SECTION 2. INNOVATION IN EDUCATION

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2.1 Blockchain as a tool for the inclusion of educational organizations in the civilizational context

Education is a fundamental public good, a foundation for peace and a prerequisite for sustainable development, and therefore education is a priority for UNESCO. Already UNESCO's first report, "Learning to Be: The World of Education Today and Tomorrow" (1972) warned of the threat of growing inequalities, deprivation and suffering, and it also stressed the need for continuous development of education and lifelong learning systems.

The next report, Education: The Treasure Within (1996), offered a comprehensive vision based on four key principles--learning to know, learning to do, learning to be, and learning to live together in the context of lifelong learning. In 2015, a report entitled "Rethinking Education: Toward a Global Common Good?" was published, redefining the purpose of education and defining it as the promotion and preservation of human dignity and the potential of the human person in relationship to others and to nature [283].

One of the most important strategic directions in the development of education is its informatization [279]. Digital transformation of education is a practical embodiment of the concept of "Education 4.0. The concept is focused on the creation of such an educational system, which in its focus corresponds to the requirements of the "fourth industrial revolution", which consists in the mass implementation of cyber-physical systems in production (Industry 4.0) and service of human needs, including education. According to experts, without adapting informatization of education to the requirements of the "fourth industrial revolution", human civilization can expect even greater "information inequality" in society, deepening institutional problems associated with "information asymmetry".

Understanding of information educational space makes it possible to identify the conditions of its functioning, to analyze the changes occurring in it, given that qualitative and quantitative changes in it occur with varying intensity.

Qualitative characteristics of the space include the effect of hysteresis, digital transformation, information asymmetry, and conditionally quantitative - the quality of the Global Education Space, meaning its ability to provide the labor market with specialists, which is a quantitative category, as well as strategic objectives of the global educational process in terms of sustainable development (UNESCO Global Initiative 2050 "Prospects of Education") [284]

This approach forms the basis for a profound revision of the conditions of functioning and standardization of existing qualitative characteristics of the Global Education Space, standardization of criteria for comparing cross-country big data to monitor the achievement of SDG 4, formation of a mechanism to ensure equal access of subjects of educational activities to all elements of the Global Education Space, standardization and monitoring of the conditions of such participation, security and sharing [273].

It was proved that the information component is a fundamental basis for the implementation of the Global Action Program on Education for Sustainable Development and the Roadmap for the implementation of this program.

In this process, technologies such as blockchain are attracting attention, making it possible to create common educational services and resources, control educational content and the quality of educational programs, and identify educational documents.

Blockchain technology is used for operations with personal data, replenished personally for a particular child by teachers and specialists, making information for the work of supervisory groups. Blockchain is also necessary for checking the portfolios and certification of teachers and specialists who are invited to work in inclusion classes, for tracking the dynamics of their professional development in the field of special pedagogy and special psychology [270].

Blockchain is also indispensable for creating a common data bank of professional literature for educators and specialists in the field of inclusion, including the possibility of professional advice to school staff in difficult situations.

Modern trends and prospects of blockchain technology implementation in the digital educational space are defined.

Blockchain technology as a technology for collecting and storing information in a sequential chain of blocks with protection by means of cryptographic ciphers, its basic concepts, organizational principles of construction, architecture and classification of blockchain networks, blockchain proxy level are characterized. Blockchain technologies based on Ethereum, EOS, Parity, Cosmos SDK are compared and analyzed. The method of issuing digital certificates and diplomas, the consensus mechanism, and the sharding method are considered on the example of a number of universities and educational programs [274]. It is concluded that the advantages of blockchain technology (distributed register) in education are:

a high level of transparency (distributed control over the network, transferred to the users themselves),

efficiency (high potential for fast and cheap transactions increases due to the removal of the need for intermediaries, third parties or a central regulatory authority),

security (due to the innovative information storage system in a database distributed throughout the network, such a system is extremely difficult to break, and data can not be changed or altered) [275].

This makes it possible to use blockchain in the Global Education Space to solve new tasks: creation of common global educational services and resources, collection of big data of the world countries on the SDG implementation progress, unification of cross-country approaches to the implementation of the Global Action Programme on Education for Sustainable Development and the Roadmap [276].

Analysis of the scientific literature allowed us to formulate a definition of blockchain in relation to the educational environment.

Firstly, we consider blockchain as a system for storing specific information related to the educational sphere, using a software module that implements an

algorithm that processes the information content of ordered interconnected data blocks as a whole using cryptographic and data protection technologies to ensure and maintain the integrity of the Global Learning Space. This system controls the passage of transactions carried out by the educational organization, which can be considered the minimum amount of information transactions that make sense and are considered to be fully completed (e.g., operations on the issuance of a certificate of education).

Second, blockchain technology provides a high level of security for data storage and transmission, an open and transparent network infrastructure, decentralization, and low operating costs.

The functioning of blockchain in the Global Education Space is based on a set of sequential operations, as a result of which conditions are formed for the circulation in the educational space of reliable information, its storage and use; in order to optimize the interaction of subjects of education and education management

In the context of globalization, blockchain technology in educational institutions offers enormous opportunities for its effective use, this technology can already potentially be "embedded" in national education systems:

- in pedagogical management processes, in the development of educational programs and standardization of educational systems, in activities related to information protection and protection of personal data of learners (for example, a learner can at any time check which body or entity of educational activity had access to his/her electronic data, since any such access to personal data is documented and thus ensures transparency, security and authenticity of use of information concerning learners); if on global

- into unified document management systems, as well as into digital services of formation, use, storage of information and/or control over information used in the educational sphere, which ensures trust in electronic data and documents; if at the global level the problem of trust and security, confidentiality, identifiability will be solved;

- to a blockchain infrastructure focused on academic research and publications, which will build an infrastructure that will automatically record data on new

publications in blockchain and store a constantly updated picture of the links between publications (references, citations), which will solve the problems of stratification of scientific publications by the impact factor of a particular publication, the citation index, etc.

- in educational disciplines devoted to the use of blockchain technology, as well as massive open online courses, the popularity of which is constantly growing, as they give the opportunity to get practical knowledge from anywhere in the world, and also have a lower cost of training. Based on the ability to combine individual courses, forming separate blocks of courses, it is possible to synthesize different learning strategies for narrowly focused specialties, while blockchain allows the standardization of certificates and diplomas of universities and online educational portals, which will make them legal for all participants of the Global Education Space [272, 280, 281].

We have highlighted the problems that currently hinder the full participation of countries in the global transformation. These are inactive marketing policy of education, insufficient effectiveness of distance learning and online education, lagging information infrastructure of universities, including in the use of blockchain technology, lack of awareness of educational organizations and teachers about global trends in education development, the Global Action Programme on Education for Sustainable Development, Sustainable Development Goal 4.

The latter circumstance is associated with a low level of scientific interest and technological support of blockchain technology. It is

the low readiness of teaching staff to use digital technologies;

obsolete computer equipment of rural schools;

the presence of remote areas with unstable Internet;

psychological problems of using blockchain, which in the minds of many people is firmly associated with cryptocurrency and the shadow market;

cautious attitude of teachers to global processes as a risk of losing national advantages of education, etc.

The analysis leads to the conclusion that the global educational space is under formation and is subject to the same laws of functioning as the global socio-economic

space, meaning that the organization of the educational process is centered on the principles of freedom of choice of types and forms of educational activities, market competition, self-regulation and free pricing.

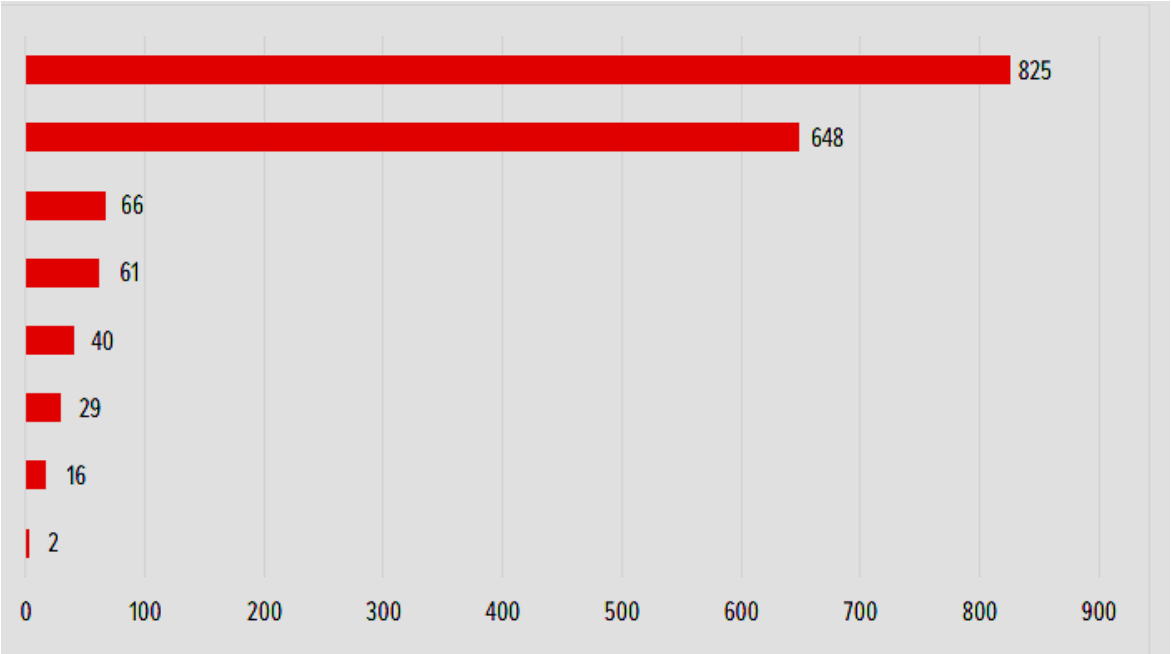

Figure 1: Number of blockchain technology patents in different countries (as of April 2020). From top to bottom:

China

U.S.

Korea

Japan

Australia

Germany

India

Russia

In this case, the objective conditions of the subjects of the Global Education Space demonstrate circular interconnection and hysteresis effect (the gap between the requirements for the quality of students and the real capabilities of the educational system to meet these requirements), and information asymmetry and digital transformation effect are an objective result affecting the structure of the "Global Education Space".

It is also important that the relationship between the global and national in education, nationally specific ways of entering the educational systems of different countries in the global educational process (UNESCO, 2015, 2021), the dialectic of the general, the singular and the particular, in particular in the use of blockchain technology in the development of modern education are often not taken into account [271, 278].

Using the method of content-analysis we set the task to determine the main directions of blockchain use in the process of digital transformation of the education system. A fundamental conclusion is made about the fact that these technologies are used selectively, their introduction into education itself (due to the limited use) cannot positively affect the quality of the education system [277].

The analysis has shown that the goals of "inclusive equitable quality education", "embedding the individual into the big reality in which the individual lives", "develop students' ability to verify information on their own reflective experience", "critical reflection of others' ideas", etc., now cannot be achieved outside the creation of a universal mechanism of information exchange, standardization and control, which is the blockchain. It has been determined that at the beginning of the 21st century the global educational system is at a turning point in its development. Future forms, paradigms and models of education will be influenced by the evolution of civilization, and education as its important global component must contribute to those forms of development that will implement the strategy of human survival and biosphere preservation to the greatest extent [282].

Let us consider the possibilities of blockchain in providing the activities of an educational organization in accordance with the Global Action Program on Education for Sustainable Development.

Activity Area: Synthesis and advisory provides:

collecting examples of best practices reflecting the implementation of the Global Action Programme on Education for Sustainable Development and the Roadmap for the implementation of this Programme, as well as institutional-wide approaches used

at the governmental level, in the public and private sectors, and education, aimed at its implementation.

The programmatic and substantive pillar includes the creation of global information platforms that can be loaded with best practices in the implementation of the Global Action Programme on Education for Sustainable Development and the Roadmap for the implementation of the Programme and common institutional approaches.

The Regulatory strand is the development of a practical guide in the form of a checklist showing how to implement the Global Action Programme on Education for Sustainable Development and the Roadmap for Implementation through a whole-institution approach. This guide will include specific questions to facilitate reflection on a whole-institution approach at the institutional, governmental, educational, and organizational levels.

This includes the development of accreditation modalities and a set of quality criteria for the implementation of the Global Action Programme on Education for Sustainable Development and a roadmap for the implementation of the Global Action Programme to monitor its implementation. All of these areas involve the benefits of blockchain technology.

We have developed an integrated model for the implementation of blockchain technology in the digital environment of the educational process based on the improvement of PBFT. We propose a consensus mechanism (Boneh - Lynn - Shacham) that is linearly scalable in terms of communication complexity. The proposed consensus uses an approach that differs from those previously considered - with Proof of Share (PoS) as a validator registration mechanism or Sybil attack prevention mechanism. Such a method contains a main chain and a Chardi set. The main chain serves as an identity registry, while the Shardi chains store individual blockchain states and simultaneously process transactions.

This algorithm uses randomness generation by combining a random function check function (VRF) and a delay check function (VDF) and includes PoS in the sharding process, which shifts fragment protection issues from a minimum number of

nodes to a minimum number of voting shares. The criteria, indicators and methods for evaluating the performance of the integrated model of blockchain technology implementation in the digital environment of the educational process are presented. It is concluded that blockchain technology in education is a public good that ensures the development of the educational institution on the path of transparency, democracy, security, accessibility, sustainability, efficiency and inclusiveness, the implementation of the concept of "Education 4.0".

As a result, it is concluded that blockchain technology is an indispensable tool for the development of modern education system, given its globalization, the dialectic of national and global, the desire for informatization and informational openness.