An educational portal with elements of blockchain technology in higher education institutions of Kazakhstan: opportunities and benefits

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ABSTRACT: In this article, the authors explore the feasibility, challenges, benefits and risks of blockchain technology in education, with an emphasis on using blockchain to create an educational portal. This study provides an overview of the use of blockchain for education and its possibilities when creating electronic portals. Digitalisation concerns all areas of human life, and directly affects the educational process, with higher education institutions trying to attract more and more people to receive a quality education. The aim of this study was to develop a digital educational portal, with the implementation based on the use of blockchain technologies to ensure the reliability and transparency of data and operations. The significance of this study is determined by the practical application of new technologies for the electronic educational process in higher educational institutions. In this study, the authors established that blockchain technology is mainly used for issuing and verifying academic certificates, exchanging knowledge and academic achievements of students, as well as assessing their professional abilities. In addition, the technology provides some important benefits for education, including a secure platform for student information sharing, lower costs, and increased trust and transparency.

Keywords: Internet platform, self-study, integration, technologies in the educational process, blockchain

INTRODUCTION

The use of blockchain technology in higher education in Kazakhstan is still at an early stage of development, as not many educational institutions make attempts to introduce blockchain technology into the educational and administrative processes of the university. At the same time, according to the results of various studies, blockchain technology has a huge potential in the field of higher education and in general [1].

The study of the application of blockchain technology in Kazakhstan is based on the need for the digitalisation of economic processes, as well as educational activities. Blockchain has all the prerequisites to make a global transformation of the monetary system. Big data and ubiquitous connectivity are among the factors behind the *sharing economy* that is spreading globally at an accelerated pace [2].

Another argument in favour of the transition of education to blockchain technology is the integrity of the block structure, i.e. changing and deleting data or elements in the blockchain will result in the failure of the entire system and the destruction (break down) of the entire blockchain. This, in turn, prevents the imperceptible hacker's impact on the blockchain-based system, which combined with cryptographic methods based on the use of public and private keys, is virtually invulnerable [3].

In Kazakhstan, the pioneer of the introduction of blockchain technology in all spheres of human activity, including education, was the Association of Developers and Users of Blockchain Technology - BlockchainKZ. Thus, in the field of education, in 2019 the Association launched an automated on-line learning platform - Academy BlockchainKZ, which presents a course, through which users can gain knowledge in the field of blockchain technologies, cryptocurrencies and mining, as well as to improve their level of financial literacy [4]. Also, successful participants of the course are issued with a certificate upon its completion, which can proof useful for further studies as credits and/or in job applications.

Nowadays, some educational institutions of Kazakhstan introduce various special courses on cloud solutions to improve the content of education [5]. But information about the implementation of blockchain technology in educational processes at Kazakh universities is currently not widely available. The main way to use blockchain technology is to protect data from unauthorised access and maintain integrity and decentralisation. However, it appears that the actual application of blockchain for solving administrative and other problems in higher education institutions is at an early stage.

LITERATURE REVIEW

According to recent studies on how exactly the use of tools and other equipment based on information technology affects the learning of the current generation of students, it was found that it generates increasingly more interest among students [6]. Various on-line courses can be seen as a useful tool for promoting self-directed learning through digital technologies [7]. The effectiveness of the educational process increases and the transfer of knowledge is simplified without compromising the completeness and quality of the transferred knowledge and acquired competencies. This means that with the help of modern technology, the student tends to work faster in any area of life.

There can be distinguished four main aspects in the application of blockchain technology in education and various developments based on it. Blockchain technology can be included in the curriculum as a separate discipline, as a training system in which the assimilation of practical skills takes place, as an aid in performing laboratory tasks and as a tool to improve the learning process in general. Thanks to blockchain technology, modern education is beginning to move from a passive to an interactive and proactive state.

According to Kussy et al, blockchain technology will change any field of activity based on keeping records of property rights [8]. In education, activities that can be changed by blockchain technology include awarding qualifications, licensing and accreditation, managing student records, managing intellectual property and payments. Chen et al discussed the use of cryptographic methods and distributed consensus algorithms in blockchain to create functions, such as decentralised storage, tracking, immutability of data and their properties [9].

Blockchain technology, which is also known as distributed secure ledger technology, was introduced in 2008 and was first used as a peer-to-peer electronic money system transaction for the bitcoin cryptocurrency [10]. Blockchain technology is a block of time series data that is interconnected, forming a chain structure built into cryptography and distributed registries [11]. The technology has gained attention due to its extensive cybersecurity capabilities, which can be used in a number of businesses that are related to finance, business administration and healthcare. Potential blockchain services expand its current applications and make a huge contribution to the scientific community.

MATERIALS AND METHODS

Despite the fact that blockchain technology is a relatively recent innovation in the field of informatics, it has become a revolutionary cross-industry global technology, which according to various scientists, will contribute to the growth of the world economy over the next few decades [12]. The value of decentralised registries based on blockchain technology was discussed by Hwang who pointed out that it can bring important benefits to stakeholders in the education sector, with a particular focus on the potential for digital accreditation of personal and academic learning [13].

Blockchain has the following key characteristics [9]:

1. Decentralisation: it can be divided into three forms including architectural, political and logical decentralisation.
2. Safety: all records in the entire network cannot be forged and any falsification can be easily detected.
3. Anonymity: the user can generate multiple addresses to avoid identity disclosure - this keeps transactions confidential.
4. Reliability and verification: this feature improves the traceability and transparency of the data stored in the blockchain [9].

According to Casino et al, blockchain technology is open source for various areas [14]. The advantage of blockchain lies in the ability to move from centralised data logging to a distributed system that guarantees that information does not change and confidentiality is maintained. In their study, Alammary et al present blockchain as a new technology in the field of education [15]. Accordingly, they conducted several research analyses, reviewed various scientific publications, and proposed a framework for three main topics: applications, benefits and challenges for the topic. As a result, it was revealed that blockchain technology is usually used for the following purposes: issuance and confirmation during the verification of academic transcripts and certificates, decentralised exchange of knowledge and educational achievements of students, including the assessment of their knowledge, skills and professional abilities [15].

Moreover, blockchain technology creates a number of significant advantages for the educational process, such as an open and secure platform for storing and exchanging confidential data of teachers and students, reducing the cost of centralised data collection and increasing trust, reliability and transparency of the entire process. Blockchain technology can become an engine in the development of motivation and enthusiasm for the learning process. Moreover, the blockchain stores a complete, trustworthy set of records of a student's educational activities, including the processes and results of work in both formal and informal learning environments. In addition, this technology can create certain guidelines in the construction and evaluation of the quality of the educational process by the teacher due to the registration of the behaviour and activities of both teachers and students' progress during training. Thus, blockchain technology has great potential for application in the educational process, including tracking and analysing the behaviour of students, and for teachers in the formation of final grades.

The authors of this article propose the use of blockchain technology in education, based on Sun et al, who described the experience of implementing blockchain as a platform for continuous education [16]. They consider blockchain technology as the basis for an information and educational environment with elements of motivation; namely, receiving digital awards (coins) for solving problems, tests and ultimately the possibility of exchanging awards (coins) for a digital certificate.

RESULTS AND DISCUSSION

An educational portal was developed with elements of blockchain technologies for use in the educational process at universities. The portal involves the placement of courses and materials that can be used in the learning process. Completion of these courses involves the receipt of certificates of professional development, which can be used to offset subjects at university or be attached to a resume as an advanced training course. Entrance to the portal involves two levels of access and separation of rights: teacher and student. The purpose of separation is to form the correct environment for learning. After authorisation, the student gets access to available courses, received certificates and a personal page where their information is located. After authorisation, the teacher is given access to existing courses, the ability to add new ones, as well as the ability to evaluate students and track their progress. The educational portal is available on the Internet, and it is built using blockchain technology, which has a graph structure. The portal is implemented using blocks (size 1024 bytes). Each block consists of the following sections:

1. Header: it contains information about the block type, timestamp and block hash. All types of blocks have a header, and its structure always remains unchanged (Table 1).

Table 1: Header structure.

Field name	Data type	Size	Description
block_type	int32	4 bytes	block type
timestamp	int32	4 bytes	Timestamp in UNIX format
hash	byte[] x 32	32 bytes	Hash based on the sum of the hashes of the previous blocks and the payload of the current block and the type of the current block

2. Links to parent blocks: there can be several of them, for different types of blocks and a different number of parent blocks is possible. This part of the block is used to authenticate the block, and also when generating a block hash.
3. Payload: this is the information that the block stores. An example of the block structure is presented in Table 2.

Table 2: Block structure example.

Header	Block type (4 bytes)	Timestamp (4 bytes)	Hash (32)	
Links to parent blocks	Link to block 34 (4 bytes)	Link to block 51 (4 bytes)	Link to block 68 (4 bytes)	
Payload	Full name (32 bytes)	Individual ID number (12 bytes)	Login (16 bytes)	Password (16 bytes)

The basic block authentication algorithm is about calculating its hash. The hash algorithm is *SHA256*. If the data in the block changes, the hash function of the block will also change when it is recalculated, since it includes the useful information stored in the block. In the case of the block hash re-creation based on the new payload, all blocks referring to this block will not be valid, since their hash value is calculated based on the hash of the previous block.

The formation of the main blocks of the portal can be described as follows:

1. The *LECTURER_BLOCK* is formed when a teacher registers (*block_type* = 1). The *payload* field contains information about the teacher and the teacher's public key (the private key is kept by the teacher). The first 256 bytes are allocated for such data as the teacher's full name, individual ID number, login, password and additional information (Figure 1). The remaining payload space is allocated under the public key.

Figure 1: An example of a lecturer's block.

2. The *STUDENT_BLOCK* is formed when a student registers (*block_type* = 2). The *payload* field contains information about the student and the student's public key. Similarly to the lecturer's block, the first 256 bytes are allocated for such data as the students full name, individual ID number, login, password andadditional information. The remaining payload space is allocated under the public key.
3. The *KURS_BLOCK* (course block) is formed when a teacher creates a course (*block_type* = 3). The *payload* field contains the name of the course and its description, the first 128 bytes are allocated for the title, the next 256 bytes are for the description and the minimum number of *coins* for change, the remaining space is allocated for the digital signature of the teacher (a hash of the name and description, and the minimum number of *coins* for change, encrypted with the teacher's private key). *Coins* within the portal means points earned (Figure 2).

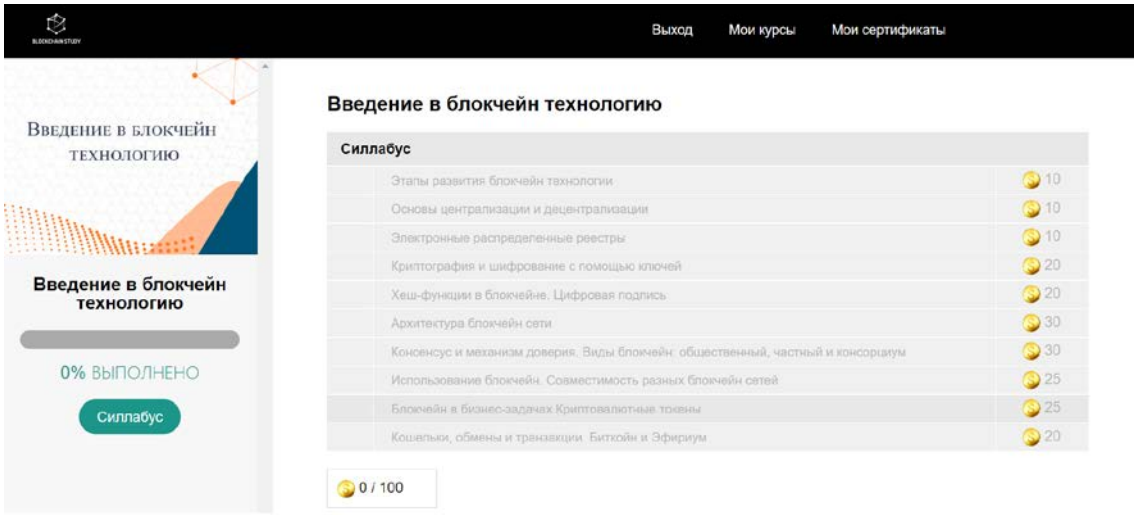

Figure 2: *KURS_BLOCK* (course block) data visualisation page.

4. The *TASK_BLOCK* is formed when a teacher creates a task (*block_type* = 4). The *payload* field contains the maximum number of *coins* that can be received for this task, the signature of the task file by the teacher (a hash that consists of the sum of prev_block, the hash of the file and the number of *coins*, encrypted with the teacher's private key).
5. The *TASK_COMPLETE_BLOCK* is formed when the teacher checks the student's tasks (*block_type* = 5). It is a confirmation of the successful completion of the task. The *payload* field contains the number of *coins* accrued by the teacher (the number of coins specified in *task_block*) and the teacher's digital signature (the hash of the number of *coins*) encrypted with the teacher's private key.
6. The *CERTIFICATE_BLOCK* is formed when a student purchases a certificate of course completion using earned *coins* (*block_type* = 6). A block is valid only if the total number of coins in all *task_complete* fields of the current course collected by the student, is greater than or equal to the number of coins specified in the *task_block* field. The *payload* field is the student's digital signature (a hash encrypted with the student's private key). It is worth noting that each course corresponds to a certain number of *coins*. *CERTIFICATE_BLOCK* data visualisation on the portal is shown in Figure 3.

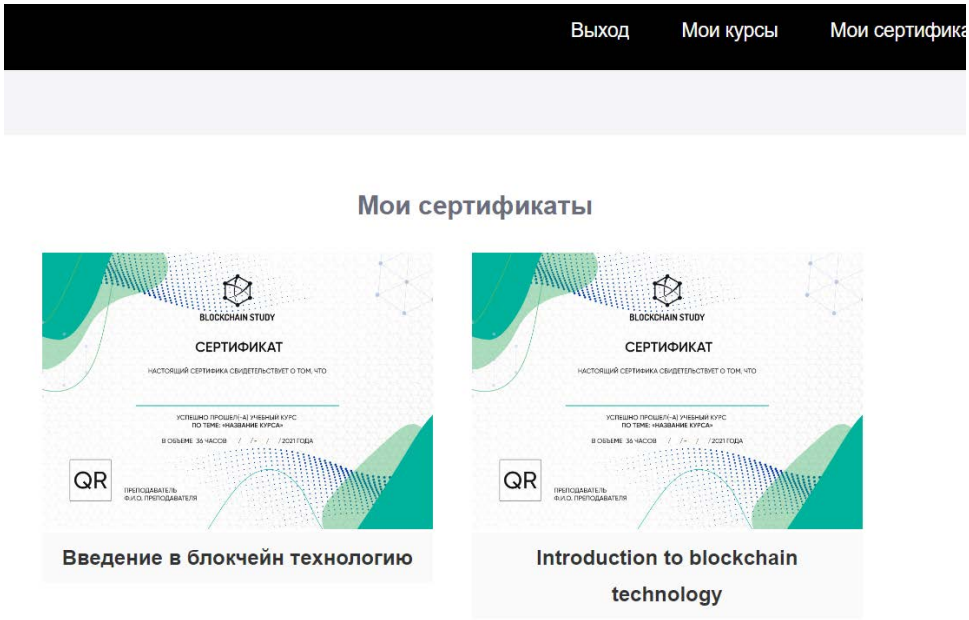

Figure 3: *CERTIFICATE_BLOCK* data visualisation page.

As described above, an educational portal was developed, which includes elements of blockchain technology. Its use increases the interest and improves the performance of students, thus facilitating these educational goals. The diversity of the educational process allows to create interactivity and captivate students. Certification of learning outcomes is yet another benefit of this application, as blockchain technology allows for simple and effective certification. Student results can be easily found and checked even if they are lost. The decentralised use of materials, content and other resources simplify and thus encourage information exchange. The blockchain application allows for the free exchange of information and does not require third-party verification. Data confidentiality and process transparency are highly valued features of blockchain. The safe storage of students' personal data, the correctness of their grading and certification, and the protection of materials are all ensured by the blockchain application .

Although many applications of blockchain technology cannot yet be imagined, during the course of this study it was found that as far as education is concerned in the near future, the impact of the implementation of blockchain technologies will be gradually more noticeable. For example, the following changes can already be noted:

1. Blockchain technology can significantly speed up the process of moving away from the traditional paper issuance of diplomas and certificates. Any type of transcripts, diplomas and certificates issued by both higher and other educational institutions, in particular on the assignment of qualifications or advanced training with a record of achievements, can be permanently and securely protected in a decentralised database using blockchain technology.

2. Blockchain technology allows participants in the educational process to automatically verify the authenticity of transcripts, diplomas or certificates directly using the technology, without having to contact the educational organisation that originally issued them to the student. Thus, it is likely to simplify if not eliminate the need for constant verification of credentials and reduce the bureaucratisation of educational organisations. This ability to automatically issue and validate certificates can be applied to other educational scenarios as well. Blockchain technology is also applicable to copyright and intellectual property management, to track first publications and citation tags, without the need for a central authority to store and manage these databases.

3. Reducing data management costs on the part of educational institutions. This could be achievable, due to the potential of blockchain technology to create decentralised structures in data management, in which users can easily control their own data and share it if necessary.

4. The increasing resource availability of cryptocurrencies based on blockchain technologies can be used to make payments and increase motivation for learning by accumulating coins for completing a particular course in some educational institutions and platforms. The ability to create one's own cryptocurrencies could also mean that blockchain will find significant use in education funding based on grants or vouchers in many countries.

It can be concluded that the benefits mentioned above are only achievable through the adoption of open technologies that implement stand-alone data management solutions, use open standards for data and use open source software. It is also worth considering that blockchain technology opens up more opportunities in the presence of a network effect of transnational application. In order to ensure the development of open blockchain implementations, it is necessary that countries work in co-operation and consider creating and promoting *open* educational materials, sources and records that protect the principles of ownership of the recipient and the author. While taking advantage of any technological offerings, it has to be stressed that innovation related to educational records cannot develop without generally accepted digital metadata standards for such records. Therefore, it is urgent to support standardisation activities in this area.

From a research perspective, the authors recommend forming an expert advisory committee to keep security policy makers up to date on developments and their implications for tool use, while funding specific implementations and/or projects of interest. The main beneficiaries of introducing blockchain-based technologies in education are likely to be networks of educational organisations and students.

CONCLUSIONS

The study demonstrates that blockchain can be used in many areas of education, such as on-line education, student learning outcomes monitoring and assessment, student data privacy protection, meta-diplomas, awards and certifications issuance, operational skills competitions, university evaluations, rankings, education-industry co-operation, and much more.

To this end, the authors developed a learning portal for blockchain technologies, which allows to understand and use the benefits of the technology and to incorporate the principles underlying this technology into digital skills training.

The on-line portal will allow students to acquire new knowledge in an asynchronous learning mode. The teacher, in turn, will be able to correctly assess the knowledge of the student. Blockchain allows to protect the data that is stored on the portal, ensure the safety of student achievements and maintain the transparency of this data.

The study could be improved by including several other applications using blockchain technologies in education. Such a study would allow educational institutions to evaluate and decide which application of blockchain in education could be beneficial for them depending on their respective organisations.

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BIOGRAPHIES

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