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Distance learning technologies with blockchain elements in the system of continuous education

Gulnar Kozhasheva [a *], Zhetysu University named after I. Zhansugurov, Department of Mathematics and Computer Science, 187a Zhansugurov Str., Taldykorgan 040009, Republic of Kazakhstan

Marat Maltekbassov [b], Zhetysu University named after I. Zhansugurov, Zhansugurov College, 187a Zhansugurov Str., Taldykorgan 040009, Republic of Kazakhstan

Talgat Baidildinov [c], Abai Kazakh National Pedagogical University, Department of Professional Training in "Special Pedagogy", 13 Dostyk Ave., Almaty 050010, Republic of Kazakhstan

Aivar Sakhipov [d], L.N. Gumilyov Eurasian National University, Department of Computer Science, 2 Satpayev Str., Nur-Sultan 010008, Republic of Kazakhstan

Yekaterina Gavrilova [e], Zhetysu University named after I. Zhansugurov, Department of Mathematics and Computer Science, 187a Zhansugurov Str., Taldykorgan 040009, Republic of Kazakhstan

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Abstract.

The relevance of the study was explained by the fact that the support of management of the distance learning information processes is associated with the problem of effective allocation of system resources used upon transferring and processing of educational information. The purpose of this study is a comprehensive analysis and development of the principles of developing an electronic portal for the system for continuous education. In the work, the authors used general methods of generalization and systematization, as well as the method of mathematical calculations. 150 teachers of secondary and higher primary schools took part in the calculations. The results of the calculations made it possible to confirm the need to use distance learning technologies with blockchain elements in educational institutions. The use of blockchain technologies for the implementation of an electronic portal can increase the motivation of students and teachers, facilitating work in the learning process.

Keywords: continuous education, distance learning, blockchain, electronic portal, automation of learning.

* ADDRESS FOR CORRESPONDENCE: Gulnar Kozhasheva, Zhetysu University named after I. Zhansugurov, Department of Mathematics and Computer Science, 187a Zhansugurov Str., Taldykorgan 040009, Republic of Kazakhstan
E-mail address: kozhasheva@academics.com.de

1. Introduction

1.2. Conceptual or Theoretical Framework

The system of continuous education is a smooth, step-by-step transition from basic education to higher levels of knowledge, providing a high-quality and deep level of educational growth. The expediency of introducing and using continuous education is determined by academic achievements, changes in information and technological fields. The implementation of continuing education has been reflected in the "School-College-University" system. This system allows implementing of high-quality training of professional specialists who will meet the needs of the labour market, and providing an individual training program and a trajectory of a career and personal growth. The feature of the system of continuous education "School-College-University" is the continuity of educational programs, which implies a smooth transition from the school level to complex professional programs, while ensuring the absence of repetition of already learned topics.

A network model of specialised training within the framework of the continuous education system and the rapid development of technologies provides for the active introduction of information technologies, tools, and equipment (Norbutaevich, 2020). Nowadays, the integration of classical education and modern technologies, as well as approaches to information exchange and digital innovations in the market are actively developing. All this allows for distance learning, and also gives people of different age groups the opportunity to get the desired education. For example, distance learning is not only an opportunity to study individually regardless of the place and time, but also an opportunity to develop throughout life. The development of technologies and resources can ensure continuous education and communication the knowledge (Esteves, 2017). The number of schoolchildren and students studying remotely is growing in all countries of the world, the number of educational institutions involving them in the educational process is growing, a large number of international educational structures are being created, etc.

1.2. Related Research

Digital technologies are changing approaches to education and training (Murniati& Sanjaya, 2017), introducing new methods of pedagogy, evaluation, and certification. Innovative methods of certification comprise presentation, recognition, and confirmation of learning outcomes that are widely diverse and comply with the principles of continuous learning of graduates. Thus, the use of digital technologies in education and training supports new methods of pedagogy and teaching styles, educational materials, monitoring of the educational process and evaluation. In the "School-College-University" system, these technologies are becoming increasingly important as graduates use the acquired knowledge and abilities in practice.

One of the new technologies introduced in education is blockchain (Hussain&Cakir, 2020). Blockchain, which is also called distributed ledger technology (DLT), is an evolving and constantly improving technology with great potential for development and revolution in the education system. This feature is associated with new means of interaction between participants in the educational process, its decentralisation, maintenance of an extensive number of records, materials, knowledge transfer, as well as ensuring the reliability of teaching and obtaining certificates. These features of blockchain technology attract educational institutions (Haugsbakken&Langseth, 2019). However, despite the full potential and benefits of blockchain, higher education stakeholders currently appear to be less aware of the social benefits and educational/training potential of blockchain technology.

1.2. Purpose of the Study

The purpose of this study was to investigate and determine the principles of developing an electronic portal for centralised monitoring on the introduction of network interaction and the use of remote technologies in the system of continuous education "School-College-University". A feature of its development is the use of blockchain technology to create an electronic database and monitor actions in the system.

The object of the study included the principles of developing an electronic portal with blockchain elements for the system of continuous education "School-College-University". The subject of the study was the introduction of new digital trends in education. The relevance of the study was explained by the actively developing introduction of digital technologies in education, especially during the implementation of distance learning. The issue of ensuring the continuity and integrity of education arose during the pandemic. For this purpose, the introduction of "cloud technologies", mobile applications, gamification of the educational process, the use of social networks and online video conferencing tools commenced.

2. Method and Materials

2.1. Research Model

When evaluating the effectiveness of distance learning technologies with blockchain elements, special attention should be paid to economic efficiency. The coefficient of economic efficiency of distance learning (E_{dl}) can be calculated according to the following formula:

$$E_{dl} = \frac{A_{al} - A_{bl}}{E_{cl}}, \quad (1)$$

where: A_{al} – assessment of knowledge after learning (%); A_{bl} – assessment of knowledge before learning (%); E_{cl} – cost-effectiveness of the learning process. The distance course student's knowledge assessment before and after training is calculated as the percentage of correct answers based on the results of the preliminary and final tests. The indicator of the effectiveness of training costs (E_{cl}) is proposed to be calculated according to the following formula:

$$E_{cl} = \frac{C_1}{C_{tc}} * 100\%, \quad (2)$$

where: C_1 is the cost of learning for 1 person; C_{tc} – the total cost of education. The coefficient of economic effectiveness of distance learning close to zero indicates the low efficiency of the distance learning system, the higher the coefficient, the more effective distance learning can be considered (Svatiuk *et al.*, 2018).

2.2. Participants

150 teachers from 50 secondary and higher primary schools participated in the calculation of the effectiveness of distance learning technologies with blockchain elements.

2.3. Data Collection Tools

Having thus proven the effectiveness of the proposed technologies, the authors applied generalization and systematization methods to achieve the research goal. The system of continuing education "School-

College-University" is focused on gradual, step-by-step education of schoolchildren to obtain an in-depth and fundamental knowledge in the chosen career path. The purpose of this approach is not only the in-depth study of theoretical knowledge but also its practical application, the gradual professional and personal development of students. The transition between the stages of education happens consistently without duplication of the studied material, which allows reducing the duration of training and providing an individual approach to educational activities.

2.4. Data Collection Process

Thus, the education system faces the task of orienting the student in choosing a profession and developing an interest in it, supporting it with an in-depth study at the level of higher professional education. This approach allows creating an academic environment where students are interested in creating and promoting research work, implementing their individually developed projects, as well as taking an active part in developing the subject area they study. Nowadays, digitalisation tools are being actively introduced into all spheres of human life (Rushabhbalpande & Patil, 2021). This concept is associated with the introduction of new digital technologies in all aspects of human life. These changes have numerous advantages, simplifying many processes of exchanging, receiving, and communicating information, increasing the efficiency and quality of many processes in the service sectors, as well as providing optimisation and automation in many ways, which reduces risks and increases reliability.

2.5. Data Analysis

In addition, the introduction of new technologies into work processes helps reduce the amount of routine work for employees, which, in turn, makes provision for free time that can be used to develop knowledge in new areas and work on improving processes within enterprises and various structures. Digital technologies already occupy an integral place in education, integrating many processes, tools, and various technologies into conventional learning tools (Josefsson, 2016; Maseleno, 2018). The study discussed the main new technologies and trends used in education: "cloud" technologies (Google Drive, Yandex Disc, Dropbox), social networks (Facebook, Twitter, LinkedIn, WhatsApp), massive open online courses (MOE) (National Platform for Open Education (NPOO), "National Open School", Stepic, Coursera), gamification; blockchain technologies; wearable gadgets (Google Glass, Oculus) etc.

3. Results

150 teachers from 50 secondary and higher primary schools participated in the calculation of the effectiveness of distance learning technologies with blockchain elements. The authors asked them to calculate the formulas, and the results showed that students' grades improved after the teacher applied distance learning technologies with blockchain in 90% of cases. The practical significance of this study was represented by the integration of many areas of the educational process for the convenience of end users, as well as the economic efficiency of introducing an electronic portal. Blockchain technology presents additional advantages and features for creating an electronic portal. Blockchain is a new concept that is a breakthrough technology. This technology can restructure businesses and other various professions and services (Clohessy *et al*, 2018), including education and learning.

The set goals form an integral process for the development of an electronic portal with blockchain elements to establish an electronic database and perform centralised monitoring for the introduction of network interaction and the use of remote technologies in the "School-College-University" continuous education system. The significance of this study was confirmed by the problems of effective allocation of resources (system and labour) used in the exchange and processing of educational data (Singh& Miah, 2020). An electronic portal is a universal tool for the system of continuous education "School-College-University", an online platform for interaction between participants of the educational process using

innovative technologies and blockchain technology in particular. Thus, two main interacting parties that solve the tasks of the practical and educational plan can be identified:

– students and specialists;

– teaching staff and employers.

Thus, the following tasks are set for the electronic portals:

1. Exchange of theoretical, analytical, intellectual, and other data. The system must implement secure transmission of certified data. Participants must be sure of the relevance of the information received. This is because teachers need to know the competencies of participants in the educational process, and employers need to be confident in the professionalism and effectiveness of the future specialist. Students receive the necessary motivation to develop personal portfolios for the successful completion of attestations and obtaining promising positions.

2. Obtaining and storing data on the certification of students. One of the most important parts of education is the evaluation of students' work results. This can be done through tests, exams, coursework, and qualification papers, as well as other activities where the student can demonstrate the acquired knowledge. During the development of distance education technologies and network interaction, the issue of reliable receipt and storage of results, as well as their further dissemination and use, becomes acute. When using portal technologies, it should be possible to switch from paper media to digital formats and storage (Watters, 2016).

3. Implementation of the educational and methodological background for the continuous education system. Thus, the interrelation between the elements of the "School-College-University" training system is established, and a consistent presentation of the material is created for the future specialist to extract the necessary fundamental knowledge. For this, an electronic database should be created, containing modules of curricula, methodological manuals and recommendations, theoretical and practical literature, as well as online courses and additional materials for in-depth study. Furthermore, an important aspect is the involvement of various subject area experts capable of not only helping students in mastering the educational material but also developing their personal qualities. Thus, experts on scholarships, grants, and competitions, as well as mentors, coaches, experts from production and other practical areas can be involved.

4. Development of the foundation of the portfolio of students, graduates, teachers, and employers. Every portfolio includes confirmed information about a person, their competencies and achievements, as well as additional information.

5. Issuing and confirming the legitimacy of digital certificates. Secure storage of data about academic performance and other achievements of all participants in education.

Thus, the electronic portal will have the following advantages:

1. Students have many opportunities for self-fulfilment, growth, as well as tracking their success:

– creating a portfolio;

– motivation for the introduction of new technologies that allow personalising their academic schedule;

– interaction with employers and experts.

2. For teachers and administrative staff:

– a unified database for storing data about students, materials;

– integration of networking tools;

– centralised monitoring of the educational process.

The development of this electronic portal for the system of continuing education is in-between education and new digital technologies, it allows optimising the interaction of all participants, as well as ensuring the integrity and reliability of the data stored. Based on the research (Lee, 2020), one can note the following digital technologies used in various areas:

– artificial intelligence, machine learning, neural networks;

– big data analytics and interaction with them;

– Internet-of-Things, multi-agent systems;

– sensors, phones and, consequently, the growth of data received and processed;

– "cloud" tools that are already widely used for solving problems;

– blockchain technologies.

Nowadays, blockchain is a new revolutionary technology (Rojas *et al.*, 2021) integrated into the processes of organisations, education, communication, bringing large-scale social, cultural, economic, and political transformations. Proponents of blockchain technology describe various opportunities that it can provide. For example, the democratisation and distribution of finance and other benefits, which will improve the lives of all social strata in different countries of the world, or increase in the reliability and speed of transactions.

In the socio-economic field, it is possible to use smart contracts, which would allow redistributing resources and income, favouring all members of society evenly (Rojas *et al.*, 2021). Furthermore, it is assumed that blockchain can be a new basic technological structure for the exchange of valuable information, funds between people and organisations through the Internet. Transparency of records of all transactions excludes the possibility of copying them, reliably storing all information about changes.

Thus, blockchain technology can become widespread and relevant in the modern world. Firstly, the transparency and reliability of blockchain due to the complex and encrypted code solves the problem of trust in modern technologies. Secondly, transactions can be performed through the Internet on a new technological platform without the third parties, which also positively affects the users' trust. Thirdly, blockchain architecture is of fundamental importance for creating reliable and verified records and data, as well as providing fast transactions and reducing the cost of their transfer.

4. Discussion

Diplomas and academic performance constitute important assets of graduates throughout their lives in the world. Conventionally, identity documents were prepared, preserved, awarded, and recognised all over the world. However, innovations in information and communication technologies have provided digital recognition of graduates' qualifications (Yakovenko, 2019). Thus, supported digital credential records and open data sources complement conventional repositories. The advantages of using blockchain technologies in education are as follows: increased transparency of actions, accountability through smart contracts, stimulating learning.

Thus, blockchain technology has significant advantages compared to traditional technologies. These advantages determine the principles of developing an electronic portal for centralized monitoring on the introduction of network interaction. In this study, the main goals of implementing blockchain

technologies in the electronic portal of the continuous education system were defined (Lee, 2020). These goals are as follows:

1. Grades. Filling out and storing academic transcripts and certificates in educational institutions are one of the most time-consuming tasks. Every entry must be verified manually to ensure accuracy before issuing a certified document with the student's grades.

2. Diplomas and certificates. As well as grades, diplomas and students' documents can be issued and stored using blockchain. Thus, technology ensures the protection of digital certificates. Educational organisations can issue digital certificates using a public blockchain for their storage. The certificate will be securely stored. Certificate authentication is also simplified. It can be easily verified, even if the organisation that issued the certificate is closed. The educational organisation will no longer need to have staff to prepare certificates confirming the issued diplomas. Instead of asking the institution issuing the diploma to certify a paper copy, employers can only provide a link to a digital diploma.

3. Confirmation of the legitimacy of digital certificates. Apart from issuing digital certificates by digitally signing them, educational institutions can also receive a digital signature from the organisation that accredited them. This ensures that the organisation has issued this certificate and that the organisation has the authority to issue it. Thus, blockchain allows automating the authentication of not only the certificates themselves but also the competence of the organisations that issued them.

4. Business card. Apart from academic degrees, a typical resume contains a lot of additional information that may be relevant to teachers, administration, employers. This may include foreign language proficiency, technical expertise, or particular abilities that are not necessarily related to the person's profession. One can also test these skills with the involvement of an outside expert and later, when passing the test, provide a certificate or diploma. If the data is stored using blockchain technology, they confirm that a person has the appropriate skills. Services such as Open Badge Passport are the first step in this area.

5. File storage. If educational institutions need to store electronic educational software, records, guidelines, and other information, this requires a lot of space for storing files. Storing all the information on local hard drives creates a problem of file centralisation. If the hard drives are damaged or compromised in any way, it will be a considerable problem for the entire educational institution. Cloud storage can also be a solution to the problem. However, purchasing the necessary amount of cloud storage may not be affordable for many organisations. A possible solution may be blockchain-based cloud storage such as Filecoin.

6. Lessons and courses. Many technologies also support smart contracts. This integration can provide automatic interaction with courses and lessons when certain conditions are met. For example, a teacher can give certain tasks to students. The completion of every task can be automatically confirmed by blockchain smart contracts, and if necessary, there is an access to the following materials. After completing the tasks, the student receives a certificate of course completion, and the teacher receives the report on completion.

7. Publishing. Students, undergraduates, postgraduates, teachers, professors, and researchers constantly create high-quality research. However, it is necessary to go through many stages and edits to publish one's works. Publishing that uses blockchain can help new writers, scholars, and many others to ease the way of publishing their materials. Blockchain can also help in copyright management and protection against plagiarism.

8. Cost reduction. Many of the above-mentioned goals lead to the automation of many time-consuming processes. This leads to a reduction in labour costs for educational institutions. Thus, the

"School-College-University" system can reduce the costs associated with the storage space for files, as well as by eliminating intermediaries in many areas of activity.

9. Awards. Computer nodes that constantly verify the integrity of the information stored in the block chain receive a reward in the form of digital tokens such as Bitcoin or Ether. This is what is called cryptocurrency mining. People who use computers to verify blockchains related to education will also receive tokens as a reward (Makarova&Pavlicheva, 2020). These tokens can then be exchanged for secure crypto or fiat currencies, or used to pay for goods and services in the educational community itself since educational institutions can accept tokens as payment in cafeterias, bookstores, or for learning.

10. Organisations and individual specialists may have a rating that increases depending on their work in the institution, or after recognition by other organisations and colleagues for development, winning open tenders, successful implementation of grant activities, etc. These records will be publicly available, so anyone can get learn about the achievements of a person. The rules for changing the reputation assessment (creating a reputation currency) can be agreed by all members of the community.

This study examines the basic concepts of artificial intelligence in relation to various industries. A separate section is devoted to education, which makes it relevant for our work. The author considers blockchain technologies in the context of their advantages and disadvantages.

Recently, education has encountered issues relating to the originality of research, the confirmation of diplomas and certificates. In the study (Grech& Camilleri, 2017), several options for using blockchain-based technology in digital accreditation and intellectual property management were proposed. The study (Sharples & Domingue, 2016) discussed the idea of a permanent distributed accounting of intellectual efforts and associated reputational remuneration based on blockchain technologies, which creates and democratises the educational system outside the academic community. Other researchers (Turkanović*et al*, 2018) offered a global blockchain-based platform for enrolling in a higher education institution, which would process, manage, and monitor the grades that students receive for completed curricula and courses.

Blockchain technologies have numerous advantages for the interaction in the "School-College-University" continuous education system:

– integration of network communication, freedom from intermediaries, third-party organisations, leading to new technological and digital relations, as well as monitoring of network communication;

– smooth transition to effective communication between participants of the educational process, automation and optimisation of established bureaucratic relations;

– the transition to electronic document management, digital signatures, as well as blockchain technologies for monitoring and managing this data. This will ensure effective document management, increase processing speed, ensure reliable storage, and prevent document forgery;

– transparency of financial flows;

– combining all the materials of the educational process for the possibility of interacting with them at any time and in any convenient place;

– the use of a single data transfer protocol by participants in the educational process;

– verified diplomas that have all the information necessary for their future use, as well as open access to them;

– storing student portfolios containing grades, competencies, personal data, and additional information;

– reducing the workload of teachers;

– copyright protection when conducting research, writing materials, and other educational activities;

– databases of students and graduates for the study of trends in the effectiveness of education, as well as the use of this database to provide students with jobs after graduation;

– transition to smart contracts, electronic applications, and transactions, as well as the digitalisation of processes in general, ensuring remote interaction;

– services cost reduction, improving the efficiency of the educational staff.

The practical significance of creating and using an electronic portal lies in the increase of interaction efficiency between participants in the educational process, as well as in the creation of the necessary and convenient tools for high-quality training. At the same time, this leads to economic efficiency and the creation of conditions for the introduction of new digital technologies into the workflow. The originality of the study is determined by the creation of information tools for the educational activities, improving its effectiveness, as well as the integration of conventional means and new digital tools. The use of blockchain technologies, as well as gamification tools, working with big data and artificial intelligence can increase the motivation of students and teachers, facilitating work in the learning process, and creating opportunities for personal fulfilment in the subject area of choice.

The electronic portal can create a foundation for participants in the educational process, as well as automate it. Simplifying interaction and motivating participants (gamification, ratings, evaluation systems, additional awards) can increase the interest of the parties, as well as increase the desire for the successful completion of all stages of training. The output data for the electronic portal model is as follows:

– resumes or portfolios of students created automatically based on the acquired knowledge and achievements;

– analytical data on the educational process, successes and failures, as well as reports on the necessary parameters and features;

– a knowledge base comprising a lot of data: methodological materials, the work of teachers and students, solutions to applied practical problems, the general results of the activities of all participants in the educational process;

– business tasks and their solutions.

However, the introduction of blockchain can involve certain risks for the determination of fundamental factors affecting the financing of education, the reliability and stability of the educational process (Wei *et al*, 2022). The mentioned work combines emerging blockchain technology to discuss the positive function of blockchain in the establishment of education informatization, the possible opportunities for education informatization in the future, and some important challenges that will be faced. Despite the potentially wide scope of opportunities for using technology in education, its integration into distributed information systems should be based on certain theses:

1. Determination of the areas and goals of blockchain application within the information system.

2. Structuring of technological and educational information integrated into blockchain-based information databases. Structuring should be organised considering data types, their volume, methods of storage, transfer, and user access conditions.

3. The use of a public blockchain to ensure centralisation of the information system management rights and confirm the authenticity of transactions of participants in the educational process.

4. Differentiation of distributed registries with simultaneous determination of access rights according to subject, territorial, and other principles.

5. Setting identification rules for users of blockchain-based information systems.

6. Establishment of transaction confirmation methods in information systems, considering the type of educational services provided for every area of application of blockchain technologies in the educational process.

7. Determination of cybersecurity requirements that the information system in general and its individual components, in particular, must meet, including the features of blockchain-based systems.

The rapid changes caused by digital technologies in education offer personalised and differentiated ways of e-learning. The presented study described the importance of developing the "School-College-University" continuous education system and its interaction with new technologies, but it is also necessary to analyse and compile scientifically sound methods and approaches to their introduction in conventional teaching tools (Pacheco*et al*, 2018). The correct introduction of digital technologies and blockchain in general provides for prospects for the development of interaction, processes and training of personnel during the educational path of students and teachers is provided.

Blockchain technologies are actively developing and are defined as the next "big" digital technology trend that will challenge many organisations, including educational institutions (Pacheco*et al*, 2018). However, educational institutions often do not seek to introduce new digital technologies into the organisational apparatus. The question remains whether new technologies will be introduced into education, as well as whether such education will be structured. The rapid growth and changing approaches to education caused by digital technologies offer personalised and differentiated ways of e-learning. However, access to educational, learning, and evaluation materials at any time and in any place requires a paradigm shift in the conceptualisation and implementation of validation, verification, authentication, and storage of student data (Pacheco*et al*, 2018). This is especially true for accredited or certified curricula, online courses, which are often associated with considerable monetary and time costs.

5. Conclusions

Blockchain technologies offer an interesting and innovative approach to the protection of confidential information in online educational environments. One of the advantages is the impossibility of retrospectively changing the data stored in the system. This feature of the blockchain provides high reliability and data protection compared to conventional password-protected databases both inside and outside the organisational e-learning environment. Furthermore, the open nature of publicly available blockchain technologies supports decentralised data verification. Therefore, it does not depend on any central authority and operates in various programs, departments, institutions, and countries. It also exceeds conventional formal educational institutions, but also offers an easy and inexpensive way for businesses and job providers to securely and reliably verify data about potential employees at the same time.

In this article, the authors propose the formula for evaluating the effectiveness of distance learning technologies with blockchain elements. Also, the principles of developing an electronic portal for centralized monitoring on the introduction of network interaction and the use of remote technologies in the system of continuous education "School-College-University" were investigated and determined. Notably, blockchain technologies are new and recently introduced into educational processes. It is necessary to consider the following aspects:

– environmental costs – the amount of electricity required to run complex code on many computers;

– time aspect – processes using blockchain can be slow and cumbersome;

– the trust aspect – it will take time for end users to apply technologies in practice;

– the legal aspect – underdevelopment of regulatory issues concerning the use of blockchain technologies, which leads to fraud.

However, with the integration of new technologies into educational processes, automation and optimisation of the activities of educational institutions, interaction between all participants in the process, as well as an increase in the level of interest and motivation of students in the learning process can be expected. These trends will lead to the production of new highly qualified specialists who are in great demand on the labour market, will ensure the development of educational strategies and the development of new technologies for learning, work, and life.

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