Application of blockchain technologies for creation of innovative ecosystem in higher education

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Abstract. The authors reveal some problems in education, which can be solved by the means of blockchain technology. Such problems as authentication of documents on education, confirmation of higher education institutions accreditation, identification of students, etc. are included. Besides, the use of blockchain technologies reduces the paper document flow, making its contribution to saving of working time, resource-saving and improvement of the ecological situation. The blockchain technology allows to create the uniform digital ecosystem for students, higher education institutions and employers, to solve the problems of reliable storage and providing information without neither any increase in the load for the stuff nor the growth of costs. The conclusions and results received by authors of article can be used by management of the highest education institutions for improvement of their work.

1 Introduction

The modern reality imposes certain requirements for the applicants at a job position. They have to be mobile, ready to provide the documents, confirming their education, qualification and work experience at any time, to be able to transfer relevant information on themselves quickly and precisely. In turn the graduates of higher educational institutions wait for the corresponding preparation.

The higher education needs the implementation of the innovation technologies; that can help to increase the quality of education, to overcome the discrepancy of competences of graduates to the labour market requirements, to increase the chances of the fastest employment of graduates.

According to the data of the All-Russian Public Opinion Research Center [1] 91% of the interviewed Russian employers note the lack of practical skills, demonstarted by young specialists. 55% of the interviewed graduates (applicants) recognize, that it is very difficult for them to find a job. Respectively, it is possible to expect that in the nearest future some directions in education will be very demanded, including:

1) educational programmes for the development of soft and digital skills;

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2) programmes of advanced training of the personnel and occupational retraining;

3) online courses for students and graduate students with the subsequent issue of electronic diplomas or their mailing in paper option;

4) tools of the development of content and creation of courses, intended for work of teachers authors [2, 3].

Except such substantial problems, the higher education system suffers organizational problems. Firstly, cases of fraud, presentation of counterfeit diplomas are not excluded. The demand of online education led to wide dissemination of electronic diplomas, which are rather difficult to be to verified. To verify the authenticity of the diploma, it is necessary to send the written request which is processed in turn, and that takes a lot of time. On the other hand, the issue of paper diplomas is an expensive and labour-consuming tradition. There is the need for issue of the electronic diplomas, defended from counterfeit and identified easyly by employers or during the following education levels.

Development of the higher education system demands the innovation approaches nowadays, it also demands new tools, and the blockchain technology, borrowed from the financial sphere in which it arose initially, is capable to become one of them.

The questions of the innovative development of education were already considered in works of such Russian authors as Grebenyuk I.I., Golubtsov N.V., Kozhin N.V., Chekhov K.O., Shmatkov V.V., Belokobylsky S.V., Glukhov V.V., Rodionov D.G., Kalinina O.V., Latuha O.A., Volkov A.T., Vladimirov A. I., Simonenko E.S., Velichenkova D.S. [4], Chuev I.N. and also such foreign authors as Abbott M., Keffri J., Landvall B.-A., Santo B., etc. The possibility of the use of blockchain technologies in education was studied by V.V. Grigoriev [5], K. Matsuura, P. Druker, M.F. Stew [6], D. Tapscot [7], I.D. Zverev, V.P. Maximova, M.N. Skatkin, P.R. Atutov, V.S. Ilyin et al. [8, 23].

Within this research the authors consider how the introduction of blockchain technology is capable to solve some problems of higher education without the increase in the load of employees and growth of cost, and in the long term it will help to create a uniform digital ecosystem for students, higher educational institutions and employers.

2 Materials and methods

Works of domestic and foreign authors in the field of the higher education as well as works on issues of the development and widespread introduction of blockchain technologies formed the theoretical basis of this research.

The authors studied the experience of application of blockchain technologies in the leading organizations of the higher education, including Masachussets Institute of Technology (USA), University of Nicosia (Cyprus), Holberton School (USA), University College of London (Great Britain), State University of Melbourne (Australia), Financial University under the Government of the Russian Federation, Moscow physics and technology university (Russian Federation), Lomonosov Moscow State University (Russian Federation).

Theoretical methods of knowledge (analysis, modeling) and empirical methods (comparison, experiment, survey) were applied within the research.

3 Results

Blockchain - one of the information technologies, which originally arose in the sphere of finance, but found the application in other directions, including work of educational institutions, over time [8].

D. Tapskott and A. Tapskott [7] were the first to point out the main principles of the creation of the blockchain systems (Fig. 1). They also marked that at the current stage of the digitalization of the economy the information transfer is carried out with the help of modern computer systems, mathematics, cryptography and behavioural economy.

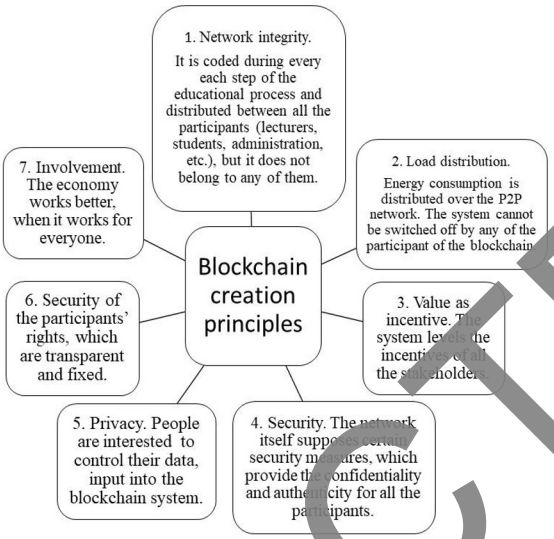

Fig. 1. Principles of the creation of the blockchain systems

We have also to consider the following properties of the blockchain technology.

1. The decentralized character (the information in the system is distributed among numerous computers, which are in turn are united in the network. The participants of this network can work with the neccesary information).

2. The identical and equal rights for all the users, who take part in the information management directly and do not need any intermediaries for carrying out their actions, their confirmation or check of the status (completeness) of transactions.

3. Safety of all the data, once entered into the system (each action, made by the participants of the system and registered in it remains in the database forever, it does not change and is not removed during the information transfer, resaving of files in the system, etc. Information is only supplemented, but it is never liable to destruction. Any registered user has the opportunity to browse the history of his or her operations).

4. Anonymity of data in the system (only the address of the user, which he or she uses for the confirmation of the personality is used during the work in the blockchain).

5. Clarity and transparency of all the communications and relationships among the users of the system (that allows to minimize the quantity of bureaucratic procedures, to reduce the number of levels in the hierarchy of the relations, to reduce the probability of mistakes in the data, caused by so-called "human factor". Nobody has the opportunity to add a piece of false information to the database or to remove any information from it, so that ii would remain unnoticed for other participants of the system, for example, to forge results of examination, to add the counterfeit diploma to base, to change the list of the students who paid for the study, etc.);

6. Checkability of the data (audit of the blockchain is supposed with a certain frequency or if necessary).

Blockchain technology are capable to satisfy the requirements both of students, and higher education insitutions and employers, the introduction and the use of technology also will increase the quality of educational process considerably without the increase (and even with decrease) of the teachers loads.

Nowadays many countries have their experience of the development of the blockchain technologies in the field of education.

The Nicosia University in Greece uses blockchain since 2017. Besides, the blockchain technology is used for financial transactions of the University. The Nicosia University actively uses cryptocurrency for payment for the educational services and it was the first university in the world that began such practice. The blockchain technology keeps data on the invoices and payments made by the students of the university or by their representatives. As for the educational process itself, the Nicosia University is going to develop such blockchain system which would allow communicatins among all the teachers and students, irrespectively of their physical location, to keep track of the students' progress and achievements. As the result all education levels, offered by the Nicosia University (primary, secondary and higher education) will be available to the students in 83 countries worldwide. Diplomas and certificates, issued by the University, will be recognized and it is easy to be checked everywhere.

Massachusetts Institute of Technology in the USA became the first educational institution, which began to issue digital education documents in 2015. The MIT Media Lab laboratory, which worked at the Institute, issued certificates for teachers of the Institute, which could not be equated to diplomas yet, but could be considered to be the prototype of the digital certificate. Then this laboratory together with the Learning Machine company continued work on the distribution of digital education documents and in October, 2016 they published the Blockcerts standard based on the Bitcoin blockchain and which provided the possibility of access and instant verification of diplomas, certificates and awards. Nowadays the MIT Media Lab does not participate in Blockcerts functioning any more, and Learning Machine, which is known as Hyland Credentials now, remained the general manager of the project.

In 2017 the Ministry for Education and Employment of Malta announced the beginning of development of the pilot project on the transfer of all the education documents, including university diplomas, to blockchain and thus became the first European country to introduce the blockchain technology at the highest level and in scale of the whole state.

In 2018 English-speaking Caribbean countries, including Barbados and Jamaica began to issue digital diplomas on the basis blockchain. Malta joined them the same year.

In 2019 University of Bahrain and 18 educational organizations of Singapore, which used the OpenCerts platform working at Ethereum blockchain, began to use digital documents on education.

Holberton School in USA also has the experience of the decentralized storage of digital diplomas.

State University of Melbourne is one more educational organization, actively and successfully developing the blockchain technology. Nowadays more than 100 graduates of this university have the opportunity to use the digital diplomas, verified by the means of information technologies and protected from any counterfeits.

The growing demand for the blockchain technologies for issue and storage of diplomas brought to the establishment of great quantity of the companies, dealing with this problem, for example, Hyland Credentials (creators of Blockcerts) and TrustED.

As for Russia the use of blockchain technology only begins in our country, however it is already possible to speak about some results. The programmes of digital economy development already exist and gradual implementation of the blockchain technology in the sphere of education takes place at the moment [11,13,16].

Blockchain systems are created and are actively used in the leading higher education institutions of the country, such as Financial University under the Government of the Russian Federation, Moscow physicotechnological institute and Lomonosov Moscow State University [4, 5,12,15,17]].

The experience of the Financial University seems to be especially successful and interesting. Work in the field of blockchain has been going on since 2017 at the university, and in 2018 a blockchain laboratory was founded, which was originally engaged in the financial technologies (so-called fintech) and cryptocurrencies, and now it is ready to share its developments with the departments of the university for the educational purposes.

The financial university is ready to issue diplomas in the blockchain, providing employers with the opportunity to verify their authenticity on the official website of the University.

The unique identifiers created on the basis of personal data, including name, series and number of the diploma are appropriated to each digital diploma. Data are ciphered according to the SHA-256 algorithm therefore each diploma gained its unique identifying code (diploma hashtag). The hashed diplomas are loaded into blockchain, the record about each diploma is certified by the University.

Though the Financial university is not the first educational institution which began to issue digital diplomas through blockchain, and Massachusetts Institute of Technology, University of Melbourne, University of Glasgow already have more experience, Financial university is the only one which places data on the issued diplomas publicly, protecting them cryptographically. Thus, the Financial University brings Russia to good positions in the world of blockchain.

Generalizing the experience of the listed higher education institutions, it is possible to call the main advantages which are got by the educational institution when using the blockchain technologies.

The paper document flow is reduced or alleliminated. All the documents exist in the digital form in the system. It positively influences the speed of the information exchange, provides availability and transparency of data to the registered users, reduces the risk of loss of information, emergence of counterfeits and modification in the documents.

The transparency of the educational organization management can be provided as well as the transparency of its financial operations, distribution of its financial resources among the divisions and the directions of its activities.

The common resource, which provides the necessary information about the educational organization for anybody all over the world appears.

Every participant can use the copy of the database thanks to the unified protocol.

The process of retaking tests and exams in the educational organization becomes very simple and convenient.

The system of the blockchain presents all the diplomas, certificates and different awards, gained by the students.

The educational organization can issue digital diplomas, verified by the means of modern information technologies, which can be defended from any counterfeits well.

A potential employer can get access to the information on any person education and get confirmation of his or her alma mater, competences gained and achievements.

A potential employer can search any specialist with the required education and skills using the database of the blockchain.

There appear the database of the graduates, their transition to other university or other job.

The load of lecturers and administration of the educational organization becomes less.

The problems of stratification of the scientific publications, made by the lecturers and students according to the impact-factor, index of citing can be solved.

The problem of the fixation of the information on licenses and patents for the intellectual property can be solved.

Some authors [4, 5, 6] note that obligatory steps on integration of higher education institutions into regional innovation systems include:

- the use of digital technologies, cooperation with representatives of the IT industry, introduction in educational process of IT technologies; strengthening of competences of graduates through similar cooperation;

- introduction of the innovation agenda in programmes of occupational retraining and in programmes of advanced training of personnel, taking into account achievements of digital technologies, developmentof hi-tech and knowledge-intensive industries.

The role of blockchain can be very important for the innovative development of the educational system.

For example, in case of release of electronic diplomas higher education institutions will be able to use a uniform blockchain for data storage (series, number, date of issue, name of the graduate - the owner of the diploma). At the same time even liquidation of the higher education institution, its renaming, merge to another educational institution, and in general any unforeseen events in the education system will not prevent the data to remain in the distributed base of the blockchain. It will not be neccessary to spend additional time and financial resources for authentication of the document through the third parties (such as the Ministry of Internal Affairs, the Ministry of Education, etc.) The employer can check the diploma in the blockchain independently (see fig. 2) [5, 12, 13,18-22].

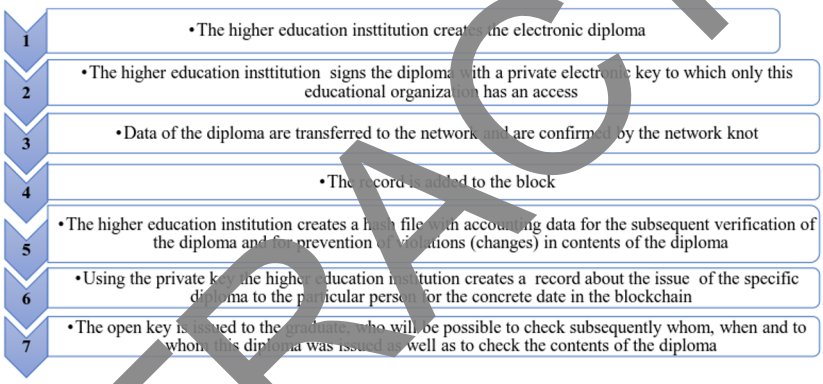

Fig. 2. Mechanism of work of the blockchain technology during the issue of electronic diplomas

The only condition, necessary for work of the described scenario, is the special software which allows to issue certificates with the signature, placed in the blockchain as well as the software for check for confirmation of these certificates is.

The authors of the paper consider the process of implementation of the blockchain in the educational organization. They prove that there should be several stages in the process.

First of all it is necessary to state the mission and the tasks of the blockchain project. Figure 2 presents as it is possible to build the hierarchy of the purposes and tasks in education with the application of blockchain technology [9, 10, 11,21-23].

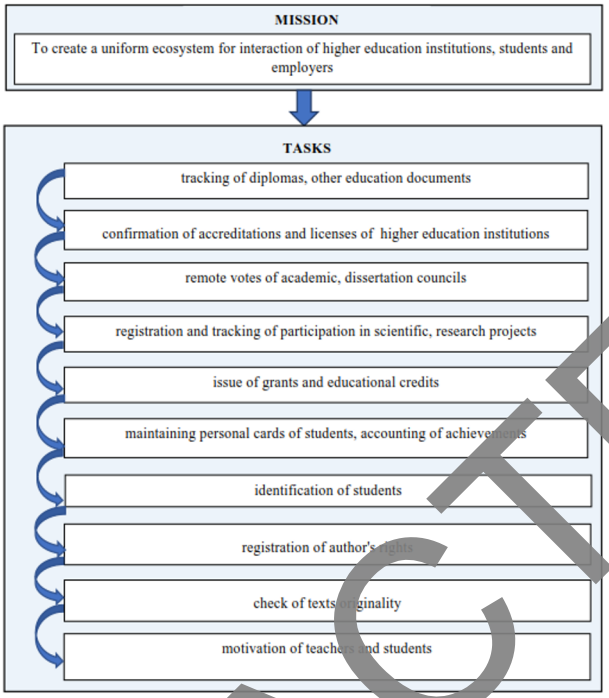

Fig. 3. Mission and purposes of the blockchain in education

Then we should define the contractors to whom the creation of a blockchain system will be assigned.

Two options are available:

1) the development of own blockchain according to the request of the educational organization;

2) acquisition of a ready soft and its adaptation for the concrete educational organization.

The first option is more expensive, however it guarantees the maximum accomplishment of effective objectives and tasks.

The second option cannot consider all the nuances of the educational organization and its requirements. But it is more budgetary and suitable for the small universities.

The next stage is the purchase or the development of the blockchain soft according to the decision, made at the second stage, and its installation.

Then the university staff have to be trained to work with a blockchain system. It in turn can be made remotely with a primeniye of modern information technologies.

The last stage requires the blockchain technology implementation project efficiency evaluation in practice of work of educational institution. Traditionally the project is considered effective if return from it (additional benefits, income or the reached economy) costs for creation of a system exceed.

The algorithm of the blockchain introduction in the educational organization is provided in figure 4.

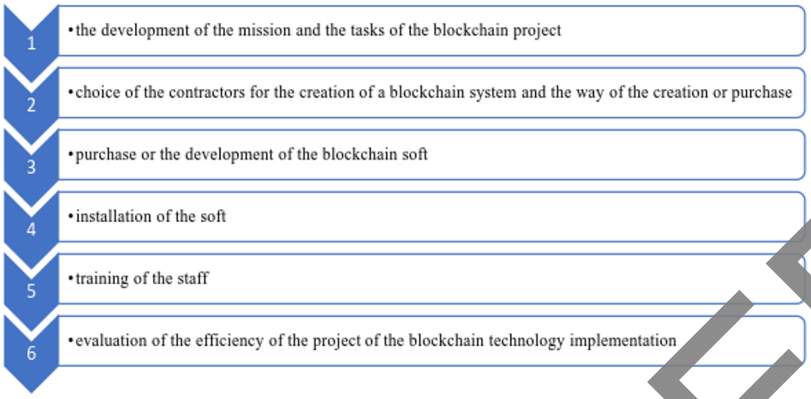

Fig. 4. Algorithm of the blockchain introduction in the educational organization

Creation of the uniform ecosystem for interaction of higher education institutions, students and employers has to become the general result of the use of this technology [5, 14].

4 Discussion

Overall, some reseachers [6, 14-20] suppose, that the market adoption challenge is essential to overcome in order to ensure that blockchain-in-education solutions scale worldwide and sustainably. This requires governments, educational institutions, and innovators to come together and promote blockchain-in-education solutions (e.g., passing policies and legislature that support such innovations, offering funding to enhance research and development in the field, raising awareness about the benefits of blockchain-in-education solutions).

Table 1. Summary of challenges faced while implementing blockchain-in-education solutions

Challenge	Description
Legal	General Data Protection Regulation (GDPR) in European Unit as well as California's Consumer Privacy Act of 2018 (CCPA) have right to implement some limitations on the way, how the educational organizations can transfer the personal information though the blockchain system. Moreover, the definition of the term "personal information" is still vague in the current legislation.
Scalability	The transactions in the blockchain are usually relatively slow, so that can be the factor of so-callled bottlenecks, when scaling all the solutions, concerning the blockchain in the education organization.
Data privacy and security	The system of the security of data in the blockchain system supposes their privacy. But in fact the privacy can be hardly achieved.
Market adoption	Lack of trust in the technology and lack of knowledge on how to harness the potential of the solutions, concerning the blockchain in the education organization may lead to a slow market adoption of such innovations.
Innovation	The relative immaturity of blockchain technologies may influence the success rate of the solutions, concerning the blockchain in the education organization.
Great energy consumption.	Big energy consumption. Data handling in the blockchain demands a huge quantity of computing power and energy. That contradicts the principles of the sustainable

	development which demand to care for energy efficiency and energy saving. Thus, the work of the blockchain system can negatively affect the state of the environment.
Immovability of data	Data, once signed up in the network, it is extremely difficult to change it and almost impossible to remove it. But this advantage sometimes becomes a disadvantage. For example, if an inaccuracy, incorrect information was put in the system (about passport data of the student, its previous education, etc.), it will be difficult to correct it without the participation of most of members of network in this process.
Danger of "attack of the majority"	The attack of the majority is also kbown as the "attack of 51%". The essence of this danger is that if the group of malefactors is able to take 51% of a blockchain, they will control all the system. Any frauds with the education documents, information on the personal achievements of the students, information on the financial transactions of the university will be possible. All the frauds will take place under the guise of normal, and it will be impossible to distinguish them in the taken blockchain. Probability of such danger is rather low, but it is necessary to take it into account. Worst of all is that this disadvantage cannot be corrected at the current level of te technologies development.

It is hard to predict how and whether blockchain will have a significant, sustainable impact in education [20]. Some of the blockchain-in-education beneficiaries claim that in five years, academic digital credentials may become extinct unless large multinationals and/or governments start to use and value digital credentials in the near future. Others (claim that the concept of lifelong education, or continuously learning new skills and updating old knowledge, will drive the need for a trusted, immutable record of learning accreditations. Thus, given that lifelong education is becoming increasingly necessary in a world driven by fast-paced technological progress, the need for blockchain-backed credentialing may increase as well.

On the other side, suppliers of blockchain-in-education solutions such as the Digital Credentials Partnership aim to build ecosystems of educational institutions that use standards that they define. However, they are also aware of the necessity, yet difficulty, of building sustainable business models and market adoption strategies in order to ensure that their visions come to life.

Overall, the world has transitioned from perceiving blockchain as the key technology behind cryptocurrencies to a technology that has potential in new industries such as healthcare and education.

One more circumstance is in than the introduction of blockchain technology just like any innovation, demands of certain costs at the first stage. Therefore, it is necessary for justification of its expediency to compare costs on one hand, and on the other hand – financial, social and other benefits [21-24].

5 Conclusion

Transition to the blockchain as to the instrument of digital economy development has already become necessary. The application of blockchain technology allows to solve some problems and to improve many procedures in the education system. The blockchain forms a uniform digital uniform ecosystem for interaction of higher education institutions, students and employers, for the exchange of information, its verification, storage, additions, protection against destruction (loss) or illegal change. Work with information becomes more exact and reliable, but at the same time neither leads to the increase in load of employees, nor creates

additional difficulties for students. In terms of economic feasibility the blockchain technology means cutting of costs for work from information in education (diplomas, certificates, certificates, licenses).

Certainly, there are problems during the application of blockchain technologies in education, which are connected first of all with legal status of new technology, scalability (exponential growth of data amount), security (personal data protection, stability of cryptographic algorithms). The specialists, who are engaged in the development of blockchain technologies, offer certain methods for overcoming the called problems already now. But it is obvious that bringing this new technology to perfection will require time.

In Russia the introduction of blockchain technology in the higher education system is only in the beginning, demands development of the system of actions for the development. But already now it is obvious that this innovation will get the great future, as the benefits from its use are very important.

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