Design of an Educational Platform for Professional Development of Teachers with Elements of Blockchain Technology

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***Abstract*—This paper presents an in-depth examination of the development and implementation of an innovative platform for teacher professional development, incorporating features of blockchain technology. The platform manifests a revolutionary step in enhancing teacher training, creating a secure, transparent, and decentralized approach for maintaining continuous professional development records. Using blockchain's inherent properties, the platform ensures immutable record-keeping and instills credibility in teachers' career progression, empowering educators through direct ownership of their professional development milestones. Additionally, the platform fosters a culture of lifelong learning, encouraging educators to actively engage in their professional growth, while providing reliable evidence of their achievements. Alongside highlighting the design aspects of the platform, the paper delves into potential challenges and solutions associated with the incorporation of blockchain technology into educational contexts. Through this innovative intersection of technology and education, the platform showcases the potential of blockchain in reshaping and enriching professional development strategies for teachers, thereby elevating educational standards and practices across the board.**

***Keywords*—Blockchain; professional development; artificial intelligence; teaching; learning**

I. Introduction

The advent of the digital age has brought about transformative changes across industries worldwide. In education, technology's role in shaping instructional strategies, fostering collaboration, and enhancing student outcomes is well-recognized [1]. However, an area less explored, but no less critical, is the use of technology to facilitate and optimize the professional development (PD) of teachers [2]. To that end, this paper aims to describe the design and development of a novel platform that leverages elements of blockchain technology to revolutionize the PD landscape for teachers.

Teacher PD refers to a comprehensive set of specialized training, formal education, and advanced professional learning aimed at enhancing teachers' pedagogical skills and knowledge [3]. The effectiveness of a teacher's professional development program is central to the quality of education imparted. Research has indicated that high-quality PD positively impacts teacher quality, which, in turn, improves student achievement [4]. However, the traditional methods of documenting and validating PD efforts often involve arduous, time-consuming paperwork, and a lack of transparency and credibility.

Blockchain technology, renowned for its robust security, decentralization, and immutable record-keeping capabilities, can provide efficient solutions to these challenges [5]. While blockchain has mostly been associated with cryptocurrencies like Bitcoin, its potential extends far beyond, having disruptive implications for sectors like healthcare, finance, and supply chain management [6]. In the realm of education, blockchain holds promise for academic credential verification, student record management, and, as explored in this paper, enhancing teacher PD.

In response to the need for a more efficient, transparent, and credible system for managing teacher PD, we have developed a unique platform incorporating blockchain technology. The platform serves as a decentralized ledger for recording, verifying, and sharing professional development activities [7]. It provides teachers with direct control over their records and the ability to share their verified qualifications and skills seamlessly, fostering greater trust and collaboration within the educational community.

The application of blockchain technology to teacher PD also aligns with the increasing emphasis on lifelong learning [8]. The platform supports a culture of continuous learning and improvement, allowing educators to document their professional growth over time reliably [9]. By reinforcing the value of PD and enhancing its accessibility and transparency, blockchain technology can contribute significantly to enriching teacher quality and, consequently, student learning experiences [10].

This paper provides a comprehensive overview of the platform's design, development, and implementation processes, demonstrating the practical application of blockchain in education. It also discusses potential challenges and strategies to overcome these in the context of blockchain integration into educational systems.

In essence, the fusion of blockchain technology with teacher professional development marks a promising step towards a more technologically enriched educational sphere. By presenting a blueprint for integrating blockchain into teacher PD, we hope to contribute to the ongoing dialogue on

harnessing technology to elevate educational practices and outcomes.

II. Related Works

A. Professional Development of Teachers

The essence of professional development (PD) lies in its potential to foster an enhanced understanding of pedagogical methods, curriculum intricacies, and student learning mechanisms among teachers. Studies emphasize the role of effective PD in augmenting teacher quality, thereby improving student outcomes [11]. However, the means of validating and documenting PD activities often lack transparency and efficiency, leading to skepticism about their credibility and consistency [12].

The role of professional development (PD) in the educational landscape is paramount. It embodies the continuous growth and learning teachers undertake to refine their pedagogical skills, adapt to evolving educational trends, and ultimately, enhance student learning outcomes [13]. Fig. 1 demonstrates GoSTEAM model that use block chain in STEAM education.

The common thread running through these diverse modalities is the objective of equipping teachers with the knowledge and skills necessary for effective classroom management and instruction. In this context, [14] proposed that effective PD must be ongoing, focused on the curriculum, and collaborative in nature. It should allow teachers to experiment, receive feedback, and reflect on their practice.

Moreover, the effectiveness of PD extends beyond individual teacher performance. Well-structured PD programs have been linked to fostering collaborative cultures within schools, thereby boosting overall institutional performance [15]. In contrast, ineffective PD programs characterized by disconnected, short-term training sessions have shown minimal impact on teachers' practices and student outcomes.

However, the current systems of documenting and validating PD often involve cumbersome paperwork and are vulnerable to inconsistencies. In addition, these traditional methods often lack transparency, leading to questions about their reliability and the credibility of the PD efforts documented [16]. These challenges underscore the need for innovative solutions that can streamline the PD process, enhance its credibility, and encourage teachers to actively engage in their professional growth.

Recently, emerging technologies, such as blockchain, have been suggested as potential solutions to enhance the credibility, transparency, and efficiency of teacher PD. Blockchain technology, with its secure, transparent, and decentralized features, could serve as a means to authenticate PD efforts reliably and sustainably. This paper extends the exploration of this potential solution, presenting the design and development of a platform for teacher PD incorporating elements of blockchain technology.

B. Blockchain Technology: Beyond Cryptocurrency

The inception of blockchain technology, originally designed to support Bitcoin, a digital currency, has had far-reaching implications beyond the financial sector. Essentially, blockchain provides a decentralized, secure, and transparent environment for transactions and record-keeping [17]. Its application spans a multitude of sectors including healthcare, finance, and supply chain management, owing to its potent capabilities of data integrity and traceability [18].

Blockchain technology, born out of the desire for a decentralized and secure digital currency system, was first introduced by [19] in his seminal work on Bitcoin. However, the implications of this technology extend far beyond its initial application. The fundamental features of blockchain – decentralization, immutability, and transparency – make it a potent tool for diverse sectors beyond finance [20]. Fig. 2 demonstrates an example of using blochchain technology in cryptocurrency.

At its core, blockchain operates as a decentralized ledger of transactions distributed across a network of computers, known as nodes. Each transaction is recorded as a block and linked to the previous one, forming a chain. Once information is stored in a block, it becomes virtually impossible to modify or delete, thus ensuring the immutability of data. Furthermore, the absence of a central authority reduces the risk of single-point failures and increases system resilience [21].

While the initial hype around blockchain revolved around cryptocurrencies, researchers and industry professionals have recognized its potential in various other domains. For instance, in healthcare, blockchain can ensure secure patient data management, facilitating interoperability while maintaining data privacy [22]. In supply chain management, blockchain's ability to provide traceability can enhance transparency and minimize fraud [23].

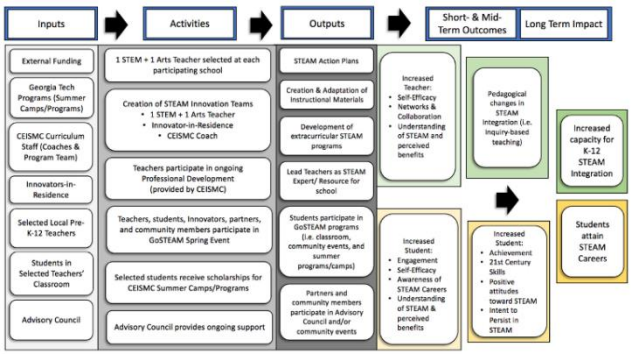

Fig. 1. Applying blockchain in education.

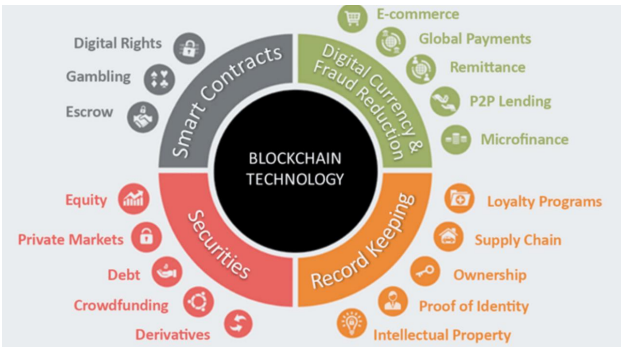

Fig. 2. An example of a lecturer's block.

In the context of education, blockchain can have transformative implications. It can provide a secure, decentralized, and transparent system for academic credential verification, potentially eliminating the prevalent issues of credential fraud [24]. Furthermore, it could offer a reliable method of managing student records, giving students ownership of their educational data [25].

However, while the potential applications of blockchain are vast, so are the challenges. Technological understanding, data privacy, cost, and the issue of integration with existing systems are some of the critical considerations that must be addressed for successful implementation [26].

This paper explores the practical application of blockchain technology in an uncharted domain within education – teacher professional development. It delves into the design and development of a blockchain-based platform for documenting and verifying teachers' professional development activities, offering a novel perspective on the potential of blockchain technology in education.

C. Blockchain in Education

In the context of education, the potential of blockchain has been increasingly recognized, particularly in credential verification and student record management. The study [27] highlights the utility of blockchain in creating secure digital badges, asserting the credibility of academic achievements. Meanwhile, [28] demonstrates the successful use of blockchain in managing student records, providing a decentralized and immutable record of student progress and accomplishments. Yet, the realm of teacher PD remains a largely uncharted territory in blockchain-related research.

The potential of blockchain technology in the education sector is considerable and is beginning to draw substantial interest from researchers and practitioners. Its core characteristics of decentralization, security, and immutability offer unique solutions to some of the longstanding challenges in education, particularly in the domains of record management and credential verification [29]. Fig. 3 demonstrates example of application of blockchain technology in high education.

One of the most touted applications of blockchain in education is credential verification. With the rise of online learning and micro-credentials, traditional methods of credential verification have become increasingly cumbersome and susceptible to fraud. Blockchain technology can address these issues by providing a secure, immutable, and universally accessible system for issuing and verifying academic credentials [30]. By storing credentials on a blockchain, institutions can ensure their authenticity and longevity, while learners can retain lifelong ownership of their achievements, irrespective of institutional longevity.

Additionally, blockchain holds potential for student record management. Traditional systems for storing and transferring student records often involve significant bureaucratic processes and are vulnerable to loss or misplacement. A blockchain-based system could offer an efficient, secure, and transparent method for managing these records. Students could control and share their academic history, ranging from grades to extracurricular activities, providing a comprehensive, verified record of their learning journey [31].

Moreover, blockchain could revolutionize open and distance learning. By facilitating the secure exchange of digital assets, blockchain could provide the infrastructure necessary for implementing self-sovereign education, where learners have complete control over their educational journey [31].

However, despite these potential benefits, implementing blockchain in education is not without challenges. Concerns about data privacy, cost of implementation, interoperability with existing systems, and the need for digital literacy among stakeholders are considerable [32]. Addressing these challenges is a crucial step toward harnessing the potential of blockchain in education.

This paper contributes to this growing area of interest by exploring the application of blockchain technology in a relatively less explored domain within education: teacher professional development. Specifically, it describes the design and development of a blockchain-based platform for managing teacher professional development activities, thereby adding a new perspective to the discourse on the potential of blockchain in education.

D. Blockchain for Teacher Professional Development

The idea of employing blockchain in teacher PD stems from its potential to enhance transparency, security, and immutability of PD records. By decentralizing the control over PD documentation, teachers can gain direct ownership of their professional milestones and demonstrate verified skill acquisition [33]. The research [34] posits that blockchain can foster lifelong learning by making professional development a tangible, continuously evolving process. However, integrating blockchain into education systems is not without challenges. Issues related to technological understanding, data privacy, and cost must be addressed for successful implementation [35].

As the exploration of blockchain applications in education continues to unfold, an area worthy of attention is the integration of blockchain in the sphere of teacher professional development (PD). Traditionally, PD records have been plagued by issues of inefficiency, lack of transparency, and questionable credibility. Blockchain technology, with its inherent properties of security, immutability, and decentralization, can provide solutions to these challenges [36]. Fig. 4 demonstrates sample of using blockchain in professional development.

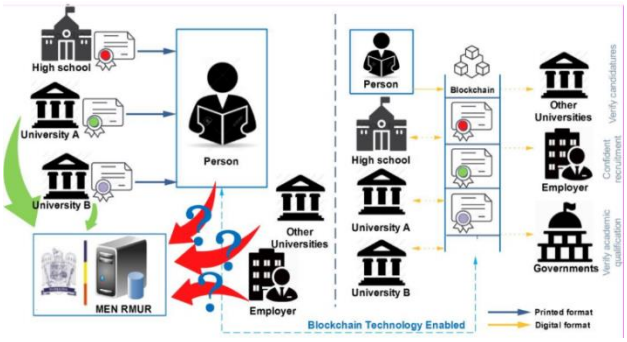

Fig. 3. Blockchain in education.

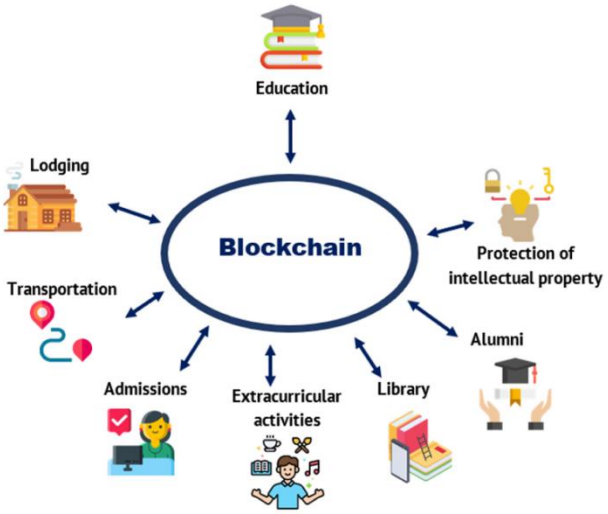

Fig. 4. Blockcahin in professional development.

The application of blockchain in teacher PD can redefine the way PD efforts are recorded, validated, and shared. A blockchain-based platform can serve as a decentralized ledger, documenting teachers' PD activities in a secure and immutable manner. This not only streamlines the documentation process but also enhances the credibility of the records by ensuring their permanence and verifiability [37].

Furthermore, blockchain's decentralization aspect gives teachers direct control and ownership over their PD records. This facilitates the transparent and seamless sharing of verified qualifications and skills, fostering a culture of trust within the educational community. Consequently, teachers are empowered to take an active role in their professional growth, and the value of their PD efforts is reinforced [38].

The use of blockchain in teacher PD also aligns with the shift towards lifelong learning. As continuous learning and upskilling become increasingly important in the fast-evolving educational landscape, blockchain can serve as a tool to document this lifelong learning journey securely and consistently [39].

However, the integration of blockchain technology in the educational sphere is not without hurdles. Potential obstacles include technological understanding among stakeholders, data privacy concerns, potential costs, and the challenge of integrating the new system with existing ones [40].

This paper addresses this gap in the literature by detailing the development of a blockchain-based platform for teacher PD. Through this exploration, the paper provides insights into the practical application of blockchain in the PD landscape, contributing to the wider dialogue on leveraging technology to enhance educational practices and outcomes.

This paper attempts to bridge the gap in the literature by presenting a platform for teacher PD that utilizes blockchain technology. By exploring the platform's design and development processes, we offer insights into the practical application of blockchain in teacher PD, contributing to the discourse on the use of emerging technologies in enhancing education practices.

III. Materials and Methods

Even though blockchain technology emerged as a relatively new advancement in the realm of information technology, it has rapidly evolved into a globally influential technology with multi-industry applications. Numerous scholars posit that it is poised to significantly enhance the global economy in the coming decades [41]. Hwang illuminated the significance of decentralized ledgers, underpinned by blockchain technology, accentuating their potential to introduce considerable advantages for participants in the educational landscape. Specifically, Hwang underscored the opportunities for digital validation of individual and academic achievements [42].

Blockchain technology possesses several distinct attributes [43]:

1) Decentralisation: This characteristic manifests in three aspects - architectural, political, and logical decentralisation.

2) Security: It ensures the infallibility of records across the network, allowing any attempt at manipulation to be promptly identified.

3) Anonymity: It permits users to generate multiple addresses to safeguard their identities, thus maintaining transaction confidentiality.

4) Verification and reliability: This aspect amplifies the traceability and transparency of data embedded in the blockchain [43].

Casino et al. identified blockchain approach as an open-source tool with extensive cross-sector applications [44]. The distinct merit of blockchain resides in its transition from centralized data. Next research highlighted the blockchain as an emerging technology in education [45]. Consequently, they found that blockchain technology is predominantly employed for purposes such as issuing and validating academic transcripts and certificates, facilitating decentralized knowledge exchange and educational accomplishments of students, and assessing their knowledge, skills, and professional competencies [45]. Furthermore, blockchain could potentially stimulate motivation and enthusiasm for learning by maintaining a comprehensive, trustworthy record of a student's educational activities, encompassing both formal and informal learning environments. Additionally, the technology could inform the construction and evaluation of the educational process's quality by recording teacher and student activities and progress [46]. Drawing on the work of Sun et al., who described the approach, this proposition suggests a paradigm in which blockchain technology can significantly influence educational processes, providing insights into students' behaviors and aiding teachers in grading.

IV. Results

A pedagogical platform, incorporating elements of blockchain technologies, has been engineered for utilization in university-level educational processes. This platform encompasses an array of courses and resources that can be incorporated into learning trajectories [47].

Access to this platform is bifurcated into two tiers, delineating rights: educator and student. This segregation aims to create an optimal learning environment. Upon authorization,

students gain access to a wealth of available courses, their accumulated certificates, and a personalized page containing their relevant information. This educational portal, accessible via the Internet, is underpinned by blockchain concept exhibiting a graph architecture. It is structured using blocks of 1024 bytes each, each of which comprises the following sections:

1) Header: This section includes details about the types of blocks, timestamp, and hash of the blocks. All block varieties possess a header, the structure of which remains constant (refer to Table I).

TABLE I. BLOCKS AND THEIR DESCRIPTION

Field	Data_type	Data_size in bytes	Explanation
Block_type	Int_32	4	Type of blocks
Timestamp	Int_32	4	Timestamp
Hash	Byte[]x32	32	A hash underlying on the other blocks.

2) Parent block links: A block may have multiple parent block links, the quantity of which can differ among block types. This segment of the block is employed for block authentication and in generating the block hash.

3) Payload: This constitutes the data stored within the block. An illustration of the block architecture can be found in Table II.

TABLE II. SAMPLE OF BLOCKS STRUCTURE

Header	Block type (4 bytes)	Timestamp	Hash	
Parent block's link	Link to 34th block	Link to 51th block	Link to 68th block	
Payload	First name and last name	Identification number	Login	Password

The fundamental algorithm for block authentication entails computing its hash, utilizing the SHA256 hash function. If the data encapsulated within a block undergoes modification, its hash function, when recalculated, will likewise alter, given that it contains the beneficial data stored in the block. In instances where the block hash is regenerated due to a new payload, all blocks referencing the initial block will become invalidated, as their hash values are computed based on the preceding block's hash. The assembly of the portal's primary blocks can be delineated as follows:

1) The LECTURER_BLOCK is created upon an educator's registration. The payload field encapsulates details about the educator, along with their public key. The initial 256 bytes are considered for the educator's personnel data. The remaining space is assigned to the public key. Fig. 5 demonstrates the description of the LECTURER_BLOCK.

2) The STUDENT_BLOCK comes into existence when an educator registers to the course. The payload field accommodates the student's details and their public key.

3) The KURS_BLOCK (course block) is created when an educator introduces a course. The payload field houses the course title and its description. Here, coins represent earned points within the portal. Fig. 6 illustrates a working example of *KURS_BLOCK* in the proposed system.

4) The TASK_BLOCK is created when an educator introduces a task (block_type = 4). The payload field accommodates the maximum number of coins that can be earned from the task, the task file's signature by the educator (a hash consisting of the sum of the prev_block, the file hash, and the number of coins, encrypted with the educator's private key).

5) The TASK_COMPLETE_BLOCK is created when an educator evaluates a student's tasks.

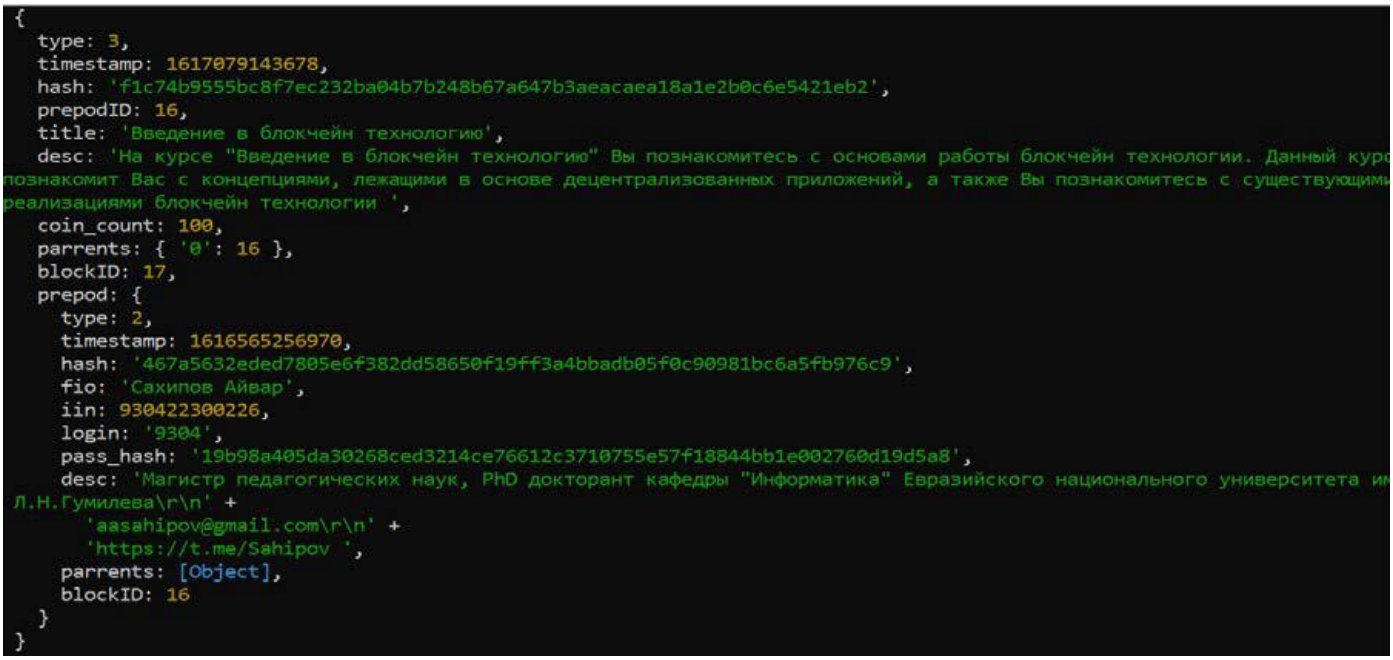

Fig. 5. An example of a lecturer's block.

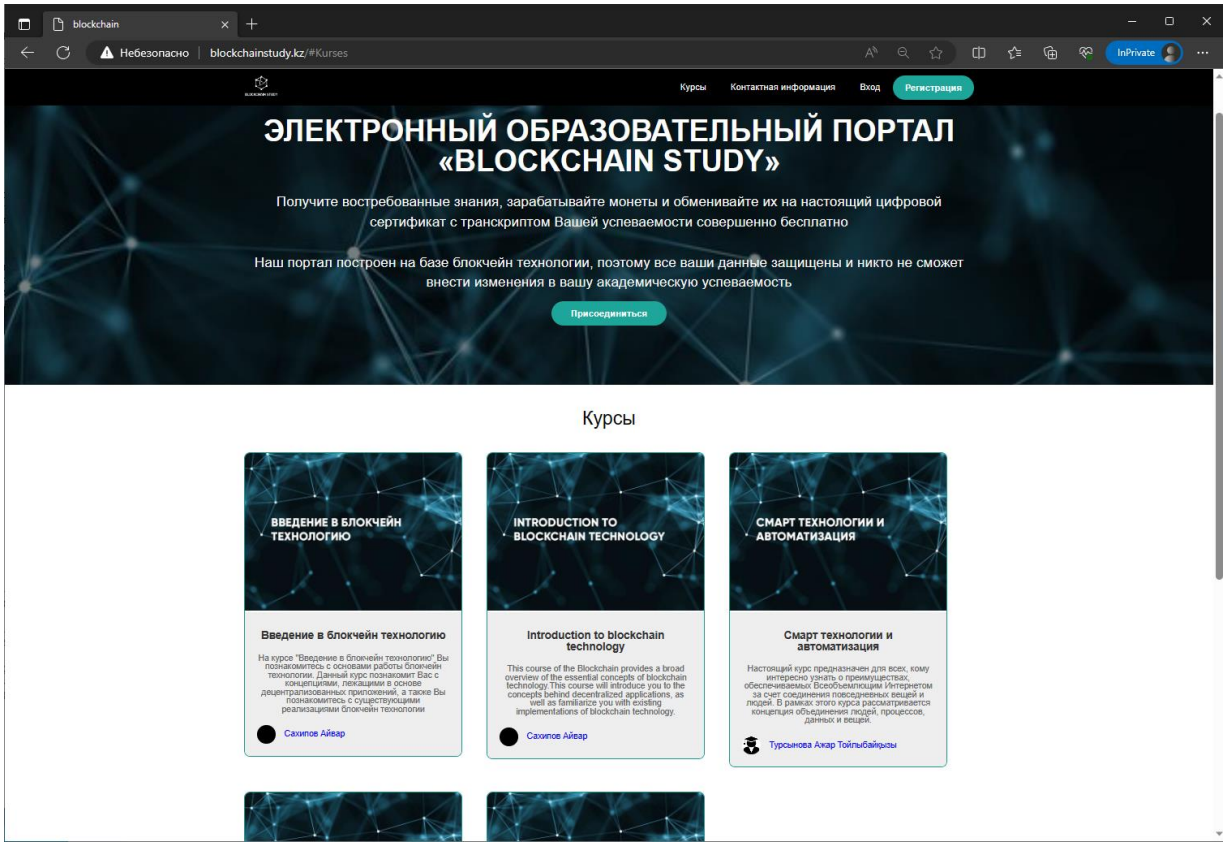

Fig. 6. Visualization page of the KURS_BLOCK.

6) The CERTIFICATE_BLOCK is created when a student exchanges earned coins for a course completion certificate. A block is considered valid only if the sum of all coins collected by the student from the task_complete fields of the current course is equal to or exceeds the number of coins specified in the task_block field. Fig. 7 demonstrates working principle of the CERTIFICATE_BLOCK.

In summary, an educational portal has been developed incorporating blockchain elements. Its utilization fosters student interest and enhances performance, thereby facilitating educational objectives. The diversification of the educational process engenders interactivity and student engagement. The platform further benefits from the verification of learning outcomes, facilitated by the blockchain technology's ability to provide simple and effective certification.

Whilst the expansive potential applications of blockchain technology remain largely speculative, this study indicates that its influence on the educational sector will increasingly become palpable in the foreseeable future. Some emergent implications are as follows:

1) Blockchain technology could considerably expedite the transition from traditional paper-based issuance of academic credentials. All forms of records, diplomas, and certificates granted by tertiary and other educational institutions, including those pertaining to qualification assignment or advanced training, can be securely and indelibly stored in a decentralised database through blockchain technology.

2) Blockchain technology facilitates automatic validation of academic records, diplomas, or certificates directly via the technology itself, obviating the need to liaise with the issuing educational institution. This development could greatly simplify, if not eradicate, the need for incessant credential verification and attenuate bureaucratic processes within educational institutions. This autonomous certification issuance and validation capability could also be utilised in various other educational contexts. Furthermore, blockchain technology's application extends to copyright and intellectual property management, allowing for the tracking of initial publications and citation tags, without the requirement for a centralised authority to maintain these databases.

3) The potential reduction of data management costs for educational institutions is another prospect offered by blockchain technology. This could be actualised through the creation of decentralised structures in data management, enabling users to effortlessly control and share their data as needed.

4) The growing prevalence of cryptocurrencies, built upon blockchain technologies, could be utilised to facilitate payments and bolster learning motivation by accruing coins upon course completion in certain educational institutions and platforms. The ability to generate proprietary cryptocurrencies could also signify the future usage of blockchain in educational funding, potentially through grants or vouchers, across numerous countries.

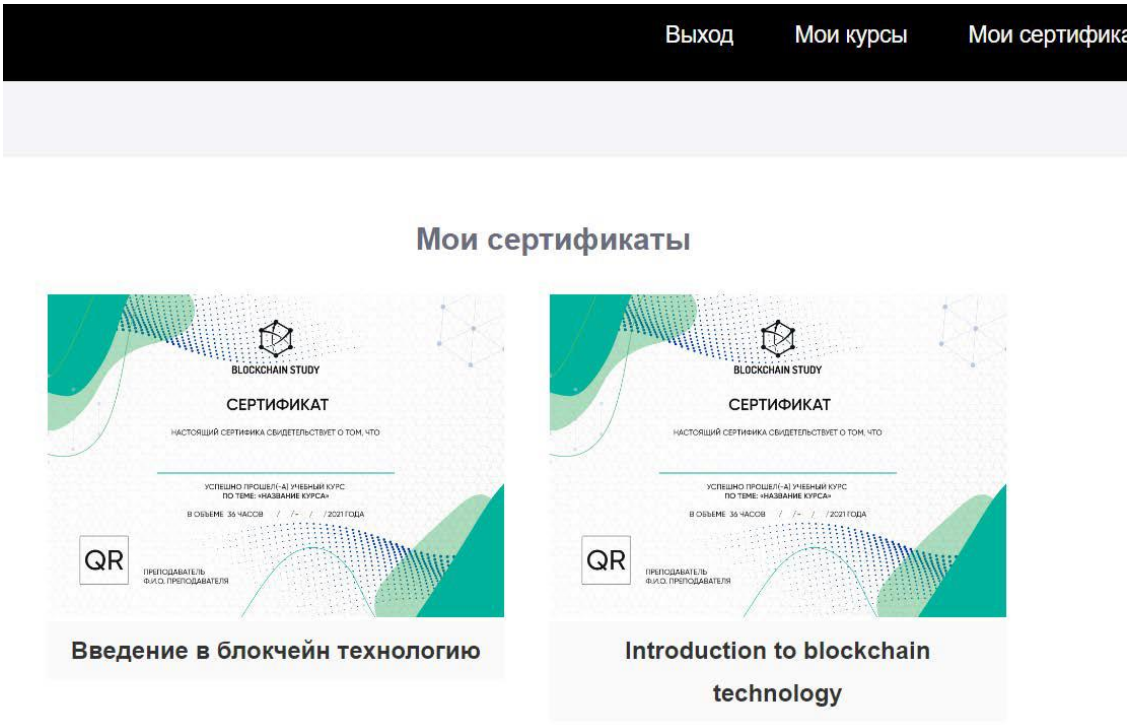

Fig. 7. Visualization page of the CERTIFICATE_BLOCK.

V. Discussion

The integration of blockchain technology into the educational sector, as underscored by this study, bears the potential to bring about revolutionary changes in the processes of learning, teaching, and administration. It is anticipated that this technological incorporation can assist in developing a more inclusive, transparent, and efficient educational system.

The deployment of blockchain technology in the proposed platform for teacher professional development enables a decentralised and verifiable record system that is tamper-proof and fosters trust. This inherently aligns with the requirement of ensuring transparency and integrity in teacher professional development programs. Additionally, the ability to monitor and verify teacher development through a decentralised ledger provides a more egalitarian approach to professional learning, given that the power of validation and accreditation does not reside with a singular authority.

However, the implementation of such a technologically complex system within an educational setting is not devoid of challenges. While the literature has presented the capabilities of blockchain technology extensively, it remains a nascent field within the education sector [48]. As such, substantial development, understanding, and research are required before it can be fully embraced by educational institutions.

Issues pertaining to the digital divide and access to technology are critical considerations. Not all educators and students may have equal access to the necessary devices or sufficient internet connectivity to engage effectively with a blockchain-based system. Therefore, while designing such platforms, it is essential to ensure that it can be accessed through multiple forms of devices, including mobile technology, to mitigate potential accessibility issues [49].

Furthermore, the platform's usability is a critical determinant of its success. Even the most innovative technologies will fail to gain traction if they are not user-friendly and intuitively designed. As such, the role of human-computer interaction principles is crucial in the design and development of such a platform to ensure optimal user experience.

The role of privacy and security within the blockchain also necessitates careful attention. As an immutable record, it is critical to ensure that the information stored within the blockchain respects user privacy and adheres to local and international regulations. Additionally, while the blockchain's decentralised nature can enhance security, it also means that breaches, when they do occur, can have far-reaching consequences [50].

In terms of curriculum development and pedagogy, this paper illustrates that blockchain can serve as a powerful tool to motivate teachers towards continuous professional development by providing them with tangible, verifiable records of their growth [51]. However, the integration of this technology into education is not a panacea. It should be supplemented with other research-proven teaching strategies and ongoing support to ensure it serves its purpose effectively.

The potential integration of blockchain into educational administrative processes is a promising prospect, but it will require a significant cultural shift within institutions. Change management strategies will be required to help stakeholders understand the benefits and potentials of this technology and gain their buy-in [52].

In conclusion, the advent of blockchain technology presents an exciting frontier in the world of education, particularly in teacher professional development. It offers the possibility of a more transparent, equitable, and efficient system for recording and verifying professional learning. However, the successful implementation of this technology requires careful attention to accessibility, usability, privacy, security, pedagogical integration, and change management strategies. Further research is necessary to explore these issues in greater depth and to pilot and refine this technology's use within real-world educational contexts.

VI. CONCLUSION

In conclusion, this investigation has underscored the transformative potential of blockchain technology in reimagining the realms of education and teacher professional development. The distinct features of blockchain such as decentralisation, verifiability, security, and transparency offer the possibility of constructing an innovative platform for professional learning. This platform, characterised by autonomous control, seamless tracking of progress, and the preservation of records, can foster an environment of trust and integrity for the stakeholders. Additionally, the potential of blockchain in the context of digital accreditation signifies a paradigm shift towards more efficient and tamper-proof validation processes. However, the successful integration of this technology necessitates careful attention to issues of accessibility, usability, data privacy, and security. Simultaneously, pedagogical considerations and change management strategies are crucial to ensure a holistic and efficient adoption within the educational sector. It is evident that while blockchain technology has the potential to revolutionise the education sector, more empirical research is needed to further investigate its applicability and implications. This study thus acts as a stepping-stone towards understanding and leveraging the profound potential of blockchain in reshaping the landscape of education and teacher professional development.

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