain constructed by several organizations is partially decentralized since only a small portion of nodes would be selected to determine the consensus (Sania Sagheer & Nadeem Javaid, 2019).

Table 6: comparison of the three categories of blockchain in six major

Property	**public blockchain**	**consortium blockchain**	**private blockchain**
Consensus determination	All miners	The selected set of nodes	One organization
Read permission	Public	Could be public or restricted	Could be public or restricted

Mutability	Nearly impossible to temper	Could be tempered	Could be tempered
Efficiency	Low	High	High
Centralized	No	Partial	Yes
Consensus processing	permission less	Permission	Permission

The selection of the type of blockchain will be determined by the sensitivity of the data, interest of the university, and reason for ranking as directed by the promoters. No ranking institution has ever used blockchain technology for the purpose of transparency and security during the ranking process.

2.3 Blockchain Security

Blockchain is a distributed technology with several blocks sharing content. The content of this decentralized system is distributed in all blocks and spreads digital technology to several areas uniquely. It is used to record dealings and information across many network systems so that the record cannot be altered retroactively without the alteration of all subsequent blocks and the collusion of the network management (Pinyaphat Tasatanattakool & Chian Techapanupreeda, 2019). There are two main categories of security, security objectives and security primitives also called cryptography. Security objectives are like integrity, non-repudiation, time stamping, authentication, etc and cryptography includes a symmetric key (also called public-key cryptography), asymmetric keys, digital signature, etc. Blockchain technology for this study is asymmetric-key cryptography. Asymmetric-key cryptography uses a pair of keys: a public key and a private key that are mathematically related to each other. It is possible to make public key public without dipping the security of the process. This is contrary to the private key which must remain secret if the data is to retain its cryptographic protection (Mell,2019). There is a relationship between the two keys, but it is not possible to determine the private key based on knowledge of the public key. One can encrypt with a private key and then decrypt with the public key. Alternately, one can encrypt with a public key and then decrypt with a private key (Yaga, 2019), (Scarfone, 2019).

Asymmetric-key cryptography enables a trust relationship between users who do not know or trust one another, by providing a mechanism to verify the integrity and authenticity of transactions while at the same time allowing transactions to remain public (Daylan et al, 2019). The first step is to organize the data into digital components. This means that a private key is used to encrypt a transaction such that anyone with the public key can decrypt it. Since the public key is freely available, encrypting the transaction with the private key proves that the signer of the transaction has access to the private key. Alternately, one can encrypt data with a user's public key such that only users with access to the private key can decrypt it.

With symmetric-key cryptography, users must already have a trust relationship established with one another to exchange the pre-shared key. In such a system, any encrypted data can be decrypted with the pre-shared key and only the user with the key can access the data. This is a

verification that confirms its source. No user without access key can view or modify the block contents. Compared to asymmetric-key cryptography, symmetric-key cryptography is very fast to compute. It is possible too to change from asymmetric to symmetric and vice versa or use both in a single blockchain system. Using both can ensure a more protection than using one but at the expense of complexity. This 'trick' can greatly affect the speed of operation of asymmetric-key cryptography in a system.

2.3.1 Ranking factors

Different ranking factors are available at the disposal of a ranking institution. Considering the impact on any implemented, the output will be different. The following will give great impact if implemented with consciousness. Clustering of universities according to number of years the university has been offering a discipline considered during the ranking process. Performance indicators become another universal ranking factor with great impact if universally agreed or collectively selected by one given cluster. The last factor here is the encryption algorithm. Security of ranking data is a major factor and great challenge in ranking process. All data to be used in the ranking process must be reliable and valid during the ranking time. Access or modification of ranking data by none authorized persons should be treated as a security gap and deterred.

2.4 Paradigm of the research

The fundamental approaches based on the existing literature used here can be categorically be identified by positivist and critical realism. Other methodological and strategies can be implemented with care to avoid loss of interest. In this study and for now, the two takes centre stage although additional approaches may be found to be viable.

2.5 Security and availability of data

The decision of a University to be ranked vested on the university and therefore it is the university that should give information needed during the rankings. At times and instances, a university may provide relevant information to researchers, students, research funders, governments, or other stakeholders for a given achievement. This information may offer a useful international proportionality during ranking. The university database for far must be updated frequently not only for ranking. Database should include even the projects not published and published with time-specific and current affiliations. Alumni records will not be a serious factor because not all alumni work in the parent institution.

3.0 Formulation and implementation

The block chain can use to mitigate the following cases in higher education:

3.1.1 Improve record keeping

The most promising use case for blockchain in higher education is to transform the “record keeping” of degrees, certificates and diplomas, making credentials digital and under the learner’s control, without the need for an intermediary to verify them. Blockchain could be also used for accreditation of educational institutions, a complex process in many countries, enabling them to

verify quality or qualification to teach. Blockchain's ability to improve record keeping also makes it a natural fit for solving intellectual property (IP) management problems, for example, by using blockchain to determine if an idea or invention is unique or to register IP assets, copyright and patents.

3.1.2: Increase efficiency in existing business processes

Blockchain-based university diplomas are a great leap forward, but perhaps the ultimate use case is the creation of a virtual transcript or record of all education achievements throughout one's entire lifetime. A verifiable lifetime transcript would reduce CV fraud, streamline student transfers between universities, reduce the overhead related to credential verification, and make moving between states and countries less complex. This kind of initiative goes beyond record keeping and seeks to streamline processes, making it an "efficiency play."

3.1.3 Create a new market for digital assets

Processing student payments is labor-intensive and may involve the student, parents, scholarship-granting agencies, financial institutions, governments and educational institutions. In the future, cryptocurrencies — perhaps even custom cryptocurrencies — could be used as a method of student payments.In 2014, King's College in New York City became the first accredited U.S. institution to accept bitcoin as payment, eliminating the credit card transaction fees previously charged to students. This is a good example of how blockchain could be used in higher education to create and trade new digital assets.

3.1.4 Create a disruptive business model

To date, higher education blockchain use cases have focused on record keeping and efficiency, while the real disruptive power often lies in creating new business models.
Woolf aspires to become the first blockchain-powered, nonprofit, borderless university. Founded by a group of academics from both Oxford and Cambridge, it will rely on blockchain and smart contracts as the basis of the relationship between learners and educators — aiming to create the Airbnb of degree courses (Daylan et al, 2019).

Promising use cases address problems that have proven difficult to solve using traditional technologies. If achieved, this new educational platform will aim to lower tuition fees at the same time it increases faculty remuneration by using blockchain smart contracts to automate administrative tasks, protect and secure faculty and students, and reduce administrative overhead costs. Instructors can choose to be paid in Woolf tokens or in their native currency. The university will seek EU accreditation and anticipates a global launch in 2019. "The most promising use cases address problems that have proven difficult to solve using traditional technologies, are uniquely digital and represent key barriers to scalability," says Thayer.

3.1.5 Seamless payments

Since processing student payments is labor-intensive and may involve the student, parents, scholarship-granting agencies, financial institutions, governments, and educational institutions, DLT makes the process a whole lot easier. In fact, the blockchain will allow students to store their very own cryptocurrency funds – which should be usable over time to pay for their higher education fees(Daylan et al, 2019). Although a lot of educational institutions are reticent about accepting crypto as payment there is some exception like King's College in New York City was one of the first universities in the world to start accepting cryptocurrency fees. This step also eliminated all of the hidden fees.

3.1.6 Teaching and storage space

Given its versatility, blockchain technology can take care of a lot of interesting tasks. For example, lessons, courses, tests, and quizzes can be coded into the tech and executed on their own when all of the qualifying conditions are verified. The smart contract feature of a blockchain can easily verify when the task has been completed, making it an ideal tool for evaluating students. Besides that, blockchain technology can also be used by universities and students to get access to more storage space (Mitchell et al,2019). Since not all institutions can afford to purchase terabytes of cloud storage for all of their files, blockchain can provide an affordable and seamless file storage solution.

3.2 The Research Building for Blockchain Technology in the Higher Education Sector to Date

The present study carried out on Blockchain in higher education in order to understand its current position nowadays. To attain this goal, the up to date research on Blockchain applications in higher education was addressed by outlining the major contribution trends in the issue. In this way, we discuss the findings based on the research questions and the results obtained. What is the research building for Blockchain technology in the higher education sector to date? We can notice that Blockchain application in higher education is over enhanced in literature in terms of two major themes: its applications for HEIs and for students. It is significant to mention that Blockchain in higher education has been addressed from different but intertwined viewpoints and an agreement on its classification has not yet been achieved (Daylan et al, 2019). Firstly, literature posits that Blockchain provides a digital and decentralized learning infrastructure to all stakeholders through learning platforms (Arndt et,2019), of relevant data security for administrative use and with flexible design in terms of shared compliance for decision making. It allows us, therefore, to build links between diverse universities in academic programmers, to improve governance by supporting the management in higher education with innovative resource allocation (Ceke et al,2020) and to augment its human resources effectiveness and digital competency. Blockchain literature therefore favours

technical knowledge and innovation in higher education. A better coordination between universities in sharing educational resources, experimentation and new creative solutions, for example, is suggested. It is a new technology able to bring up improvements in what comes to managing information, while ensuring its privacy and authenticity for all stakeholders, in particular HEIs and students, which are considered central actors in the at once organizational and technological process.

Secondly, with regard to HEIs, Blockchain allows improving technology in terms of securing and sharing authentic digital certificates (Ceke et al,2020), whereas for students, it guarantees the safe sharing of critical academic data between them and key agents such as sponsors, editors, loan providers and employers. Additionally, Blockchain application is particularly useful for students, with regard to the accreditation process and knowledge management in engineering education, related with the acquisition of technical knowledge through experimental methodologies. Besides HEIs and students, most actors interested in this technology also include teachers, researchers, government, and the industries of digital platforms and education itself. Thirdly, literature suggests Blockchain technology as a huge contribution for all stakeholders as it enables the facilitation of knowledge organization, for example in the case of issuing certificates, to prevent counterfeit or falsified documents and ensuring its privacy. Hence, it allows, safely and by a decentralized platform, moving of students' learning records from one institution to another, between sponsors and students, employers and students. Furthermore, it facilitates student mobility programs and share pieces of writing between authors and editors. The applications are numerous and allow partnerships and collaborative customer relationships that, in the end, enhance the whole educational ecosystem (Vidal et al,2020).

Fourthly, literature suggests that the teaching interest on Blockchain relies on the e- learning and digital platforms and contents for teaching, therefore improving the didactics reliant on data from shared sources and innovation through educational projects, thus promoting academic curriculum, organizational innovation and experimental learning. In the end, innovative teaching allows contributing to the added value of stakeholders overall. Blockchain technologies are quite innovative as they create and store transactions within distributed ledgers and between different educational agents, thus ameliorating knowledge applications for e-learning and trust in online higher education procedures.

Fifthly, this technology is presented as central to intermediate contexts, of scarce resources, wherein the process of organizing documentation and support students is in its early stages and needs to keep up with these innovative technologies. In this way, according to the literature, Blockchain applications in higher education rely on varying environments of distinct actors, processes/structures and cannot be analyzed detached from it. Instead, it rather needs to be integrated into distinct organizational protocols and learning practices. Moreover, these protocols, attained by a chain of decentralized verified records, are based upon secured platforms of digital hashes and allow corrective operations without altering the existing data. Likewise, it allows to process and manage documentation innovatively, involving varying

organizations in which contents are distributed in such a way that they are kept unchanged and can be verified, traced and validated.

Sixthly, Blockchain technology comes up mostly through the form of diverse smart contracts that favour learning, data sharing and organization of documentation, whilst ensuring privacy to the accreditation process. These varying contracts of distinct interests and from different contexts, by means of automatically discarding the need for an intermediary, ensure trust and transparency to elearning protocols for all those involved, while augmenting the number of potential learners(Fernández-Caramés et al,2019)..

Finally, one can conclude that the literature presents Blockchain technology through varying perspectives, although it posits a consensus regarding its advantages when applied to higher education. In sum, it is a technology achievable and timely in higher education because on the one hand it matches the researchers'/students' interests, who expect to seize the opportunity to study, irrespective the hurdles of time and space, while acquiring digital skills for the labour market; and, on the other hand, it addresses HEIs' concerns in developing content delivering, enhancing educational quality and replacing the traditional educational services. The introduction of Blockchain infrastructures is therefore opportune , (Pinyaphat Tasatanattakool & Chian Techapanupreeda, 2019 in terms of learning content, innovative lecturing and research, although it means a significant change, involving multiple limitations and challenges that are discussed below.

3.3 The Current Challenges and Future Research Paths

The results of this paper highlight the challenges identified by previous research on Blockchain, which point out mainly its technical limits. The reviewed articles have principally focused on the need to develop new algorithms and frameworks for implementing Blockchain in higher education. Building upon the review, we have listed the existing limitations in seven key issues, which comprehend usability, scalability, platform and algorithm suitability, societal constraints, cost, privacy, and immutability.

Firstly, Blockchain technology usability is a main limitation in higher education. The technology jargon is relatively new and lacks development. It is noteworthy that Blockchain includes very different specifications that can make it difficult for end users. Furthermore, users should deal with diverse issues that complicate security, such as primary keys and public keys (Fernández-Caramés et al,2019). Hence, Blockchain usability should be improved through new design interfaces that are more responsive to users, while training in its use should be delivered to professors, students, and staff, as the majority of the academic community is unaware of this technology. Therefore, further studies on Blockchain usability are required.

Secondly, scalability regards the way the rising number of users and transactions can affect access to Blockchain network (Vidal et al,2020. Studies have posited that high usage ratios may influence the intrinsic stability of a framework and ensuing performance. As a campus can cover a large number of users requesting smart services, it is essential for the application to be easily scalable, to proportionally adapt its performance. Prior system architecture should consider this issue with regard to education, as it is difficult to predict the path of Blockchain

technology in terms of potential future scale. It needs to add functionality to the systems while scaling them up with a larger quantity of data, to explore, by smart contracts, its capacity with respect to higher education learning outcomes and to ensure that the platform can be implemented as a widereaching system. It is therefore an issue that requires further research to understand how many participants, assets and increasing in transactions would impact the access latency.

Thirdly, the application of different shared algorithms may also be considered constraints for Blockchain deployment, while there is a lack of smart campus standards with respect to a common framework, capable of enabling an effective Blockchain-based higher education ecosystem. The small integration of smart campus applications makes it necessary to design devices that allow for switching between new architectures such as big data, machine learning (Daylan et al, 2019), deep learning, and new communications platforms. Interchangeable platforms and algorithms allow for comparing curricula from different courses/degrees so that students can move from one higher education institution to an- other and resume their studies in an equivalent degree. Future research therefore needs to develop an integrated model and ensuing value chain, from the moment students enter higher education to the moment they get their diplomas. It should focus on making the application more efficient in connecting platforms, ensuring decentralization and a potential ecosystem among distinct software of universal standard file formats (Vidal et al,202). It may potentially evolve into a united, simplified and globally ubiquitous higher education credit and grading system through novel Blockchain platforms able to augment its ensuing scalability and usability. One will have to keep compatibility issues in mind to ensure service flexibility by multiple services, while safeguarding transaction data of sensitive academic information.

Fourthly, our review suggests that societal constraints such as the lack of enthusiasm around Blockchain with regard to the ethical and secure use of data may constitute a substantial challenge that may hinder the adoption of Blockchain by HEIs. On the one hand, it is difficult to persuade education actors to implement Blockchain systems because of its novelty, which could be mitigated through appropriate training and the development of usable Blockchainapplications. Moreover, Blockchain reduces university administrative staff-related expenses and therefore, university administrations may resist its implementation. On the other hand, the extensive adoption of Blockchain systems requires political support amidst a context of indistinct legal status when it comes to deciding, for example, the Blockchain versions for governance decentralization. In so doing, both the will to adopt the platform and the legal mechanisms to support it play important roles in terms of its successful deployment (Mitchell et al,2019). For example, some scholars posit that the wide use of Blockchain for IP commercialization purposes and the increasing number of conflicts related to the inclusion of IP objects in various registries require prompt progress on mitigating its legal risks. In this way, further studies in terms of legal frameworks on Blockchain transactions are needed.

Fifthly, another limitation concerns the costs involved in Blockchain transactions, because dealing with large amounts of academic data on the platform may increase costs. It principally relates to the time, resources, and monetary costs associated with carrying out a Blockchain

framework, in which it is necessary to carefully monitor costs of usage in traditional education systems (Vidal et al,2020). This can inhibit the adhesion of universities, because, for example, one cannot predict the rate of transactions in Bitcoin in the long term. Current solutions, such as legacy credential verification systems, are awkward and are neither time- nor cost-efficient, whereas educational institutions can reduce costs by sharing infrastructure, academic programmes and services, for instance, in online education using Blockchain technology. Research is thus needed in the delivering of a more user-friendly and efficient platform that effectively integrates into the existent credential verification ecosystem.

Sixthly, it is important to consider how data can be securely accessed and used while maintaining privacy. Blockchain systems use both private and public keys to protect user identities, but since public keys are visible they cannot ensure transactional privacy. Additionally, students may lose all academic diplomas whenever they lose the secret key information required to prove ownership. Thus, Blockchain privacy mechanisms present weaknesses that may lead to abuse, being therefore central to protect the identities of users by mapping a linkage between the pseudonyms and real identities. Further research should add greater emphasis on accurate mechanism of learning logs and ensuing privacy measures are needed to build standardized formats for permissions on the Blockchain, such as a distributed storage medium to avoid forged diplomas.

Finally, Blockchain's immutability consists of its impossibility for the data stored in the blocks to be changed, which is a critical feature of Blockchain technology. Nonetheless, immutability is a key limitation to using Blockchain technology for education, for instance in the case of diploma revocation, in which the diplomas that are stored on the Blockchain cannot be changed. For this reason, immutability can reduce Blockchain use with respect to students' sensitive data as in the case of admissions, certificate/degree verification and exams/assessments that require the right to delete (Mitchell et al,2019). The scalability and performance efficiency of a framework is, in this way, affected by requirements for continual upgrades by the utilized system. Further research is therefore needed with regard to the trade-off between resource protection and flexibility.

4.1 Conclusions

This paper aimed to understand the extent of Blockchain application in the higher education field in Kenya. The findings were used to sum up existing knowledge on Blockchain application in the distinct domain of higher education and summarize current thematic trends of academic work in this issue. The principal and emergent insights and challenges comprehend compatible digital platforms to safely share and organize data, flexible smart contracts, affordable innovative projects, and privacy/learning issues to all the stakeholders involved in the administrative and learning processes in higher education.

These insights should be considered in light of their limitations. First, the review focused exclusively on articles appearing in peer-reviewed publications available in the SCOPUS database of scientific articles published by 2020. Second, the review considered Blockchain as an umbrella keyword and did not consider compatible keywords, such as smart contracts. These

limitations may be addressed in future research by considering supplementary interchangeable keywords, to expand the scope of information

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