

APPLICATION OF BLOCKCHAIN TECHNOLOGY IN HIGHER EDUCATION INSTITUTIONS

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This scientific study examines the use of blockchain technology in higher education institutions in the context of the development of the technical base of the modern education system. The relevance of the study is determined by the wide spread of the latest technologies in the system of modern education and their substantial impact on the quality of education in higher educational institutions and other educational institutions. The purpose of this study is to investigate the main areas of application of blockchain technology in higher education institutions in order to create optimal learning conditions in modern realities. The main approach of this study involves a combination of a systematic analysis of the factors of theoretical justification of the use of blockchain technology in universities with an analytical study of the technology itself in relation to the realities of the modern higher education system. The main results of this study lie in the definition of the main areas of application of blockchain technology in modern higher education institutions and the justification of the practical benefits of using this technology in the modern system of higher education. The prospects for further research in this area are determined by the spread of blockchain technology in the current higher education system and the need for a comprehensive study for practical purposes. The applied value of this study lies in the possibility of practical application of the results obtained in order to ensure a real return on the implementation of this technology in the educational process of modern universities.

Keywords: *Informatisation Of The Education System, Modern Digital Technologies, Higher School System, Organisation Of Training In Higher Education, Digitalisation.*

1. INTRODUCTION

At present, blockchain technologies are becoming one of the leading paradigms of the digital economy. Such technological solutions, constantly developing and modernising, penetrate into all new spheres of social and economic development [1-3]. In this context, the higher education system is no exception. In the modern world, there is a revolutionary transition from the informatisation of the main spheres of human activity to their digitalisation. Therewith, if informatisation involved the modernisation of certain types of human activities based on the use of communication and information technologies, then digital transformation (or

digitalisation) involves their qualitative transformation, a departure from the usual types and forms of activity to new ones based on the use of digital models and technological solutions [4].

Blockchain technology has aroused great interest in the academia. Security and privacy features allow the use of blockchain technology in many areas, as the approach to storing and processing large flows of information, BigData, is changing. All known databases are considerably outdated compared to the opportunities that open up with the advent of the development of new computer systems. In this context, the availability of blockchain technology and the immutability of information, as its main characteristics applicable in the higher education

system of the Republic of Kazakhstan, can provide substantial assistance in confirming the real qualifications of students and the authenticity of higher education documents [5].

In this regard, the current process of storing and issuing diplomas of higher education is extremely long and time-consuming. Numerous problems with fraud, forgery of real documents, identified in the practice of modern higher educational institutions of the Republic of Kazakhstan and a number of other countries, consider the use of blockchain technology as a solution to the issue of high-quality storage of higher education diplomas. In this case, higher education institutions that issue digital diplomas will use a single blockchain to store them. Unique diplomas signed with a private key will be provided directly to employers. Thus, verifying the authenticity of the diploma requires only a comparison with the hash stored in the blockchain. This would solve the problem of fraud in the field of forgery and the problem of document security [6-8]. Even considering that most universities are switching to digital information systems, blockchain will greatly speed up the operations associated with finding the information and will allow to fully and safely use electronic documents. From the practical standpoint, it will save crucial funds that could be used for improving the education process. Big amounts of information could be stored not on one centralized server, but on many working stations that already exist in universities. It is also worth noting that the frequency of cyber-attacks has only increased recently. Most likely, this activity is associated with the increasing digitization of critical information related to the management of universities and the desire to take possession of expensive patents and developments. Blockchain technology is the most important invention in recent decades, capable of completely turning over various spheres of life, including education. The blockchain constitutes a database comprising chains of consecutive transactions, which has specific, strict rules and provides the ability to access information. All this completely eliminates fraudulent actions, theft of personal data, protects property rights, etc. The principle of operation of this technology can be described, on the one hand, as a huge number of spreadsheets combined in a common database, on the other hand – as a group of registries that allows ordinary users to change the base code and observe the general passage of the transaction process. This principle is really easy to use, which allows working in this database without intermediaries [5].

In the realities of the higher education system of Kazakhstan, blockchain technology can become a standard for scientific publications, data and media files that are associated with these scientific articles. This technology can be effectively used as a universal cataloguing system and library of scientific papers. Furthermore, the economic functions of the blockchain can significantly facilitate the purchase of digital copies of these scientific papers, since each such paper would be equipped with its unique QR code or bitcoin address, which would allow users to avoid registration on the websites of publishers. In addition, the teaching staff of universities in Kazakhstan would have the opportunity to use blockchain technology to detect plagiarism in scientific papers and block it, a smart contract or a decentralised autonomous organisation that performs a literature search and automatically cites all related studies would save a lot of time. To implement this functionality, one can use document stores located outside the distributed log of records and links to such documents by the blockchain key [5].

Thus, the use of blockchain technology opens up great opportunities for the teaching staff of universities in terms of storing and systematising educational information, as well as opportunity to optimise usage of IT resources and improving educational process.

2. LITERATURE REVIEW

The use of blockchain technology in higher education institutions occupies a prominent place in the research of authors who engage in scientific developments in the field of modern technologies and their place in modern life in general and in the system of modern higher education in particular. Thus, T. M. Shamsutdinova, considering the problems of using blockchain technology for issuing digital diplomas in her scientific study, notes the following: "At the moment, there is information on several successful examples of issuing digital diplomas and certificates with the use of blockchain technology. The Massachusetts Institute of Technology (MIT) was one of the first to announce that it has issued more than a hundred digital diplomas as part of its pilot project" [1]. For their part, the team of authors represented by D. A. Kirillova, N. S. Maslov and T. N. Astakhova, assessing the prospects for the introduction of blockchain technology in the modern education system, points to the fact that "Blockchain gives the entire humanity the opportunity to optimise the most diverse spheres of life. One of the advantages of this

technology is that it is almost impossible to hack and there is no need to involve third parties. The entire principle of operation of the blockchain is based on mathematics and cryptography. Over time, the blockchain will be implemented in all spheres of activity, including education" [6].

Furthermore, the team of authors points out the clear advantages of blockchain technology in comparison with conventional methods of preserving university graduates' diplomas. In their opinion, "even if the institution that issued the diploma is closed or the education system has collapsed, the diplomas would remain in the distributed database of the blockchain. In addition, there is no need to spend additional resources to verify the authenticity of the document through intermediaries, the employer can directly verify the diploma in the blockchain" [6]. In turn, S. D. Karakozov and A. Yu. Uvarov, exploring the application of the technology under study in the higher education system, draw the readers' attention to the fact that "...in modern conditions, the development of digital technologies involves the support and development of both existing conditions for the development of promising end-to-end digital technologies and platforms, and the creation of new ones" [4]. The authors also note that "artificial intelligence is already represented on the market by developments in the segment of adaptive training software. All of them are made by innovative commercial structures, are widely advertised and cause a public stir" [4]. Also S. D. Karakozov mentions the possible unreliability of the blockchain due to the need for all participants to adhere to the same "rules of the game", but the applications developed by the authors will fully satisfy the security needs of educational institutions given their decentralization and communication principles.

L. S. Pobedin, in his study of blockchain technology as the basis of document management automation in higher education, addresses the fact that the use of this technology contributes to the improvement of the document management system in modern higher education institutions. According to the researcher, "the analysis of the existing document management systems of a number of national universities has led to the conclusion that the level of informatisation of processes directly related to pedagogical activities in higher education institutions can currently be described as relatively low... an effective approach to solving the above problems can be the creation and application of a new generation of electronic document management systems based on the most promising information

technology at the present stage – blockchain [9]. Based on this highly specialized work, the authors were able to highlight for themselves the key points regarding the organization of effective workflow in the blockchain system.

Thus, the use of blockchain technology in the system of modern higher education as a new, effective tool for automating processes is actively studied by modern scientists, and this determines the importance of the issue under study and the need for its subsequent in-depth investigation. The researchers' discussion of various aspects of the theoretical justification of the need to use this technology contributes to its detailed study and improvement of the details of practical use. Thanks to the above studies, it is possible to put together an overall picture of the necessary methodological base and processes for which the new technology would be most suitable. And even though individual applications can work perfectly, all solutions must have synergy with each other.

3. MATERIALS AND METHODS

This study aims to investigate various aspects of the use of blockchain technology in higher education institutions. The study investigates the main areas of application of this technology in modern universities and provides a theoretical justification of the need for its practical use in the system of modern higher education.

The main methodology of this study involves a combination of a systematic analysis of the factors of theoretical justification of the use of blockchain technology in universities with an analytical study of the technology itself in relation to the realities of the modern higher education system. The theoretical justification of the effectiveness of the use of blockchain technology in the system of modern higher education is necessary to highlight various aspects of the functioning of this system, as well as to explore the possibilities of its optimal, effective application in the system of higher education in the current modern conditions. The analysis of blockchain technology, in relation to the realities of the current system of higher education, organically complements the theoretical justification of the effectiveness of its application, which is extremely important from the standpoint of analysing the effectiveness of the introduction of blockchain technology in the system of modern higher education. In the course of this study, a considerable amount of information was taken from publications in foreign scientific sources that published the studies of modern researchers in this

subject area. To facilitate the perception of information and to create the most objective picture of this study, the entire volume of information taken from foreign sources and provided in this study has been translated into English. The chosen methodology of this study contributes to the most objective and qualitative disclosure of its subject matter, in the context of studying the need to introduce blockchain technology into the system of modern higher education in terms of improving the functioning of various areas of higher education institutions and using the latest information and digital technologies in university practice.

The modern system of higher education requires the introduction of the latest technological solutions in order to maximise the quality of its functioning and create optimal conditions for subsequent technological development. In this context, blockchain technology acts as a modern technological solution to many problems facing the system of modern higher education; therefore, the optimal choice of the methodology of its study is of great importance in terms of obtaining the expected practical result. The main areas of application of blockchain technology in the modern system of higher education through their system analysis are covered as objectively and fully as possible, which, combined with the analysis of the main advantages of this technology, determines the qualitative creation of an overall picture of this study in terms of the application of this particular methodology. The materials on which the course of this study is based determine the scientific developments of Kazakh and foreign scientists in the field of modern digital technologies and the features of their practical use in the practical activities of modern educational institutions. In general, the chosen combination of materials and methods of this study fully meets the tasks set and can be successfully used in the future upon research on the practical application of modern

digital technologies in the system of modern higher education.

4. RESULTS AND DISCUSSION

The study of the general issues of the use of blockchain technology in modern higher education institutions has led to the following results. Blockchain technology involves building a consistent, continuous chain of blocks that contain certain information according to certain rules. Each such block contains its hash sum, as well as a similar hash sum of the previous block; in addition, the blocks are linked by a certain numbering. Any changes to the information in the chain change the hash sum parameters. To comply with the chain building rules, any changes to the hash amount are registered in the subsequent block, while its hash amount changes, and the previous blocks are not affected. The storage of the specified block chains, as well as their copies, is performed on a set of computers that are independent from each other [10-13]. In relation to the modern system of higher education, the use of blockchain technology can affect many areas of activity of higher education institutions. The main such areas should include:

- implementation of distributed registry technologies, for the purpose of secure storage of information, as well as its rapid transfer to the destination;
- automation of management processes in higher education institutions;
- improvement of the effectiveness of targeted management of the course of scientific research conducted in higher education institutions.

The scheme of practical application of blockchain technology in relation to the procedure for the development and issuance of a higher education diploma is presented in Figure 1.

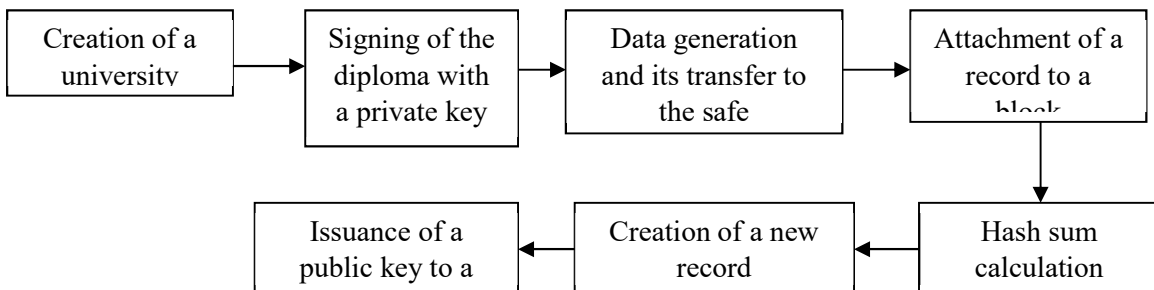


Figure 1. The scheme of the blockchain technology in relation to the procedure for creating and issuing diplomas of higher education

In the event that higher education institutions switch to the system of registration of higher education diplomas in the blockchain, each potential employer would be able to easily verify the fact of training of an employee in a particular educational institution. Furthermore, such information would be useful for investors looking for promising graduates, as well as for higher education institutions themselves, for making decisions on repeated credits of programme disciplines to individual students in cases when they change places of study [14-16]. In addition, the use of blockchain technology substantially simplifies the procedure for moving students from one university to another, since there is no need to provide documents about their education on paper, because all information is stored digitally. First and foremost, a digital file is created, which contains the basic

information: the name of the higher educational institution, the student's passport data, the date of issue. The content is then signed using a key that only the university administration has access to. The network node confirms the data, after which it is transmitted to the network and the record is attached to the block.

The educational institution generates a hash sum, which constitutes a set of numbers and letters, and its function is to verify the integrity of the content of the diploma. Only one possible combination of numbers and letters corresponds to a particular digital file, changing it will create a new hash sum. The presented Figure 2 schematically reflects the main areas of application of blockchain technology in the higher education system of the Republic of Kazakhstan.

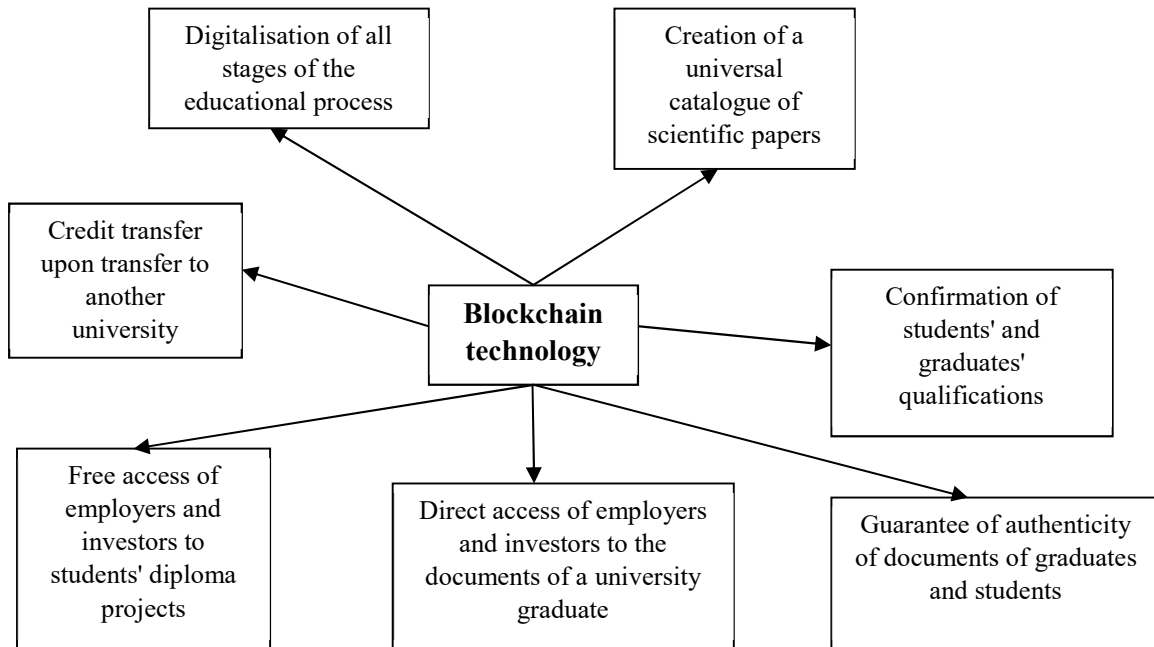


Figure 2. The main areas of application of blockchain technology in the higher education system of the Republic of Kazakhstan

Blockchain technology involves the creation of a distributed data storage system, where devices are not connected to a common server. In such a database, an ever-increasing list of ordered records (blocks) is stored, each of which has its label and a link to another block. With encryption, the user can change only that part of the data which they have the keys to.

Application of blockchain technology in the context of modern higher education contributes to the increase in the popularity of online education, which would substantially reduce the unemployment

rate worldwide and facilitate employment, since the diplomas contained in the blockchain are valid and legitimate, thereby legitimising online education in the future.

Among other areas of use of blockchain technology in higher education institutions, the following should be noted:

- Financing of research and development projects with the allocation of grant funds and tracking the sequence of contract performance.

– Collection, storage, and distribution of data for its intended purpose with the ability to quickly search for them (scientific information, specific publications on specified subjects).

- Review of scientific papers.
- Copyright protection of scientific papers.

The system of distribution of grants for scientific studies is one of the most relevant, potential areas of use of blockchain technology. The allocation of grant funds requires the conclusion of a complex contract with many components; therefore, it is necessary to clearly identify its terms and responsibilities for their implementation. It is also mandatory to provide interim and final results of the work performed. The fact that such conditions are met is decisive for the transfer of the agreed amount of funds. The regulation of all the provisions of the contract with the help of blockchain technology ensures the automatic operation of the system and eliminates its possible failures. Blockchain technology as a means of collecting and storing information at all stages of research is of great importance in working with empirical data. The technology under study would provide uninterrupted access to such data at any stage of the work. There is no need to wait for the results for a long time, they are used immediately for analysis and refinement. Blockchain technology provides reliable protection

of property rights to information of any kind, which in this case is impossible to forge. Blockchain technology opens up new opportunities for the implementation of the procedure for reviewing scientific papers. The use of this technology positively solves the issue with the quality of the review and allows putting forward the payment terms. According to experts in this field, the blockchain allows creating a permanent connection between the author of a scientific paper and the reviewer. The use of blockchain technology in reviewing scientific papers allows evenly distributing the load between researchers and control the results in the open access. Blockchain technology makes the procedure for confirming the authorship of scientific papers as transparent as possible. All actions performed in the network are continuously recorded due to the use of the technology in question. An example of such a network is a team of project developers who record their developments in a particular interface. The blockchain eliminates the possibility of unauthorised edits and adjustments to previously entered data without the consent of other project participants.

Figure 3 demonstrates the scheme of functioning of the blockchain technology in relation to the order of procedures for the diploma defence and subsequent employment of a graduate of a higher educational institution.

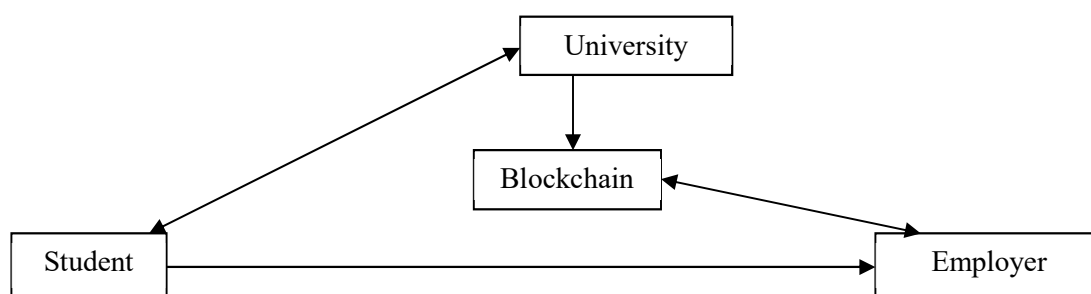


Figure 3. The scheme of functioning of the blockchain technology in the university

Diplomas signed with a unique key are sent directly to a potential employer; therefore, verifying their authenticity requires only a comparison with the hash stored in the blockchain. Each diploma gets into the database immediately after its defence and access to it is exercised via a public key. In addition, the key is received by the graduate after the defence of the diploma. Thus, the blockchain technology provides secure storage of the data of theses and access to them by particular persons, if necessary. Currently, application of blockchain technology in the higher education system is capable of taking the system of data storage and management of

information arrays, with which employees of higher education institutions deal on a daily basis, to a new level.

To date, blockchain technology is quite common in the system of higher education institutions and other spheres of public activity in foreign countries, but it is still underdeveloped in the countries and system of higher education institutions of the post-Soviet space. A consistent study of the advantages of this technology over existing, often outdated methods, followed by its implementation in the practice of modern higher education institutions,

allows gradually developing a reliable system for storing and managing databases of modern higher education institutions, which would have a positive impact on the development of the modern higher education system in general.

The use of blockchain technology in the higher education system constitutes a subject of lively discussion among researchers involved in the development of this area. Thus, T. M. Shamsutdinova notes the following in her studies: "blockchain technologies open up wide prospects in improving the concept of e-learning, taking into account the current requirements of the digital economy. These technologies can conceptually change the storage system of data archives, increase the reliability of information protection against forgery, and significantly speed up the execution of requests for information and data processing" [1]. The team of authors represented by D. A. Kirillova, N. S. Maslov and T. N. Astakhova, studying the prospects for the introduction of this technology in the modern education system, addresses the underdevelopment of this technology in the universities of the CIS countries. According to the authors, "at present, application of blockchain technologies in educational organisations is at the experimental stages. But there are already universities that have launched pilot projects to implement blockchain technology, such as the Massachusetts Institute of Technology and the University of Nicosia in Cyprus" [6]. This leads to the need for a deeper study of the blockchain technology in order to implement it in the practice of universities. S. D. Karakozov and A. Yu. Uvarov, upon exploring the possibilities of the technology under study, note the following: "in the field of education, there are many different tasks where blockchain technology can be successfully used. Like any ledger, the blockchain is only a tool. There are still open questions: what actual problems of education can be solved with the help of this tool apart from the purely organisational ones" [4].

In turn, L. S. Pobedin, in his study of the possibilities of practical application of blockchain technology as a method of automating document flow in higher education, points out that "thus, the introduction and application of modern blockchain technologies in the university document flow system opens up another innovative and promising area for solving the main task of modern higher education – improving the level and quality of professional education" [9]. The team of research scientists represented by O. V. Bychkova, I. K. Evseeva and R. V. Malyushkin, upon assessing the prospects of

the blockchain technology in the educational environment, note that "for the correct organisation of the science system through the blockchain platform, it is necessary to create an ecosystem that includes as many participants as possible, and preferably – to cover all those involved in the process, since only large-scale participation allows fully realising the potential of the new technology. The main idea of the blockchain is the functioning of a single ecosystem" [17]. The authors also draw attention to the fact that "in individual cases, the technology can also be successful, but ideologically it would not make sense, whereas in large systems, the use of blockchain becomes a necessity. But this principle turns out to be difficult to implement if the main ideological foundation of the new technology is implemented – blockchain decentralisation" [18].

The features of blockchain technology in general and in the context of the possibilities of its practical implementation in the higher education system are actively discussed in the studies of foreign scientists who engage in scientific developments within the framework of this subject area. Thus, in their joint research, S. Krishnan, V. Balas, J. Golden, T. Robinson, R. Kumar note the following: "today, blockchain technology is actively used in the banking sector, retail trade, education, industry, and other areas in order to improve the existing business methodology. Blockchain prevents double spending on financial transactions without the need for a trusted authority or a central server. It is a decentralised registry platform that simplifies verifiable transactions between parties in a secure and intelligent way" [19]. The same team of authors in another study addresses the fact that "blockchain technology is actively used in Western European countries in banking and insurance, as well as gradually infiltrates the education system. In the future, sustainable blockchain ecosystems will have a substantial impact on the quality of intellectual life in modern cities, which necessitates further studies in the field of blockchain applications" [20]. For his part, J. Ducree notes that "blockchain technology has considerable potential for organising the processes that conventionally underlie academic science and the development of commercial technologies, including financing, project implementation, intellectual property creation, documentation, and publications" [21]. The same opinion can be traced in the study by the team of authors L. Marchesi, M. Marchesi, R. Tonelli, who are engaged in the development of issues of the development of blockchains. According to the researchers, "the initial idea behind the development of blockchains is that they can be used to automatically enforce

contractual obligations without having to trust a central authority and without space and time constraints. This leads to a high efficiency of the technology application in various spheres of modern society, such as banking and insurance sectors, industry, and higher education. In the latter case, the guarantee of data security upon implementing such a system is of great importance" [21].

Thus, modern researchers generally agree on the importance and significance of blockchain technology for the modern higher education system and the need for its comprehensive study in order to develop effective schemes for practical implementation in this industry.

The application of this technology provides modern representatives of university science to place their research in the open resources of the education system, with the recording of all the links used. Such a scheme allows legally recording the date, time of publication and the author's rights to it, and also guarantees reliable copyright protection in accordance with the current legislation [22]. Furthermore, it is possible to remotely track all the facts of repeated use of any remote Internet resource on which the published scientific papers are located [23]. The use of blockchain technology in higher education institutions allows taking the document management system of a modern university to a new, much better level. This technology allows ensuring the reliable preservation of any information on various aspects of the curriculum and on students: educational, curriculum disciplines, the sequence of presentation of educational material, the volume of study of academic disciplines, the competences achieved in the learning process, and much more. This would allow a potential employer with remote access to such information to select future employees of their organisation in advance, proceeding from the data provided, with the possibility of a comparative assessment of the presented competences of graduates of higher educational institutions. Some researchers have presented the use of artificial intelligence, which can be an effective method to improve the quality of the blockchain network [24], however, in this study, the authors decided to leave this question open due to the complexity of the issue. The use of artificial intelligence would entail not only positive effects but also certain vulnerabilities. This study is considering the details of the development and application of new mechanisms related to blockchain technology. Based on past research, the authors have developed several practical applications that would be effective in the

realities of Kazakhstan educational institutions. All aspects of the use of the mentioned applications were considered both in normal and pandemic conditions, which qualitatively distinguishes this research from the past studies.

5. CONCLUSIONS

The study of various aspects of application of blockchain technology in higher education institutions has led to the following conclusions. Application of blockchain technology in modern higher education institutions contributes to the creation of optimal conditions for solving many technological problems of higher education institutions. The most promising areas of application of this technology in the system of modern higher education are as follows: control and regulation of procedures for registering and issuing digital diplomas of higher education; creation and control of databases of information on particular areas of higher education; the ability to quickly search for the necessary scientific information or any other information relevant to the activities of the institution; control and regulation of the process of reviewing scientific developments; ensuring copyright protection for scientific papers. These are just some areas of practical application of blockchain technology in the modern system of higher education.

Notably, the practical use of blockchain technology in the system of modern higher education considerably expands the possibilities of blockchain distance learning in higher education institutions, which is of great importance in the context of the current epidemiological situation caused by the COVID-19 coronavirus pandemic and the transition of all educational institutions, including higher education ones, to distance learning. The current requirements of modern digital economy also determine the importance and relevance of distance learning. In general, the technology under study can change the existing concept of database storage, increase the reliability of information protection from theft and use for various purposes, as well as conduct various types of information fraud. In addition, the blockchain technology, when applied in the system of higher educational institutions, can substantially speed up the procedure for executing queries on existing databases by using a chain structure for connecting information blocks. All the problems that arise in this situation, both organisational and legal, as well as technical ones, can be successfully solved by creating a single information space, using all the information capabilities of the blockchain technology.

Limitations of the current study arise in problems related to the high cost of ensuring effective identity when large records are accepted into the public chain. Also, quality control of information recorded into blockchain may vary, as the system strives for transparency. To address these issues, additional research is needed. So, authors see great scientific value in the development of the current topic in the future.

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