Blockchain in Education - The Case of Language Learning

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Abstract

New technological developments, such as 5G networks, smart and interconnected devices, and the development of the Internet of Things (IoT), lead to a new reality in which the secure flow of data is non-negotiable. In this new reality, blockchain technology can play a crucial role, as it has the ability to provide the necessary background for the safe and inviolable operation of systems. Blockchain is a distributed ledger, in which information and data are stored and verified. These blocks of data do not have to be related to financial transactions but may concern any other type of data that needs to be securely recorded and not changed retrospectively. Although the first application of blockchain technology was about digital currency (Bitcoin), its usefulness is not limited to cryptocurrencies or the field of economics. Blockchain, especially in its last stage v3.0, has many applications in various sectors such as data storage, certification of products and services, government, insurance, health, science, and education. This paper focuses on the current and potential educational applications of blockchain and presents how this technology can be used to solve specific education problems. Nowadays, a variety of blockchain applications concerning the issue and storage of certificates and diplomas, the evaluation of learning outcomes, the support and the academic degree management, the protection of intellectual property, the cooperation between students and their professors, learning accreditation, payment for studies, formation of an academic passport (portfolio) or administration of the educational process are implemented in some HEI and institutions. The paper analyzes the features and advantages of blockchain technology, presents some of the current blockchain applications for education, as well as the benefits and challenges of using blockchain technology in the educational sector. Finally, special reference is made to applications related to the field of language learning.

Keywords: Blockchain, education, language learning

Introduction

Cryptocurrency and Blockchain technology

Nowadays, as financial transactions between both individuals and organizations or companies are carried out through the internet, the security of transactions is emerging as a matter of paramount importance. Traditionally, banks and large financial institutions are responsible for maintaining the security and validity of transactions. This, however, on the one hand has a significant cost, which is paid by the traders and, on the other hand, allows the complete recording and control of all transactions by the intermediaries.

The idea of creating cryptocurrencies emerged as a solution to avoid these restrictions on the movement of capital and made its first appearance after the collapse of the Lehman Brothers in 2008. The first cryptocurrency to be released was Bitcoin and its goal was to create an alternative way of electronic transactions, which does not depend on intermediaries, but allows secure and unquestionable direct transactions between its users. Its creation is attributed to Satoshi Nakamoto - probably a pseudonym for a team of IT and economics experts - who first described the basics of creating an e-commerce system independent of financial institutions and free from government interference and manipulation. This system, based on a peer-to-peer network, could ensure anonymous and secure transactions, using a "proof-of-work" consensus mechanism to create a public transaction history that could not be compromised by an intruder (Nakamoto, 2008).

However, the creation of Bitcoin was based on the pre-existing Blockchain technology, which was not created for the sole purpose of applying cryptocurrencies. It was introduced in its original form by D. Chaum in 1982. Chaum proposed a similar transfer protocol, which was later further developed in 1991 by S. Haber and W. Scott Stornetta, who described the creation of an encrypted data block chain (Bharathan, 2020). At this point, it should be made clear that Bitcoin - and cryptocurrencies in general - and Blockchain are two different things. Cryptocurrency is the means by which transactions are made, and Blockchain is the system that supports, verifies, approves, records and ensures the security and validity of transactions.

What is Blockchain?

Blockchain is a chain of digital blocks that contain data. The data chain is formed so that each block is inextricably linked to the previous block, through cryptographic methods. Thus, if someone attempts to make a change to a block, all the following blocks must be changed in order for the chain to remain valid, otherwise all blocks after what has changed will be invalid (Nofer et al, 2017).

In essence, blockchain is a distributed ledger in which information and data are stored and verified. This ledger is public, and as mentioned above, cannot be modified, so there is a guarantee that all data and transactions that have been recorded are valid

and unquestionable. However, its fundamental difference from the usual ledgers and databases is that it is not maintained by a central authority, but by the users, the so-called nodes, who have installed the required software. Consequently, the registry on a blockchain platform is not located in one place but is distributed, so that it is maintained and synchronized by all nodes at the same time, so that all nodes have the same updated registry. Thus, when making a money transfer, for example, it is not confirmed by a central management that keeps the transaction register (eg a bank) but is verified by all nodes (users) who keep the same register and update it at the same time. This way, it is no longer necessary to have a trusted intermediary, such as a bank, since the trust of users is based on the automatic confirmation of transactions through the software. The data exchange takes place in the Peer2Peer (P2P) network of connected computers (nodes), which, the more they are, the greater the security and validity they offer to the system. This model ensures that security is superior to a client-server system, since, if a node stops working, the system does not crash, and the data is secure.

The four main types of blockchain are public (permission less, no central authority), private (permissioned, controlled by one authority), consortium blockchains (permissioned, controlled by a group of organizations), and Hybrid (controlled by a single organization, but with some permissionless processes) (Wegrzyn & Wang, 2021). In a public blockchain directory (eg Bitcoin) anyone can write or read. In contrast, in a private directory, all participants in the chain are known and trusted (for example, internal orders in a company or organization) and are the only ones with access to the directory. The type of data as well as the way in which the data is registered and verified are determined by the software of each specific blockchain platform.

In the case of a transaction, a consensus is first reached between the users (nodes), for the correctness of the data entered in the register. Users are anonymous, since their accounts (digital wallets) do not contain any personal information. However, the content of the accounts as well as the history of the transactions made with them is visible to everyone, as well as their address, which is, obviously, unique.

Blockchain evolution

Since its first application with the Bitcoin cryptocurrency, blockchain technology has not stopped being improved by computer scientists, cryptographers, mathematicians, and financial experts. Blockchain 1.0 was used for cryptocurrencies, payment systems of foreign exchange, small-value payments, and simple cash transactions (Swan, 2015).

A first major development was the smart contracts introduced by the second-generation blockchain system Ethereum (Nofer et al, 2017). Smart contracts are small computer applications that impose specific conditions and criteria to be met (effectively a sequence of 'if this then that' variables) before registering them in the

blockchain, a procedure that takes place without the intervention of a third party (Alammary et al, 2019). This allowed the technology to extend to financial instruments such as loans and bonds and other banking instruments instead of applying it only in cash transactions. Subsequently, Blockchain 2.0 deals with properties, securities trading, smart contracts, and other areas of finance (Bhaskar et al, 2020).

Another important technological development is the gradual evolution of consensus mechanisms, from proof-of-work, which requires enormous computing power, to proof-of-stake that uses more financial tools to offer the same level of security. Equally important is the transition to blockchain scaling, which no longer uses all computers to verify transactions, but only those necessary for each transaction, obviously providing the same level of security, while greatly speeding up the process (Gupta, 2017).

The next generation, Blockchain 3.0, uses decentralized storage and decentralized communication and focuses on the development of applications in sectors such as e-government, health care, science, culture, and art (Swan, 2015; Alammary et al, 2019). As Efanov & Roshlin (2018) put it, we can identify three phases of development: Blockchain 1.0 as digital currency, Blockchain 2.0 as digital economy, and Blockchain 3.0 as digital society.

Nowadays, research continues in Blockchain 4.0, which promises to offer solutions and approaches that make blockchain technology suitable to business demands - "Industry 4.0" demands- in order to support supply chain management, financial management systems, workflow management and asset management (Bhaskar et al, 2020).

Fields of application of Blockchain technology

According to Chen et al (2018), blockchain technology is characterized by decentralization, traceability, immutability, transparency and can handle currency properties. These technical features can lead to systems with specific advantages in terms of Reliability, Trust, Security and Efficiency.

What blockchain technology really offers is a fast, secure, valid, and unquestionable way to make transactions, as well as a reliable distributed control mechanism, which eliminates any possible breach, both because the data is public and because the encryption method is virtually inviolable. Although the first application of blockchain technology was about digital currency (Bitcoin), its usefulness is no longer limited to cryptocurrencies or the field of economics. Blockchain, especially in its last stage v3.0, has many applications in various sectors such as:

- e-government, e-voting and elections, but also digital identities, for obvious reasons of security and avoidance of violation or change,

- insurance, secure keeping of registers and records, such as the land registry, property registry,
- tax office, company accounting,
- health, secure keeping and exchange of medical records,
- the food industry and the supply chain to record all information about an animal or food, from breeding / production to final sale,
- transport, for the organization and monitoring of data and products,
- autonomous driving, payment of tolls, refueling and drones,
- certification of various products and services,
- management of intellectual property issues such as the distribution of fees or usage rights but also for the immediate payment of the relevant fees directly by users,
- the audio streaming industry for the accurate recording of the movement of each song, and, through smart contracts, the attribution of copyright to artists,
- the digital art market for the certification of the authenticity of digital works. NFT (Non-Fungible Token) technology, a form of token used in the Ethereum blockchain, has been developed in this direction and, of course,
- education.

In the following paragraphs, the different areas in which blockchain technology can be useful in issues that concern educational organizations and applications are examined.

Blockchain applications in education

Research on the use of blockchain in education has seen a significant growth in the last five years, as numerous research proposals suggest systems that try to meet a wide range of needs in various educational fields. In 2017, Grech & Camilleri (2017) published, on behalf of the European Commission's science and knowledge service Joint Research Center (JRC), a report in which they explored the perspectives that blockchain technology gives to education. They concluded that blockchain-based systems could be used for permanent protection of certificates, for automatic recognition and transaction of credits, to maintain a lifelong training passport, to verify the multi-stage accreditation, to track intellectual property, to identify or to receive payments from students and to provide financing of students. Several other researchers such as Sharples & Domingue (2016), Albeanu (2017), Pina et al (2017), Ezeudu et al (2018), Nespor (2019), Alammary (2019), and Fedorova & Skobleva (2020) proposed their own more extended or more concise categorizations.

Methodology

For the purposes of this research, a search in IEEE and Google Scholar was conducted and the most cited scientific papers from 2015 until today were collected and analyzed. A total of 64 publications related to blockchain applications in education were studied, 6 of which were related to language education. As emerged from the

above study, and in an effort to give a general perspective of the ongoing research, some of the most well-known applications are presented below divided into five general categories.

Certification - Issue and storage of certificates and diplomas

The issue, storage, verification and sharing of certificates and diplomas is the most important sector of development of educational blockchain applications, to solve trust problems in the education area (Sun et al, 2021). Certificates and individual learning records that attest someone's skills and achievements play an important role in both education and market, and, therefore, must be stored in long-term available and tamper-proof ledgers (Gräther et al, 2018). Many researchers believe that the application of blockchain technology can increase transparency and efficiency (Turcu et al, 2019), achieve decentralization, manage educational credentials and consequently reduce diploma fraud (Castro & Au-Yong-Oliveira, 2021) and certificate forgery (Reis-Marques et al, 2021).

The first application of its kind was developed in 2014 at the University of Nicosia, Cyprus (UNIC) which used blockchain technology to store and confirm its diplomas and to manage students' certificates received from MOOC platforms (Sharples and Domingue 2016). UNIC was also the first university that started to accept fees for studies as bitcoins (Fedorova & Skobleva, 2020). In 2017, The Massachusetts Institute of Technology (MIT) designed Blockcerts (and the corresponding mobile app BlockcertsWallet) based on the bitcoin blockchain, which uses open-source libraries, components, and applications in order to issue and verify digital diplomas and professional certificates (Pina et al, 2017). An example of Blockcerts application is MIT's Digital Diploma (Turcu et al, 2019). MIT is also among a group of leading universities which in 2018 started to develop the Digital Credentials Consortium, an infrastructure for digital credentials of academic achievement (DCC, 2022). Blockchain for Education platform is another system based on the Ethereum blockchain, which uses smart contracts for issuing, validating, and sharing certificates (Gräther et al, 2018). Castro & Au-Yong-Oliveira (2021) report other similar solutions based on Ethereum and smart contracts, such as those developed at the University of Zurich, University of Lisbon, and Ho Chi Minh City (HCMC) University of Technology in Vietnam. Several more attempts, functional or prototypes, are also mentioned in literature. Castro & Au-Yong-Oliveira (2021) proposed a system for issuing and validating certificates using blockchain and smart contracts; Nespor (2019) proposed a blockchain certification platform, which allows higher education providers or employers to supply official certificates for students with a high level of privacy of their information. Finally, Steiu (2020) cites some other examples of certifications and blockchain identity management applications implemented by educational institutions. These include systems developed by the University of Southern New Hampshire University, Open Source University, and the European start-up BCDiploma.

Accreditation of studies or educational institutions - Verification of personal achievements

Similar to the issue of certification of diplomas is the issue of accreditation of studies. Indeed, students acquire skills and knowledge in both the formal educational system and informal education programs, such as MOOCs. Blockchain could ensure secure "accredited educational records faithfully combined with a negotiable reputation system" (Sharples & Domingue, 2016) as well as the creation of an electronic portfolio containing information about the complete acquired knowledge by someone in his entire life (Fedorova & Skobleva, 2020).

Towards this direction, ie the accreditation of studies, the recognition and transaction of credits, and the attribution of badges certifying acquired knowledge, several universities, large enterprises, and start-ups propose systems able to simplify the process and to ensure the authenticity of students' achievements. Among the most promising initiatives is the creation of the global higher education credit platform EduCTX. The platform is based on the concept of the European Credit Transfer and Accumulation System (ECTS) and aims to offer a reliable digital solution to the -so far analog- higher education credit and grading system by reducing paperwork, improving communication between institutions and by simplifying certificate management and storage for students. The platform is based on a globally distributed P2P network and uses ECTX tokens -as academic credits- which represent an equivalent to student's credit value for completed courses. Thus, it offers stakeholders (students, HEIs, private companies, organizations, or institutions) a global and decentralized education credit and grading system (Turkanović et al, 2018).

Various systems belong to this category. They propose the award of badges that represent academic achievements such as microcredentials, nanodegrees, MOOCs, and certificates from various types of training programmes. OpenLearn is a system developed by the Open University (UK) which is based on the Ethereum public blockchain and awards badges to its study accreditations (Pina et al, 2017). OpenBadges is a system proposed by Mozilla Foundation which creates "digital badges with embedded metadata about skills and achievements" (Albeanu, 2017). Badges can be degrees and certifications, but also microcredentials or any other type of credential. OpenBlockchain is another project based on the Ethereum platform, developed by the Knowledge Media Institute (KMi) in partnership with British Telecommunications (BT) (Lemoie, 2017). For its experiments, the Institute considers Microcredentials (badges) allocated for courses available on the Open Learn website and MOOCs (UK platform FutureLearn) (Turcu et al, 2019). Massachusetts Institute of Technology (MIT) and the Learning Machine company proposed a digital badge for online learning addressed to award certification to students who have attended the projects of MIT Media Lab and passed the corresponding assessment (Skiba 2017). A similar system based on the Ethereum

platform is used by the University of Glasgow for storage of student grades at the institution (Arndt, 2019). Disciplina is a platform which permits the creation of verified personal profiles based on academic and professional achievements (Kuvshinov, 2018; Arndt, 2019). Finally, Ocheja et al (2019) proposed a platform to track learning achievements, transcripts, and certificates (Reis-Marques et al, 2021) and Liu et al (2018), proposed a student's professional ability evaluation system able to link educational institutions and employment enterprises for sharing all necessary information regarding recruitment and industry requirements.

Security and educational management

Many researchers believe that blockchain technology can address the different security issues that LMS or other e-learning solutions (MOOCs, Web 2.0 based etc.) may face in an HEI environment. Fernández-Caramés & Fraga-Lamas (2019) believe that future smart campuses should use blockchain systems to ensure transparency and security. Towards this direction blockchain and, especially, smart contracts can provide new levels of security, trust, and transparency to e-learning and collaborative learning environments, ensure the validity of assessments and exams as well as the issue of credentials and the information storage in e-portfolios, and offer a significant security and efficiency enhancement to educational institutions and learners.

To this end, Altinay et al (2020), in their research study, analyzed the uses of blockchain in school management and especially in storing records, learning identity verification and content security. Bhaskar et al (2020) reviewed 36 research papers concerning teaching, learning, and student activities management, including administration activities at the school, college and universities, and proposed a blockchain system designed to facilitate all the above. Cheriguene et al (2022) proposed a trusted online-learning framework aiming to secure online learning platforms (LMSs) and, thus, to ensure the expected standard of teaching and fairness of assessment and to promote students' and teachers' motivation through blockchain reward methods. Ezeudu et al (2018) proposed an Ethereum based system which uses smart contracts for chemistry education students' data management. Bdiwi et al (2018) introduced the Ubiquitous learning (U-learning), an interactive multimedia system designed to encourage efficient communication among teachers and students in a collaborative learning environment with a high level of security. Finally, Bore et al (2017) proposed a blockchain-based School Information Hub (SIH) designed to improve a school's learning environment by collecting, analyzing, and reporting data that can assist and support the decision-making process.

Protection of digital rights and digital content - Digital signatures, timestamps

Protection of new knowledge, digital rights, copyright, digital content, learning objects acquired by students or faculty members, as well as digital signatures and timestamps is another field of application in which blockchain can offer significant improvements. Towards this direction, Hori et al (2018) discussed the

implementation of the decentralized learning system "CHiLO" for protecting e-books' copyright and ownership, and Bond et al (2015) proposed the use of a digital signature scheme and timestamps in order to detect fake diplomas and fraud in academic certificates. Furthermore, systems such as OriginStamp are used to timestamp files, data, or documents, proving the originality and time of existence of any digital asset (Albeanu, 2017).

A lot of significant research has also been made in digital content management area. Sychov and Chirtsov (2018) developed a unified-bank of learning objects, Chakraborty et al (2017) designed a set of operations and systems to manage and control access to such digital resources, such as education certificates, Ali et al (2016) and Kishigami et al (2015) designed a platform for different kinds of distributed digital content management and Zyskind et al (2015) conceptualized a decentralized network of peers for personal data management.

Learning and educational projects

In this category several applications and systems that try to improve several processes of teaching and learning could be classified, as they were designed to store, protect, and exchange information related to students' performance and progress, to connect students with teachers and employers, to enhance students' interactions in the e-learning systems, to support learners' career decisions providing recommendations, to manage the quality of examination reviews, to store degrees and to measure learning outcomes and reward students.

Educational and learning platforms

Sony Global Education (SGE) is a global assessment platform developed in 2016 with the support of IBM, designed to store, protect, and exchange information related to students' performance and progress (Chen et al, 2018). BitDegree is a gamified online education platform that tries to connect students with teachers and employers. The system uses its own token and blockchain certificates and provides users with courses and learning incentives such as tokenized scholarships (Steiu, 2020). ODEM.io, is a platform which offers direct connections with educators, courses, and access to professional opportunities that meet students' personal profile while, by the use of tokens, ensuring the validity of their continuing education certificates (Steiu, 2020).

Holberton School was the first institute applying blockchain technology to store degrees (Chen et al, 2018). Their blockchain ledger attributes all kinds of educational information, such as learning behavior in class, micro academic project experience, and macro educational background, to a unique user ID. The Institute for Blockchain Studies uses blockchain to Coursera MOOCs accreditation, applying a "pay for success" model. The system uses smart contracts and provides a proof-of-truth mechanism to confirm that the students who signed up completed the course, as well as a payment mechanism (Skiba, 2017; Tapscott and Tapscott (2017). Among other

systems designed to enhance students' interactions in the e-learning systems are the application proposed by Zhong et al (2018) which provides recommendations to support learners' career decisions, the smart blockchain badges proposed by Mikroyannidis et al (2018), and dAppER, a system designed to manage the quality of examination reviews, proposed by Mitchell et al (2019).

Competencies and learning outcomes management

Farah et al (2018) built a system to trace the performance of students for their activities. The system produces a learning block containing the total learning profile of each student. Williams (2019) proposed a learning environment for students. The environment provides prompt/direct support and meaningful feedback. It was intended to enhance the learning process by applying a wide set of skills, encourage critical thinking and problem solving with better collaboration and communication. Wu and Li (2018) introduced a decision-making system for examining students' professional knowledge and expertise. They developed it to build up an evaluation system which measures and manages students' operational proficiencies. Finally, Purnama et al (2021) proposed the Student-Centered Learning Blockchain (SCi-B), a three element system (E-Course, E-Portfolio, and E-Assessment) which can enhance the learning process and increase the credibility of student assessment.

Reward systems

Sharples & Domingue (2016) proposed Kudos, "a permanent distributed record of intellectual effort and associated reputational reward", which is a system that transforms information about the users' learning experience into a sort of digital currency. The system can be used to measure learning outcomes and stored in a virtual wallet. A similar system is the "Learning is Earning" initiative, which can foster students' learning motivation. As they learn, students will get digital currencies according to smart contracts as rewards. This kind of money can be stored in the education wallet, used as tuition, even exchanged with real currencies (Ezeudu et al, 2018).

Blockchain applications in language learning

The language learning sector can obviously benefit from the application of blockchain technology in all the areas mentioned above, but also in some more specific areas, such as the creation of a digital personal language knowledge Identity, the design of configurable language tests, the creation of systems for controlling language learning progress, or the language course design and evaluation. Blockchain could help towards the creation of a digital language knowledge Identity, by forming a ledger of the qualifications (certificates, scores, training etc.), formal (educational institutions) or informal (web services, apps, MOOCs etc.), that a learner has attained. This record could be stored in a public blockchain in order to be available to any institution or business interested. Smart contracts could offer significant benefits to traditional procedures, such as the attribution of intellectual rights and payment processes and

allow royalties to be connected to the use of specific content. Smart contacts could also be created between learner and school or product in order to facilitate payments for specific educational services. Sayers (2016) believes that blockchain could also be a trusted base for the creation of a School or product validation system, giving access to information about the impact of a school or product on learners' language proficiency.

Literature in blockchain applications for language learning is currently limited. There are, however, some significant research projects. Sun et al (2021) proposed a blockchain-based online language learning system to monitor students' English learning process authentically and fairly. The system is able to manage students and learning materials and uses smart contracts in order to provide four functions: record students' learning behavior, calculate students' final scores, record the students' final scores and query scores. The authors believe that such a system can save teachers from heavy and complex homework and provide reliable evaluation on students' behavior. In their study Min & Bin (2022) explored the use of blockchain in course design and evaluation in Chinese universities. By implementing an experimental course based on blockchain technology, they found that the redesign of online courses based on blockchain can improve the quality of teaching and the trust of various parties in online education. Wu (2020) proposed an English Online Education Platform based on Genetic Algorithm and Blockchain Technology, aiming to improve work efficiency, to enhance the fairness and flexibility of the examination, and to make the examination work standardized and paperless. The system manages examinations, item bank, test papers, and a marking function, in order to emancipate the examiners and teachers from the traditional heavy examination work. In addition, the system considers the examination syllabus, the difficulty level, the content, and produces English language tests. Wang & Qiao (2020) proposed a virtual English teaching platform for landscape design majors based on blockchain technology, which combines unsupervised learning and machine learning. The platform is based on virtual reality technology to provide students with a more realistic visual experience. Researchers found that the combination of these technologies had a better teaching effect compared to the already existing traditional platform and is suitable for application to the actual English teaching for landscape design majors. Finally, Song & Shen (2022) designed a system for online foreign language education based on Ethereum and smart contracts. The system uses a modular architecture, it is suitable for use in colleges and universities, and aims to improve the overall teaching efficiency and quality of online language learning.

Along with the research in the use of blockchain in language learning, a very promising dynamic in the market is also beginning to arise. Du'Mmett (2019) reports that English Forward, one of the biggest learn English Q&A site, with over 250 million visitors, has implemented a blockchain application in order to accelerate the progress of English language learning and to offer a more comprehensive solution to link up with teachers, translators and other English language professionals. The company

believes that this solution can guarantee the collaboration, integration, motivation and simplicity that the current English Forward Community requires. Among the expected benefits are the more effective monetization of the expertise of teachers in a competitive and transparent manner, faster and more effective learning activities completion, easily verifiable and more secure rating and certification for both students and teachers, and encouragement of more companies to adopt blockchain, ensuring massive adoption of the platform in order to reach a better return on financial investment on the blockchain technology.

Conclusion

As evidenced by the applications and systems presented, blockchain technology seems to have great potential for exploitation in the education area. In their report, Grech & Camilleri (2017) proposed several scenarios for implementing technology in current or future educational procedures. Among them are certification, accreditation, recognition and transfer of credits, lifelong learning passport, e-portfolios, rewards, payments and funding, and management of intellectual property. Research could also go forward in learning activities design and implementation, tracking of the learning process and measure of outcomes, evaluation, and accreditation and improvement of the quality of online education. Future research could also focus in sectors such as the job driven education, and lifelong learning education, where the need for blockchain-backed credentialing will increase in the next years. Especially with the use of smart contracts, there can also be a benefit from the implementation of new secure and simplified procedures that ensure collaboration and partnership not only between educational institutions but also between teachers and schools, as well as between teachers and students. Finally, blockchain can be used to motivate teachers and students by giving rewards -in badges or digital currency- to those who meet the agreed standards or goals (Chen et al, 2018).

New technological developments, such as 5G networks, smart and interconnected devices and the development of the Internet of Things (IoT), lead to a new reality in which the secure data transfer and storage are non-negotiables. In this new reality, blockchain technology can play a crucial role as it has the ability to reduce costs, increase transaction speed and provide the necessary background for the safe and inviolable operation of systems, as well as the opportunity to create new innovative services and applications.

References

[1] Alammary, A., Alhazmi, S., Almasri, M., & Gillani, S. (2019). Blockchain-based applications in education: A systematic review. Applied Sciences, 9(12), 2400. https://www.mdpi.com/2076-3417/9/12/2400/pdf

[2] Albeanu, G. (2017). Blockchain technology and education. In The 12th International Conference on Virtual Learning ICVL (pp. 271-275). https://bit.ly/3MqIXTj

[3] Ali, M., Nelson, J., Shea, R., & Freedman, M. J. (2016). Blockstack: A global naming and storage system secured by blockchains. In 2016 USENIX annual technical conference (USENIX ATC 16) (pp. 181-194). https://www.usenix.org/system/files/conference/atc16/atc16_paper-ali.pdf

[4] Altinay, F., Beyatli, O., Dagli, G., & Altinay, Z. (2020). The role of Edmodo model for professional development: The uses of blockchain in school management. International Journal of Emerging Technologies in Learning (iJET), 15(12), 256-270. https://www.learntechlib.org/p/217556/article_217556.pdf

[5] Arndt, T. (2019). An Overview of Blockchain for Higher Education. In KMIS (pp. 231-235). https://www.scitepress.org/Papers/2019/83439/83439.pdf

[6] Bdiwi, R., De Runz, C., Faiz, S., & Cherif, A. A. (2018). A blockchain based decentralized platform for ubiquitous learning environment. In 2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT) (pp. 90-92). IEEE. https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8433463

[7] Bharathan, V. (2020, Jun 1). Blockchain Was Born 20 Years Before Bitcoin. Forbes (Online). https://www.forbes.com/sites/vipinbharathan/2020/06/01/the-blockchain-was-born-20-years-before-bitcoin/?sh=2d14c0905d71

[8] Bhaskar, P., Tiwari, C. K., & Joshi, A. (2020). Blockchain in education management: present and future applications. Interactive Technology and Smart Education. ISSN: 1741-5659 https://www.emerald.com/insight/content/doi/10.1108/ITSE-07-2020-0102/full/pdf?title=blockchain-in-education-management-present-and-future-applications

[9] Bond, F., Amati, F., & Blousson, G. (2015). Blockchain, academic verification use case. Buenos Aires. http://signatura-usercontent.s3.amazonaws.com/blockchain_academic_verification_use_case.pdf

[10] Bore, N., Karumba, S., Mutahi, J., Darnell, S. S., Wayua, C., & Weldemariam, K. (2017). Towards blockchain-enabled school information hub. In Proceedings of the Ninth International Conference on Information and Communication

Technologies and Development (pp. 1-4). https://dl.acm.org/doi/pdf/10.1145/3136560.3136584

[11] Castro, R. Q., & Au-Yong-Oliveira, M. (2021). Blockchain and higher education diplomas. European Journal of Investigation in Health, Psychology and Education, 11(1), 154-167. file:///C:/Users/Admin/Downloads/ejihpe-11-00013.pdf

[12] Chakraborty, S., Dutta, K., & Berndt, D. (2017). Blockchain based Resource Management System. Available at SSRN 3104351. https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID3104351_code2632450.pdf?abstractid=3104351&mirid=1

[13] Chen, G., Xu, B., Lu, M., & Chen, N. S. (2018). Exploring blockchain technology and its potential applications for education. Smart Learning Environments, 5(1), 1-10. https://slejournal.springeropen.com/track/pdf/10.1186/s40561-017-0050-x.pdf

[14] Cheriguene, A., TaiKabache, T., Adnane, A., Kerrache C.A., & Farhan Ahmad, F. (2022). On the use of Blockchain Technology for Education during Pandemics. DOI: 10.1109/MITP.2021.3066252, https://www.researchgate.net/publication/358807148_On_the_use_of_Blockchain_Technology_for_Education_during_Pandemics

[15] DCC (2022). Digital Credentials Consortium. https://digitalcredentials.mit.edu/wp-content/uploads/2020/02/white-paper-building-digital-credential-infrastructure-future.pdf

[16] Du'Mmett, S. (Mar 26, 2019). What Does Blockchain Guarantee for the Learn English Community? Cryptopolitan (online). https://www.cryptopolitan.com/what-does-blockchain-guarantee-for-the-learn-english-community/

[17] Efanov, D., & Roschin, P. (2018). The all-pervasiveness of the blockchain technology. Procedia computer science, 123, 116-121. https://bit.ly/3JoUFft

[18] Ezeudu, F. O., Eya, N. M., & Nworgi, H. I. (2018). Application of Blockchain-based Technology in Chemistry Education Students' Data Management. International Journal of Database Theory and Application, 11(2), 11-22. http://dx.doi.org/10.14257/ijdta.2018.11.2.02

[19] Farah, J. C., Vozniuk, A., Rodríguez-Triana, M. J., & Gillet, D. (2018). A blueprint for a blockchain-based architecture to power a distributed network of tamper-evident learning trace repositories. In 2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT) (pp. 218-222). IEEE. https://ieeexplore.ieee.org/document/8433497

[20] Fedorova, E. P., & Skobleva, E. I. (2020). Application of blockchain technology in higher education. European Journal of Contemporary Education, 9(3), 552-571. https://files.eric.ed.gov/fulltext/EJ1272331.pdf

[21] Fernández-Caramés, T. M., & Fraga-Lamas, P. (2019). Towards next generation teaching, learning, and context-aware applications for higher

education: A review on blockchain, iot, fog and edge computing enabled smart campuses and universities. Applied Sciences, 9(21), 4479. https://www.mdpi.com/2076-3417/9/21/4479/pdf

[22] Gräther, W., Kolvenbach, S., Ruland, R., Schütte, J., Torres, C., & Wendland, F. (2018). Blockchain for education: lifelong learning passport. In Proceedings of 1st ERCIM Blockchain workshop 2018. European Society for Socially Embedded Technologies (EUSSET). https://dl.eusset.eu/bitstream/20.500.12015/3163/1/blockchain2018_07.pdf

[23] Grech, A., & Camilleri, A. F. (2017). Blockchain in education. Luxembourg: Publications Office of the European Union. Luxembourg: Publications Office of the European Union 2017, 132 S. - (JRC Science for Policy Report). DOI: 10.25656/01:15013, https://www.pedocs.de/volltexte/2018/15013/pdf/Grech_Camilleri_2017_Blockchain_in_Education.pdf

[24] Gupta, V. (2017, February 28). A Brief History of Blockchain. Harvard Business Review (online). https://hbr.org/2017/02/a-brief-history-of-blockchain

[25] Hori, M., Ono, S., Miyashita, K., Kobayashi, S., Miyahara, H., Kita, T., & Yamaji, K. (2018). Learning System based on Decentralized Learning Model using Blockchain and SNS. In CSEDU (1) (pp. 183-190). https://bit.ly/3OxAVKa

[26] Kishigami, J., Fujimura, S., Watanabe, H., Nakadaira, A., & Akutsu, A. (2015). The blockchain-based digital content distribution system. In 2015 IEEE fifth international conference on big data and cloud computing (pp. 187-190), IEEE. https://ieeexplore.ieee.org/document/7310737

[27] Kuvshinov, K., Nikiforov, I., Mostovoy, J., Mukhutdinov, D., Andreev, K., & Podtelkin, V. (2018). Disciplina: Blockchain for education. Yellow Paper. https://www.disciplina.io/yellowpaper.pdf

[28] Liu, Q., Guan, Q., Yang, X., Zhu, H., Green, G., & Yin, S. (2018). Education-industry cooperative system based on blockchain. In 2018 1st IEEE international conference on hot information-centric networking (HotICN) (pp. 207-211). IEEE. https://ieeexplore.ieee.org/document/8606036

[29] Lemoie, K. (October 26, 2017). Innovations in Open Badges & Blockchain. Badgechain (online). http://badgechain.com/innovations-in-open-badges-blockchain/

[30] Mikroyannidis, A., Domingue, J., Bachler, M., & Quick, K. (2018). A learner-centred approach for lifelong learning powered by the blockchain. In EdMedia+ innovate learning (pp. 1388-1393). Association for the Advancement of Computing in Education (AACE). http://oro.open.ac.uk/55989/1/EdMediaBlockchainacceptedpaper%201.pdf

[31] Min, L., & Bin, G. (2022). Online teaching research in universities based on blockchain. Education and Information Technologies, 1-24. https://link.springer.com/content/pdf/10.1007/s10639-022-10889-w.pdf

[32] Mitchell, I., Hara, S., & Sheriff, M. (2019). dAppER: decentralised application for examination review. In 2019 IEEE 12th International Conference on Global Security, Safety and Sustainability (ICGS3) (pp. 1-14). IEEE. https://ieeexplore.ieee.org/document/8688143
[33] Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. Manubot. https://nakamotoinstitute.org/static/docs/bitcoin.pdf
[34] Nespor, J. (2019). Cyber schooling and the accumulation of school time. Pedagogy, Culture & Society, 27(3), 325-341. https://www.tandfonline.com/doi/pdf/10.1080/14681366.2018.1489888
[35] Nofer, M., Gomber, P., Hinz, O., & Schiereck, D. (2017). Blockchain. Business & Information Systems Engineering, 59(3), 183-187. https://link.springer.com/content/pdf/10.1007/s12599-017-0467-3.pdf
[36] Ocheja, P., Flanagan, B., Ueda, H., & Ogata, H. (2019). Managing lifelong learning records through blockchain. Research and Practice in Technology Enhanced Learning, 14(1), 1-19. https://link.springer.com/content/pdf/10.1186/s41039-019-0097-0.pdf
[37] Pina, A. R. B., Torlà, C. B., Quintero, L. C., & Segura, J. A. (2017). Blockchain en Educación: introducción y crítica al estado de la cuestión. Edutec. Revista Electrónica de Tecnología Educativa, (61), a363-a363. https://www.edutec.es/revista/index.php/edutec-e/article/view/915/pdf_en
[38] Purnama, S., Aini, Q., Rahardja, U., Santoso, N. P. L., & Millah, S. (2021). Design of Educational Learning Management Cloud Process with Blockchain 4.0 based E-Portfolio. Journal of Education Technology, 5(4), 628-635. https://ejournal.undiksha.ac.id/index.php/JET/article/download/40557/20151
[39] Reis-Marques, C., Figueiredo, R., & de Castro Neto, M. (2021). Applications of Blockchain Technology to Higher Education Arena: A Bibliometric Analysis. European Journal of Investigation in Health, Psychology and Education, 11(4), 1406-1421. https://www.mdpi.com/2254-9625/11/4/101/pdf
[40] Sayers, J. (July 12, 2016). The Blockchain and Possible Impacts on Language Learning. Medium (online). https://medium.com/decentralize-today/the-blockchain-and-possible-impacts-on-language-learning-c06c73c66d6
[41] Sharples, M., & Domingue, J. (2016). The blockchain and kudos: A distributed system for educational record, reputation and reward. In European conference on technology enhanced learning (pp. 490-496). Springer, Cham. https://link.springer.com/chapter/10.1007/978-3-319-45153-4_48
[42] Skiba, D. J. (2017). The potential of blockchain in education and health care. Nursing education perspectives, 38(4), 220-221. https://www.proquest.com/docview/1918308392/fulltextPDF/F89C1219C0334F92PQ/1?accountid=8359

[43] Song, Y., & Shen, Y. (2022). System Design for Online Foreign Language Education Based on Blockchain Technology. Computational Intelligence and Neuroscience, 2022. https://doi.org/10.1155/2022/5180307
[44] Steiu, M. F. (2020). Blockchain in education: Opportunities, applications, and challenges. First Monday. https://firstmonday.org/ojs/index.php/fm/article/download/10654/9726
[45] Sun, X., Zou, J., Li, L., & Luo, M. (2021). A blockchain-based online language learning system. Telecommunication Systems, 76(2), 155-166. https://link.springer.com/content/pdf/10.1007/s11235-020-00699-1.pdf
[46] Swan, M. (2015). Blockchain: Blueprint for a new economy. O'Reilly Media, Inc. Sebastopol, CA 95472, ISBN13: 978-1-492-92049-7
[47] Sychov, S., & Chirtsov, A. (2018). Towards developing the unified bank of learning objects for electronic educational environment and its protection. In Proceedings of the 2018 workshop on PhD software engineering education: challenges, trends, and programs, St. Petersburg, Russia (Vol. 17, p. 1e6). http://ceur-ws.org/Vol-2256/SWEPHD18_paper_09.pdf
[48] Tapscott, D., & Tapscott, A. (2017). The blockchain revolution and higher education. Educause Review, 52(2), 11-24. https://bit.ly/3L7uJGK
[49] Turcu, C., Turcu, C., & Chiuchisan, I. (2019). Blockchain and its Potential in Education. arXiv preprint arXiv:1903.09300. https://arxiv.org/ftp/arxiv/papers/1903/1903.09300.pdf
[50] Turkanović, M., Hölbl, M., Košič, K., Heričko, M., & Kamišalić, A. (2018). EduCTX: A blockchain-based higher education credit platform. IEEE access, 6, 5112-5127. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8247166
[51] Wang, P., & Qiao, S. (2020). Emerging applications of blockchain technology on a virtual platform for English teaching and learning. Wireless Communications and Mobile Computing, 2020. https://www.hindawi.com/journals/wcmc/2020/6623466/
[52] Wegrzyn, K. & Wang, E. (August 19, 2021). Types of Blockchain: Public, Private, or Something in Between, Foley (online) https://www.foley.com/en/insights/publications/2021/08/types-of-blockchain-public-private-between
[53] Williams, P. (2019). Does competency-based education with blockchain signal a new mission for universities?. Journal of higher education policy and management, 41(1), 104-117. https://www.tandfonline.com/doi/pdf/10.1080/1360080X.2018.1520491
[54] Wu, X. (2020). Research on english online education platform based on genetic algorithm and blockchain technology. Wireless Communications and Mobile Computing, 2020. https://downloads.hindawi.com/journals/wcmc/2020/8827084.pdf
[55] Wu, B., & Li, Y. (2018). Design of evaluation system for digital education operational skill competition based on blockchain. In 2018 IEEE 15th

international conference on e-business engineering (ICEBE) (pp. 102-109), IEEE. https://ieeexplore.ieee.org/document/8592636

[56] Zhong, J., Xie, H., Zou, D., & Chui, D. K. (2018). A blockchain model for word-learning systems. In 2018 5th International Conference on Behavioral, Economic, and Socio-Cultural Computing (BESC) (pp. 130-131). IEEE. https://bit.ly/3OB7rva

[57] Zyskind, G., & Nathan, O. (2015). Decentralizing privacy: Using blockchain to protect personal data. In 2015 IEEE Security and Privacy Workshops (pp. 180-184), IEEE. https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7163223