IJMET_10_01_092.pdf

IAEME Publication

IAEME

International Journal of Mechanical Engineering and Technology (IJMET)
Volume 10, Issue 01, January 2019, pp. 886–897, Article ID: IJMET_10_01_092
Available online at http://www.iaeme.com/ijmet/issues.asp?JType=IJMET&VType=10&IType=01
ISSN Print: 0976-6340 and ISSN Online: 0976-6359

THE BLOCKCHAIN TECHNOLOGY AS A CATALYST FOR DIGITAL TRANSFORMATION OF EDUCATION

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ABSTRACT

The article reveals the concept of blockchain as a chain of blocks, distributed database, distributed registry technology, where there is no centralized regulator that could dispose of the blockchain at its own discretion, substantiates the need for the transition to modern technologies; features of blockchain technology that reduce energy and time costs for information processing; problems of transition to digital media in educational institutions,; blockchain technologies that require changes in management, management methods, financial management, specific people, infrastructure development. The current situation with the first experiments of using the new blockchain technology for the education system is considered. The risk analysis method of blockchain technology in education and the mechanism of its application are presented. Several directions of education development based on blockchain technology are offered.

Key words: digitalization of education, internet of things (IoT), digital educational environment, blockchain technology, digital transformation of education.

Cite this Article: Irina Yakovenko, Lyazzat Kulumbetova, Irina Subbotina, Gaukhar Zhanibekova and Kenzhegul Bizhanova, the Blockchain Technology as a Catalyst for Digital Transformation of Education, International Journal of Mechanical Engineering and Technology, 10(01), 2019, pp.886–897
http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=10&Type=01

1. INTRODUCTION

The modern world is constantly changing. Innovations are introduced into various spheres of human activity, which, on the one hand, orients people to continuous development, improvement of their knowledge, skills, competencies, mastering new activities in related sectors of the economy [1]. On the other hand, according Ziyadin, Madiyarova, Tlemissov, Akybayeva, Kurmangalieva, and Tastemirova's [2] research, routine work is increasingly transferred to machines, and it requires creativity, a willingness to cooperate with colleagues in the search for new solutions, and – most importantly – the ability to critically evaluate the information for accuracy, and from the point of view of its logical integration in the current task.

Today in the world there is a revolutionary transition from informatization of the main spheres of human activity to their digitalization. If informatization involves, in fact, the modernization of certain types of human activity with information and communication technologies, the digital transformation (or digitalization) involves their qualitative transformation, a departure from the usual types and forms of activity to new, based on digital models and technologies. At the state level the problem of the digital transformation was put in the President of Kazakhstan Nursultan Nazarbayev's Address to the Nation of Kazakhstan dated January 27, 2017 «The third modernization of Kazakhstan: global competitiveness» [3], and the mechanism of its solution set by resolution of the Government of the Republic of Kazakhstan from December 12, 2017 № 827 On approval of the State program "Digital Kazakhstan" [4]. The President of the Republic of Kazakhstan, N. Nazarbayev, in his traditional annual Address to the Nation of Kazakhstan on January 10, 2018, "New Development Opportunities in the Context of the Fourth Industrial Revolution" [5], noted that it is necessary to adapt the system of education, communication and standardization to the needs of the new industrialization. He also noted the need to develop and test new tools aimed at modernization and digitalization.

According to report by the World Economic Forum [6] on the Networked Readiness Index (NRI), Kazakhstan ranks 39th among 139 countries in the world; according to the results of the use of digital technologies – 64th place after Chile, Romania, Macedonia, Lithuania, Brazil, Turkey, Costa Rica, Armenia, Paraguay, Panama. The share of the digital economy in Kazakhstan's GDP is 0.6%. In the world with a developed market economy such as the UK, Japan, USA, the share of the digital economy in GDP increased from 2010 to 2017 from 4.5% to 5.6%. The UK is the leader in GDP growth from the use of the digital economy, in which the share of the digital economy has grown from 8.5% to 12.5% over the years. The process of digitalization today affects various sectors of the economy, such as industry [7, 8], oil and gas industry [9, 10], mining and manufacturing sectors [11], transport and logistics [12], tourism [13, 14], agriculture [15], etc.

The growing importance and relevance of the problem of digital transformation led to the choice of the research topic.

2. LITERATURE REVIEW

The term "digitalization" appeared in connection with the intensive development of information and communication technologies. Davos Klaus Schwab, calling the first digital revolution of 1960-1980 "industrial", believes that its catalyst was the development of semiconductor computers, in 60-70-x-personal computers, in the 90-x-the Internet. The author has predetermined the approach of the fourth industrial revolution, which will also be digital in connection with the "ubiquitous" and mobile Internet, miniature devices, the development of artificial intelligence [16]. Wiktionary reveals the content of the concept of "digitalization" as a "digital method of communication, recording, data transmission via digital devices" [17]. A. Marey considers digitalization as a change in the paradigm of communication and interaction with each other and society [18]. E. L. Vartanova, M. I., Makienko, S. Smirnov [19] clarify the content of this concept is not only the transfer of information in digital form, and a comprehensive solution for infrastructure, management, behavioral, and cultural. Thus, it can be concluded that the development of the Internet and mobile communications are the basic technologies of digitalization.

One of the tools of the digital economy, which allows to provide all the necessary conditions and technological mechanisms that make it possible to form digital images on its platform, to fix transactions, is the blockchain technology. According to the European venture company "Outlier Ventures" [20], the blockchain technology market is dominated by the United States, where 38.9% of all blockchain startups are deployed. In second place, the United Kingdom – 16.7% of the total number of blockchain startups. In third place – Canada –3.3%, then China – 3.2%, Singapore – 2.6%, Germany and Israel (slightly more than 2%). The main industries in which startups use blockchain are communication and communications; finance and insurance; media entertainment; science and technology, etc. [21].

The blockchain was created as a medium for the transmission of values, especially financial, about the same as the Internet – a medium for transferring data such as files, emails, etc. the Blockchain is an electronic system where you can create a variety of applications. Like the Internet, blockchain has its basic principles of functioning-decentralization and multiple copying of history. "The Internet of values is one of the most successful metaphors describing the technology of the distributed register [22, 23]. Blockchain is a type of distributed, electronic database (ledger) which can hold any information (e.g. records, events, transactions)and can set rules on how this information is updated [24].

“Blockchain” is rapidly becoming part of the technology vernacular, and yet it remains very much misunderstood. The following high-level definition provides a quick introduction to the subject:

a) Simply put, a blockchain is a distributed ledger that provides a way for information to be recorded and shared by a community.
b) In this community, each member maintains his or her own copy of the information and all members must validate any updates collectively.
c) The information could represent transactions, contracts, assets, identities, or practically anything else that can be described in digital form.
d) Entries are permanent, transparent, and searchable, which makes it possible for community members to view transaction histories in their entirety.
e) Each update is a new “block” added to the end of a “chain.”
f) A protocol manages how new edits or entries are initiated, validated, recorded, and distributed. With blockchain, cryptology replaces third-party intermediaries as the keeper of trust, with all blockchain participants running complex algorithms to certify the integrity of the whole [25].

The blockchain protocols were proposed by a person (or team) under the pseudonym of Satoshi Nakamoto in 2008, and in 2009 a client program was presented, providing the activity of the first digital currency created on the basis of the blockchain protocols-bitcoin / bitcoin. Bitcoin is a kind of" digital gold", which does not need storage and intermediaries, does not depend on national borders and jurisdictions. Satoshi Nakamoto managed to solve the problem of centralization, suggesting how to store accounting without the possibility of falsification. Blockchain, one of the main technologies underlying cryptocurrencies, is an electronic Ledger, where the history of all money transfers is recorded (the record is called a block, therefore, the "block chain" — blockchain). What distinguishes it is that many network members store copies at the same time. This distinguishes the blockchain from the centralized institutions of the past. As briefly as possible, the blockchain can be described as a continuous chain of blocks containing information built according to certain rules. However, the blockchain as a perpetual digital distributed journal of economic transactions can be programmed to record not only financial transactions, but also almost everything that has value (property rights, diplomas of education, etc.).Today, the distributed blockchain database is increasingly integrated into document storage and control systems.

Blockchain technologies in educational institutions are already widespread in foreign countries and open up huge opportunities for its effective use in the future. For example, in Japan, Singapore, the USA, Hong Kong, Estonia, the UK blockchain technology is already being actively implemented, and the Singapore education system is actively using online learning and is considered one of the best [26]. In Japan intensively used platform for blockchain in the field of education. Next year, it is planned to launch an educational blockchain system, which will allow teachers to exchange information about students ' progress and their achievements. This will affect not only higher education, but also educational institutions of primary and secondary level. Melbourne state University plans to introduce blockchain: certificates and awards of Australian students will be entered into the blockchain. MIT Media Lab presented a blockchain-based academic certification system [27]. In 2017. more than 100 graduates of the Massachusetts Institute of technology received "verifiable" digital diplomas using blockchain technology, protected from counterfeiting.

In our country, there is a very slow transition to digital media, especially in educational institutions. The problem of educational institutions is that they are strongly tied to paper. This leads to the fact that the collection of information on paper creates an additional burden on employees, allows you to make any changes to documents; reports on progress in different educational institutions may not coincide, which reduces the efficiency of the staff; the lack of a complete database of graduates who have specific skills make it difficult for employers to find the right specialists; the lack of an open database on the employment of graduates and their transition to another job does not allow educational organizations to assess the effectiveness of their work on their programs and make quick adjustments; lack of openness and transparency of financial flows of educational institutions, the distribution of finance for different structural units, participation in the tender and other problems.

In order to solve all these problems and improve the efficiency of educational institutions, it is necessary to introduce modern technologies, blockchain technologies in the sphere of education.

3. METHODOLOGICAL FRAMEWORK

The 21st century has defined new skills and competencies of human capital. Global Internet and electronic libraries, information databases and automation of workplaces require it-competence of the population. World practice shows a significant digital divide in countries. To determine the possibility of using blockchain technology in education, first, it is necessary to analyze the degree of development of information and communication technologies in this area.

Since 2007, the UN has published the rating of the ICT development Index in the annual report "Measuring the information society" [28]. The index is calculated based on 11 indicators and 3 sub-indices (ICT Access, ICT Use and ICT Skills) (Table 1).

Table 1 The structure of the index of ICT development-2016, UN

Indexes	Standard value	Weight	
Access			
1. Fixed telephone service per 100 inhabitants	60	20	40
2. Number of mobile cellular subscribers for every 100 residents'	120	20	
3. International Internet traffic (bps) per person user's	976'696	20	
4. Percentage of households with a computer, %	100	20	
5. Percentage of households with Internet access, %	100	20	
Use			
6. Proportion of the population using the Internet, %	100	33	40
7. Fixed broadband Internet per 100 inhabitants	60	33	
8. Wireless broadband Internet per 100 inhabitants	100	33	
Skills			
9. Average length of study, years	15	33	20
10. Gross (General) enrolment in secondary education, %	100	33	
11. Gross (General) enrolment in higher education, %	100	33	

Source: Measuring the Information Society Report, 2016

Kazakhstan has been participating in the UN ranking since 2009. Positive dynamics in terms of availability (+29) was recorded. Thus, the indicators of international Internet traffic increased by 70 times (2009 – 1 052, 2016 – 69 615 bit / s per 1 Internet user) [28]. Accordingly, there is an increase in the use of ICT (+21) (Figure 1).

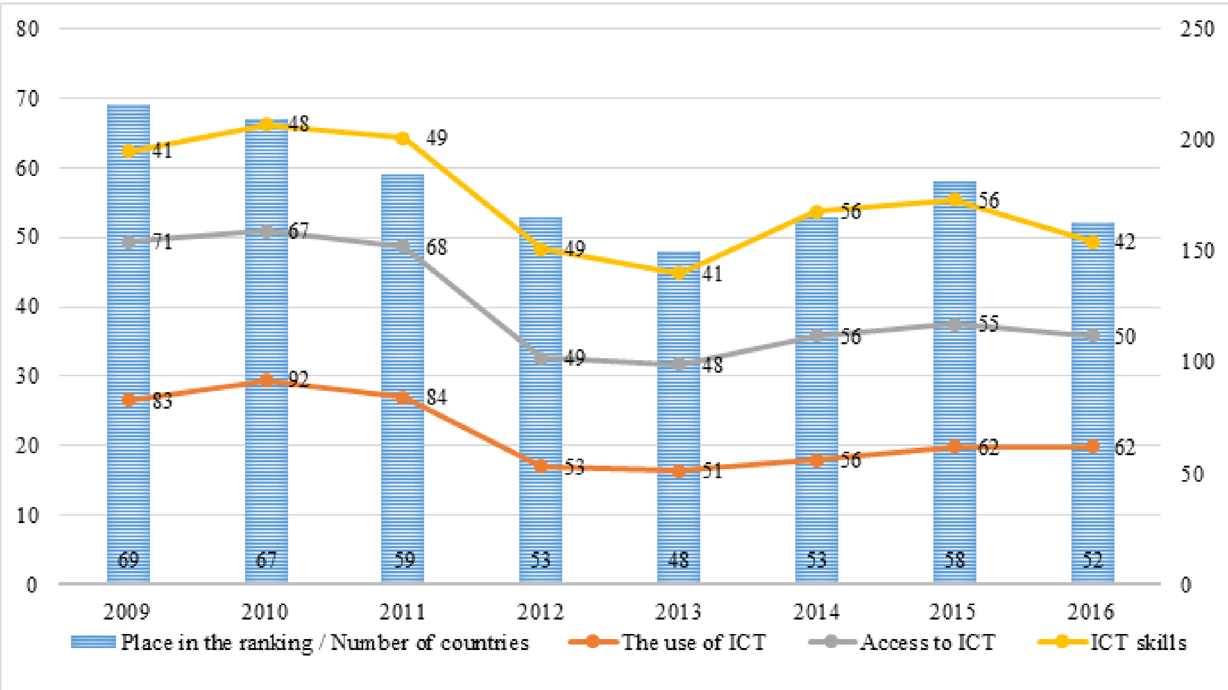

Figure 1 Dynamics of Kazakhstan's positions on sub-factors of ICT

The decrease in the ICT skills sub-index in 2016 compared to 2009 (– 9 positions, 2009 – 41 place, 2016 – 50) was affected by the decrease in the rate of coverage of the population with higher education. In 2016, the average length of training (Table 2) replaced the adult literacy rate of the Skills sub-index.

Table 2 Kazakhstan's indicators on the “ICT skills” sub-index

	2009	2010	2011	2012	2013	2014	2015	2016
Kazakhstan's place in the ranking / Number of participating countries	69/154	67/159	59/152	53/155	48/157	53/166	58/167	52/175
Sub-index "ICT skills", place	41	48	49	49	48	56	55	50
Adult literacy*, % / Average length of study**, years	99	99.6	99.7	99.7	99.7	99.7	99.8	11.4
Gross (General) enrolment in secondary education, %	92.8	92	103	99.6	101.9	97.7	97.7	109.1
Gross (General) enrolment in higher education, %	51.2	46.95	40.1	10.8	43.2	44.5	44.5	46

Source: Measuring the Information Society Report, 2016

The world leader in ICT is Korea. Kazakhstan ranks 52nd among 175 countries in the ICT-2016 ranking. In comparison with 2009, the growth of the country's positions was +17 [28].

ICTs provide people with access to global digital resources. Web platforms, online courses, video conferences, interactive applications transform education. Use the rating indicators of population coverage of education for the assessment of IT skills is no accident. The national education system has a key role to play in accelerating the introduction of new learning technologies.

The introduction of blockchain technology may carry some risks. To determine the fundamental factors affecting the financing of education, reliability and investment stability, the authors offer a unique method of determining the investment risks of crowdfunding projects, ICO and blockchain startups. For the basic concept of the methodology adopted supplemented and updated international standards of risk management, as well as digital economy, built on trained neural networks using scoring matrices, logical and mathematical methods and simulation algorithms. The concept allows early identification of adverse investment factors and deviations from the investment strategy, as well as recognition of the effects of uncertainty and financial risks. Despite the sequence of risk assessment stages in the analysis of blockchain projects, in reality the risk management process is essentially iterative (repetitive).

When developing statistics, the technique due to the limited sampling capacity, time reserves will apply some models of mathematical calculations for the effective identification of risk factors. In particular, when determining the minimum sample size, the formula of interval estimation of the General role will be applied:

$$W - Zy\sqrt{\frac{W(1-W)}{n}} \leq P \leq ty\sqrt{\frac{W(1-W)}{n}} \quad (1)$$

where, P is the estimated share of the required risk factors in the population, the volume of the initial statistical sample, W is the share of the estimated factors in the test interval sample, Z is the value of the normal standard distribution law depending on the level of reliability y.

According to this formula, we find the upper and lower limit of the confidence interval for the assessment of the General share of risk factors at the level of reliability of 95%: 0.05 and 0.09. At best in terms of risk assessment, but the worst in terms of determining the minimum sample size would be the lower limit of the confidence interval for the proportion of factors with the highest level of risk. Let us say it is about 0.05, and then it will be necessary to take the sample size of about 2500 projects with a relative error in the estimation of the share of 10%. In addition, with the share of "negative" outcomes in 0.09, 1776 observations will be enough. If we increase the accuracy of the estimation of the General share to a relative error of 5%, we will need 9887 observations (projects).

The quantitative assessment of the static factor is based on the logical-evaluative methodology of expert evaluation of answers to descriptive questions of risk factors. Each answer is assigned a certain number of points, because of which the project receives its own assessment for a certain static risk factor. It is necessary to take into account the need to assess both dynamic and static factors on a single scale of assessment (0 – 100).

According to the specified parameters, a certain variability of responses for all risk factors is obtained. When quantitative variables are included in the model, the system needs to analyze them for multicollinearity. This problem of model construction is not given enough attention, despite its relevance both in the use of quantitative predictors, as well as for the construction of a linear multiple regression model. The initial analysis of the presence of multicollinearity can be made based on the matrix of pair and partial correlations between independent variables. However, correlation coefficients may not always show the presence of multicollinearity. To diagnose multicollinearity, indicators of tolerance or tolerance of a variable determined by the formula are often used:

$$1 - Ri^2 \tag{2}$$

where, Ri^2 is the square of the multiple correlation coefficient of the i-th independent variable with all other predictors. If the tolerance of a variable is close to 0, the values of this variable can be expressed in a linear combination of other independent variables.

Sometimes, instead of tolerance, the inverse of its value, called the coefficient or factor of "swelling" of dispersion, is used:

$$VIF = \frac{1}{1-Ri^2} \tag{3}$$

In the presence of multicollinearity, the variance of the regression model parameter estimates increases in proportion to this value, which makes their estimates unstable. The high value of VIF indicates the presence of multicollinearity. The categorization of quantitative variables of static factors occurs according to the following algorithm.

Initially, the quantitative variable is divided into several groups based on equal percentiles. Then in each group is the proportion of scores of 0 and 100, and the weight value of the categories of the predictor WOE. The weights of the predictor categories help to find the limits of sensitivity to the occurrence of the simulated risk event by the variable and to categorize the quantitative variables in the optimal way. WOE metrics for each category are calculated using the formula:

$$WOE = In\frac{d\mu}{d\alpha} \tag{4}$$

where, $d\mu$ and $d\alpha$ are relative frequencies "0" and "100" respectively in the i-th group of the categorized variable; $i = 1, 2, \ldots, k$; k is the number of categories of the variable.

The mechanism of calculation of the dynamic risk factor differs from the static one in that the measurement of the first should be made taking into account its changes in time. The performance of the dynamic factors expressed in the votes, monetary units, pieces, etc. in order to estimate the dynamic factor to generate the score, relate the indicators on the considered risk factor from the average indicator.

The key assumption in the transformation of a quantitative estimate to a 100-point estimate in this mathematical model is expressed by the following formula:

$$Q_i = \frac{x_i}{2\bar{x}} * 100 \tag{5}$$

where, Q_i is an indicator of the quantitative evaluation of the dynamic factor, $x_i..\bar{x}$ respectively, the quantitative indicator of the risk factor of a particular project and the weighted average of this factor

$$\bar{x} = \left\{\sum_{i=0}^{n} \frac{dx_1}{n_1} + \frac{dx_2}{n_2} + \cdots + \frac{dx_n}{n}\right\} * \left\{\frac{1}{n}\right\} \tag{6}$$

Key model assumption:

$$\text{if } \bar{x} = x, \text{ that } Q_i \rightarrow 0.5x,$$

$$\text{if } \bar{x} > x, \text{ that } Q_i \rightarrow max_{0\leq x\leq 1} 2x\ lim_{n\rightarrow 100}$$

The option of calculating the probability of occurrence of a risk event depends on the presence or absence of statistical observations on a certain factor. If there is no statistics on the risk factor, the probability assessment is made by the expert method of weighing the estimates. A preliminary survey of experts on the significance of a factor or group of risk factors is carried out. Then the averaging of estimates and smoothing of deviations of expert opinions are made, based on which each factor is given weight. As a result, the obtained weights are corrected taking into account the mathematical error. The mathematical model is expressed by the following formula:

$$f = \frac{W_1}{W_n}; n = \frac{W_1}{W_k} \tag{7}$$

where, W_1, W_n is the weight assigned by the expert, k is the final sequence number of the risk factor.

Then the groups of factors with the lowest priority assigned by experts are calculated:

$$W_n = \frac{2}{k*(f+1)} \tag{8}$$

Further, we define the weight for the rest of the group's priorities:

$$W_n = W_i * \frac{(k-i)*f+i-1}{k-1} \tag{9}$$

The above weights should be adjusted according to the formula due to the calculation error:

$$W_{1i} = W_{0i} / \sum_{i=0}^{n} W_{0i} \tag{10}$$

We would like to note that in our own calculations we have moved away from the classical method of risk group's distribution into equal clusters in order to reduce the impact of the 100% limit of the aggregate indicator of the weights of all factors. This is because the practice of foreign experts shows that the above limit is exclusively an academic tool and does not affect the effectiveness of the scoring model using weighted priorities in practice. Because of this, we have greatly simplified the model of calculations, in particular eliminating the need to average the risk factors in all existing clusters.

4. RESULTS

Despite the vast potential of blockchain technology, it is most natural to use it in solving problems that meet several requirements at the same time. In such tasks:

a) the database is in the form of an accounting book (there is a list of transactions that is ordered by time and indicates what, from whom and for whom is transferred);
b) there are several authors of the record (several users, usually in different places, write to the database);
c) transactions must be made in the absence of trust (authors do not want to allow someone else to edit their records in the database);
d) disintermediation required (participants do not wish to grant control of the database to any Central authority);
e) There is a transaction relationship (there is an interdependence between transactions).

Many tasks in the field of education meet these requirements, and the use of blockchain technology can help solve them today. Here are some of them.

Protection of digital certificates. Educational organizations can issue digital certificates using public blockchain for their storage. The certificate will be securely stored. Certificate authentication is also simplified: it can be easily verified even if the organization that issued the certificate is closed. The educational organization will no longer need to have staff to prepare certificates confirming the issued diplomas.

Confirmation of the legitimacy of digital certificates. Educational institutions can not only issue digital certificates by digitally signing them, but also receive a digital signature from the organization that accredited them. This ensures that the organization has issued this certificate and that the organization has the authority to issue it. That is, the use of blockchain allows you to automate the authentication of not only the certificates themselves, but also the competence of the organizations that issued them.

Reputation currency. Another promising area for the use of the blockchain — the creation of the objectified system of forming of reputation of educational institutions and scientific and pedagogical workers. This can be done by developing a system of reputation transactions that are similar to cash payments. For example, each institution or individual, depending on his or her status, may receive a rehearsal Fund as a free loan at the first step. The size of this Fund may depend on their recognition in the ratings, receiving prestigious awards. They will be able to manage this rehearsal Fund, awarding small amounts of their reputation to colleagues, students and other people whose professional and / or human reputation they want to maintain. Organizations and individual professionals can receive additional contributions to your rehearsal Fund, for example, because of recognition by other organizations and colleagues for development, winning the open tenders, the successful implementation of grant activities, etc., these records can read any, so everyone can see how man achieved his reputation. The rules for changing the size of reputation (creating a reputation currency) can be agreed by all members of the community and approved by consensus.

6. CONCLUSIONS

Currently, the system of education is in the middle of unprecedented change, and the rate of change is expediting. The role of policymakers, school administrators, principals and educators will be different in the future from previous and current times in terms of beliefs, values and views at things. The rapid changing world is making present knowledge and methods of teaching out of date much faster. If current teaching is not out of date, it will be so in the expected future. In order to conform to this change, the constant professional development of teachers is necessary [29]. Today, the distributed blockchain database is increasingly integrated into document storage and control systems. The advantage of this technology is that there is no practical possibility of manipulating the data written to the system, because the information in the database can only be added, but not overwritten. At the same time, the truth of the document can be easily traced, as everyone sees who it was recorded in the blockchain. Along with the identity card and the banking sector, the “crypto-Revolution” has not spared the education system. Prospects for the use of blockchain technology is not limited to only the distributed database. Its dynamism and transparency also has the potential to revolutionize the education system as a whole (through the development and legitimization of online learning). The popularity of Massive Open Online Courses (MOOC) is constantly growing, as they provide an opportunity to gain practical knowledge from anywhere in the world, as well as have a lower cost of training. Based on the ability to combine individual courses into blocks of courses, it is possible to offer different learning strategies for narrowly focused specialties. In addition, blockchain allows standardizing certificates and diplomas of universities and educational online portals, which in the future will allow legalizing them for all countries of the world.

Thus, the development of the digital economy, the creation and transfer of educational organizations on the blockchain technology will allow:

a) transfer the entire document flow of the educational organization to the blockchain, which will increase the speed of material processing, ensure transparency and the impossibility of loss, damage or forgery of the document, since the block created once can no longer be changed, it cannot be removed from the network;
b) ensure transparency of the financial flows of the educational institution, distribution of finances among different structural units;
c) have a single resource where you can find a course of interest anywhere in the world;
d) keep a copy of the entire database for each participant using a single Protocol;
e) to simplify the process of transfer credit evaluations during the transition to another school;
f) to make certificates, awards students in the blockchain;
g) to give "verifiable" digital diplomas using the technology of the blockchain is protected from forgery;
h) potential employer to access student data and confirm where the student has studied and what competencies he / she has;
i) ensure that the employer seeks professionals with specific skills;
j) have a database on the employment of graduates and their transfer to another job, which will help educational organizations to evaluate the effectiveness of their work in their programs;
k) reduce the burden on the student history teacher, as opposed to paper;
l) confirm and retain the right of authorship of the teaching staff;
m) to solve the problems of stratification of scientific publications on the impact factor of a particular publication, citation index, the problem of recording information on licensing and patenting of an intellectual property object;
n) Move to the era of digital contracts and paperless transactions, which will significantly reduce the cost of service.

The result of the introduction of blockchain technologies will be the automation of production processes and the provision of services, which will lead to the era of digital contracts and paperless transactions, significant resource savings. This means that only educational institutions with modern digital infrastructure will be able to maintain economic stability, which will allow them to be competitive.

ACKNOWLEDGEMENTS

The authors thank all anonymous reviewers for their helpful remarks. This research was supported by the BR05236689 “Diversification of tourism in the Republic of Kazakhstan in the transition to a digital economy: strategies and implementation mechanisms” scientific and technical program and AP05135078 "Formation and development of the digital economy in the Republic of Kazakhstan: theory and practical measures of implementation" scientific project.

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