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Collaborative Learning Supported by Blockchain Technology as a Model for Improving the Educational Process

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Abstract: After COVID-19, new accreditation standards include the need for developing better learning and teaching environments. This will be supported and connected with digitization, entrepreneurship, social inclusion, and a circular economy. The orientation towards equity and quality in education clearly imposes the need for an individual approach to each student separately. This situation is especially pronounced in higher education institutions in the field of technology, whose primary goal is very often individual training for use of highly specialized software and hardware tools. In such a situation, it is necessary to move away from the classical ex-cathedra methodology and develop student-centered learning environments. Global accreditation systems for teaching, learning, practice, and business communication can be simplified using blockchain. On the basis of blockchain technology (BCTs), this paper proposes a Collaborative Learning and Student Work Evaluation (CLSW) model that includes a multi-frontal teaching method (VFN) and combines scientific peer-review standards. BCTs are used to protect student project and assessment data storage and transmission. Assisting higher education institutions in finding "employable capabilities" of proactive students is the idea of CLSW. Before implementing the CLSW paradigm, a poll of lecturers' views on BCTs was conducted. The poll results show a desire and willingness to teach with BCTs. The model's fundamental capabilities and the key participants' duties were described in a project framework. Additionally, this research and proposed model can improve educational process sustainability in general, as it is an open platform easily accessible by all the interested parties, thus contributing to life-long learning.

Keywords: blockchain; digitization; education; multi-frontal teaching method; peer assessment

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1. Introduction

Student-to-student cooperation facilitates and promotes student engagement with online learning content. We frequently believe folks engrossed in their gadgets' screens and keyboards are acting alone. Individual learning with technology is frequently a myth. Kids use computers to interact with peers [1]. These ideas emerge from collaborative learning. This study's collaborative learning models are blockchain-based and may be used to boost student participation online [2]. They are employed in practice and have a specific meaning.

The idea of analyzing other students' work dates back to early 1970s (in the same study year or attending the same subject). Students obtain specialized knowledge through thinking about the issues, checking the results, researching the content, and communicating with each other. Collaborative learning techniques assist students in developing critical thinking abilities and grasping a technique. The method requires them to exchange information. In current technological situations, when the emphasis is not on hardware or software, but on the learning experience, collaborative learning is well suited. E-learning technologies have supported collaborative learning approaches focusing on practical and project work, especially during the COVID-19 outbreak.

Collaborative learning is an approach where students work together in groups to solve problems, complete tasks, or learn new concepts. The main features of collaborative learning are interaction, cooperation, active learning, shared responsibility, and reflection. Listed below is the short explanation for each mentioned feature.

- Interaction: Collaborative learning emphasizes communication and interaction between learners, either face-to-face or online.
- Cooperation: Learners work together to achieve common goals, rather than competing with each other.
- Active learning: Learners are actively engaged in the learning process, rather than passively receiving information from a teacher or textbook.
- Shared responsibility: Learners share responsibility for their own learning as well as the learning of their peers.
- Reflection: Collaborative learning involves reflecting on what has been learned and how it was learned.

Collaborative learning is "a situation in which two or more students learn or attempt to learn something together [3]."; "instruction that involves students working in teams to solve a problem, complete a task, or create a product [4]."; and "a way of organizing classrooms and curricula that focuses on groups of students working together to solve problems or complete tasks" [5].

Collaborative learning has been used to address various problems in education.

Collaborative learning has been found to promote active student engagement in the learning process. Students in active-learning classrooms, which often involve collaborative learning, had higher exam scores and lower failure rates than students in traditional lecture-based classrooms [6]. Collaborative learning has been shown to be effective in enhancing critical thinking and problem-solving skills. Cooperative learning, which often involves collaborative problem-solving, was associated with significant gains in critical thinking skills [7]. Collaborative learning can help students develop important teamwork and communication skills. Collaborative learning activities increased students' communication and teamwork skills, as well as their engagement and motivation to learn [8,9].

Collaborative learning can be a flexible approach that accommodates different learning styles and preferences. Collaborative learning activities, such as peer tutoring and group discussions, were effective in accommodating diverse learning styles and improving students' academic performance [10].

Collaborative learning can create a positive learning environment where students feel supported and encouraged to learn from each other. Collaborative learning activities, such as group discussions and problem-solving tasks, increased students' positive attitudes towards learning and improved their academic performance [11].

Overall, collaborative learning has been found to be a powerful tool for addressing a range of challenges in education, such as promoting active engagement, enhancing critical thinking and problem-solving skills, encouraging teamwork and communication skills, accommodating diverse learning styles, and fostering a positive learning environment.

The multi frontal teaching method (VFN) is a teaching approach that integrates multiple sources, methods, and activities to provide a multi-dimensional learning experience for students. This method encourages student engagement, accommodates diverse learning styles, and enhances the learning process [12–14].

The discussion about the implementation and evaluation of the multi-frontal teaching method (VFN) in technical sciences is interesting. VFN was effective in enhancing student engagement, accommodating diverse learning styles, and improving the overall effectiveness of the teaching process [15].

Collaborative learning and the multi-frontal teaching method (VFN) share some similarities, as they both focus on engaging students in the learning process and accommodating diverse learning styles. However, there are also some differences between the two approaches.

The proposed model combines collaborative learning and a multi-frontal teaching approach. In this way, the proposed model offer several benefits for both teaching and learning, as these approaches complement each other well. Collaborative learning can promote active engagement and enhance critical thinking and problem-solving skills, while multi-frontal teaching can facilitate a structured and organized approach to teaching, ensuring that all students receive the necessary information and support.

The proposed model can improve learning and teaching in following ways:

Active student engagement: Collaborative learning can help promote active student engagement, while multi-frontal teaching can ensure that all students receive the necessary information and support. By combining these approaches, students can engage in collaborative activities while still receiving guidance and support from the teacher [16].

Enhanced critical thinking and problem-solving: Collaborative learning can help enhance critical thinking and problem-solving skills, while multi-frontal teaching can provide a structured approach to learning. By combining these approaches, students can engage in collaborative problem-solving activities while still receiving guidance and instruction from the teacher [17,18].

Accommodating diverse learning styles: Collaborative learning can be a flexible approach that accommodates diverse learning styles and preferences, while multi-frontal teaching can ensure that all students receive the necessary information and support. By combining these approaches, students can engage in collaborative activities that are tailored to their individual learning styles and preferences, while still receiving guidance and support from the teacher [19,20].

Encouraging teamwork and communication skills: Collaborative learning can help students develop important teamwork and communication skills, while multi-frontal teaching can provide a structured and organized approach to teaching. By combining these approaches, students can engage in collaborative activities that foster teamwork and communication skills, while still receiving guidance and instruction from the teacher [21].

Overall, the combination of collaborative learning and multi-frontal teaching can improve learning and teaching by promoting active engagement, enhancing critical thinking and problem-solving skills, accommodating diverse learning styles, and encouraging teamwork and communication skills.

In addition, the proposed model is supported by using blockchain technologies.

Blockchain technology has the potential to enhance collaborative learning and multi-frontal teaching by providing a secure and transparent platform for collaboration, assessment, and credentialing.

Secure and transparent collaboration: Blockchain technology can provide a secure and transparent platform for collaboration among students, teachers, and other stakeholders. Blockchain technology can be used to develop a decentralized platform for peer-to-peer learning, allowing students to collaborate on projects and assignments in a secure and transparent manner [22].

Immutable assessment and feedback: Blockchain technology can provide an immutable and transparent record of assessment and feedback. Blockchain technology was used to develop a platform for recording and verifying digital credentials, including assessment and feedback records, ensuring that students receive fair and accurate assessment and feedback [23,24].

Decentralized credentialing: Blockchain technology can provide a decentralized platform for credentialing, allowing students to earn and share credentials that are verified by a network of trusted validators. Blockchain technology was used to develop a platform for issuing and verifying digital certificates, enabling students to earn and share credentials that are verified by educational institutions, employers, and industry associations [25].

Smart contracts for learning agreements: Blockchain technology can facilitate the creation and execution of learning agreements between students and teachers through the use of smart contracts. Blockchain technology can be used to develop a platform for creating and executing learning agreements, allowing students and teachers to define the terms and conditions of their collaboration in a transparent and enforceable manner [26].

Overall, using blockchain technology can improve collaborative learning and multi-frontal teaching by providing a secure and transparent platform for collaboration, assessment, and credentialing, as well as facilitating the creation and execution of learning agreements. However, it is important to note that the implementation of blockchain in education is still in its early stages, and there are several challenges and limitations that need to be addressed, such as scalability, interoperability, and standardization.

When used in large-scale systems such as MOOCs or e-learning [27–29], collaborative learning approaches should allow for authentic, transparent, and safe evaluation of student work [2]. Testing is a common way to test student comprehension in higher education—if a student has passed or not. Not all students learn the same thing or perform in the same manner. No indication is given if the student was asked to apply scientific knowledge to real-world problems. For example, in engineering, students must complete a project. As a result, students should be able to learn through projects rather than mere repetition [30]. Practicing problem-solving abilities and critical thinking is required [31–35], and students' work must be assessed [36–38].

Blockchain extends product life cycles and maximizes resource utilization, contributing to sustainability. Blockchain is being utilized in education. New research illustrates the potential of blockchain technology in education [39]. Blockchain-based applications are fast-emerging in numerous domains of education, including competency and learning outcome management, copyright management, student assessments and examination systems, and professional capability assessment. A common approach is used by EduCTX, a platform for recording credentials [40], as well as other educational data management systems to effectively manage and securely store students' academic records and credentials [41].The use of blockchain technology in education enables for transparent data management and verification.

Each person goes through a series of educational programs and courses to obtain skills and applicable certificates. The authors Mahankali and Chaudhary emphasize the importance of having employer-verifiable documents, such as educational credentials, to assist with employment verification [42]. Digitalization and automated data verification in education are examined in this study. Sharples and Domingue [43] suggested utilizing blockchain to transmit verifiable data such as school records. The authors also propose a currency connected to a school's reputation.

The proposed paradigm allows students to self-evaluate during the educational process. It urges universities to better align their programs with market demands.

Method

This study proposes the Collaborative Learning and Student Work Evaluation (CLSW) concept with the idea of VFN using blockchain technology. Students' work and project evaluation will improve with collaborative learning. The proposed system uses blockchain technology to protect data storage and transmission for student projects, peer reviewers, and evaluations. The recommended technique can also prevent data authenticity and non-retractability concerns that may develop in a blockchain-based operation.

This will increase the quality of student work and procedure openness. Their utilization will be a part of professional growth. Students use comparable reasoning and peer review strategies when evaluating their classmates' work [44–48]. Individuals develop not only new academic skills in academic settings, but also other important skills such as social responsibility, critical thinking, communication, and teamwork, which are highly valued by employers. Participants in the work assessment process earn credibility, and those who evaluate well are praised.

The recommended paradigm also allows for cross-faculty cooperation. This allows career development professionals to evaluate student work. Employers will have access to assessments. Because corporations lack access to quality students, having them from a young age will pique their attention. The blockchain collaborative learning and student work evaluation network, an internal cryptocurrency [49–51], allows companies to access future workers. Students' efforts and transactions gain points. They will help enhance student services and attract better students.

2. Multi-Frontal Teaching Model and Students' Internal Motivation towards Learning

The main goal of each teaching methodology that pretends to raise the efficiency level of the teaching process must evoke intrinsic motivation in students. Motivation is a state of consciousness of a person that manifests itself as a specific emotional angle upon the object towards which it is directed [52]. Motivation is manifested as the existence of the desire and will to achieve a certain goal, when we mobilize physical and intellectual resources for that goal, and when we actively and permanently focus on achieving the goal we have set. For this reason, motivation emerges as a particularly important, perhaps even essential, factor in the analysis of the approach that an individual has towards some activity he performs [15].

The learning process is significantly more difficult if there is no appropriate level of motivation for each individual student. In the classic educational system, the applied evaluation principle leads to motivation that is primarily aimed at obtaining a grade that is considered satisfactory in the current value system. In this way, excellent and just sufficient students do not have the same expectations regarding the outcome of the teaching process, acquired knowledge and, in the last case, the desired grade. At this point, it is important to note that the focus of motivation in this case is oriented towards an external goal, evaluation as a reward that is formed and comes to us from the outside; that is, that the basic motivation for learning is an external, or so-called extrinsic motive.

A special class of motives that influence the learning process are the so-called psychological motives that arise from the psychological development of an individual in society. Such motives include:

- I motives, which aim to highlight or increase the value of one's own personality, both in the eyes of others and in one's own eyes;
- Achievement motives;
- Motives of competence;
- Aspirations;
- Need for social reputation;
- The need to stand out.

It is precisely on these types of motives that the aforementioned external motives for learning are based—grades, praise, competition, etc.

Internal or intrinsic motivation, in the sense of direct motivation for the learning process itself, with a sincere joy for successfully achieving the goal of acquiring new knowledge and cognition, is a very rare phenomenon in today's school system [53]. That type of motivation is internal, in the sense that its focus is not on an external, but on an internal goal—spreading personal knowledge and understanding. It is certainly the best form of motivation for the learning process [54]. If you have students motivated in this way, implementing a quality teaching process becomes extremely easy.

In the case of students whose main goal of motivation is externally oriented, the moment that external goal is realized, the interest and further motivation for learning and improving knowledge decreases significantly [55]. This also applies to cases where the actual acquired knowledge is at a very low level: after receiving the desired reward, knowledge ceases to be important [56]. With internally oriented motivation, the sincere desire and need for learning exists at every moment of the educational process, as well as outside of it. In this way, the student is introduced to self-education, which is the ultimate goal of the multi-frontal teaching methodology. The teacher becomes a moderator, a senior colleague, an experienced engineer, who, at the agreed time and place, offers their full attention to students interested in learning [57]. All other activities within the learning process are completely transferred to the student.

In contrast to the traditional frontal methodology, the model of multi-frontal teaching (VFN) implies that students learn the same teaching material at different times, i.e., to learn at their own pace, according to their individual abilities, possibilities, and other characteristics of their personality.

Teaching takes place on "multiple fronts", because "everyone does their own thing", individually or in groups, within the class. Frontal, general, non-individualized teaching depersonalizes work, mutual relationships, and students' personalities. The very setting of the teaching process deprives the student of any individual characteristics, who then becomes a part of the whole, the class group to which knowledge is transferred. In such a system, there is inevitably an averaging of the level of knowledge that is transmitted, as well as the criteria that are set before the students. It is obvious that there is no question of true individualization in such a traditional system [58].

Multi-frontal work in its very definition implies true individualization: cooperation with each student individually instead of a group. Rather than a passive consumer of the teaching process, each student becomes an active participant, but only at their own level, in accordance with their capabilities and at the level of their own understanding. One of the basic goals of the teaching process in the VFN model is to open up to each student their own path of development and enable the formation of creative individuality. After that, as a logical consequence, there is an establishment of a high level of internal motivation for the process of self-education in each individual student.

The model of multi-frontal teaching in practice functions through two basic types of lessons:

First type of lesson—learning: Students are in their places in the classroom or in the laboratory. Each student carries the literature that is necessary for them to master the teaching unit they have reached (practicum with clear instructions for independent work is prepared by the teacher). All students who attend the class independently learn the lessons they want to master in that class. The teacher is present and ready to help any student who has a problem, question, or doubt in the learning process at any time. All forms of cooperation between students are encouraged: exchange of knowledge acquired so far, joint work on concrete problems, help of students who possess greater knowledge, etc.. Positive freedom is complete, with the sole aim of acquiring knowledge.

The second type of lesson—examination: involves the examination of acquired knowledge, in the form of "referencing", i.e., presentations of what has been learned within the framework of the multi-frontal teaching format. Students who attend the class volunteer to be questioned about the teaching units (no matter how many) that they have fully understood and adopted as real knowledge. The role of the teacher in this type of class is extremely important. It evaluates the level of acquired knowledge of the student, with only two possible outcomes: the student either passed and received the highest grade, or the student is referred to additional self-work, analysis of what was missed, to additional literature, and all other creative methods that encourage the process of self-education. The grade is entered in a form adapted to this type of teaching.

The main contribution of this methodology lies in raising students' intrinsic motivation for learning. Here, it should be pointed out that spontaneous curiosity by itself is not enough for effective and successful learning. When a child or an adult is presented with a problem or a puzzle, they usually "do not rest" until they solve the problem or hear the solution. Every set intellectual problem represents a system of tension that is resolved by finding a solution to the problem. It is a natural, innate tendency of the human brain (gestalt psychology). Curiosity as an internal motive—the desire to know and understand, to master knowledge, to formulate and solve a problem—is fully put into the function of the learning process as a result of the conscious and guided shaping of natural curiosity.

In the case of internal motivation, knowledge in itself becomes a goal, a purpose, and a source of satisfaction. New knowledge is much easier to connect with what the student is already interested in, while the durability of content memory is greater. The quality of emotional attitude to the contents is raised in the sense that they become interesting and are adopted with pleasure, without straining the will. In this way, the overall quality of the teaching process is raised, which implies the fact that the contents are interconnected and easier to apply in practice.

The method of multi-frontal teaching insists on finding and establishing this type of motivation in students. This is achieved through the relaxation of the existing system with the methodology of multi-frontal teaching, whereby there is a cumulative effect of adopting such a pattern of behavior among students. Learning by imitation is ubiquitous and completely spontaneous in the learning process, which in this case is especially useful. Weaker and less motivated students at the beginning of the teaching process will very easily adopt the behavior patterns of more successful colleagues, because the joy of learning is obvious and the only goal in itself.

In such a situation, the teaching process is accelerated and interested students acquire knowledge much more easily. The learning process is greatly facilitated, whereby excess tension and scattered energy from the classical, more tense and rigid system is, as a rule, transformed into the energy of creativity, which is put to the function of the learning process [59]. In accordance with this consideration, special emphasis in the conducted research was on monitoring the motivation factor, as it is probably the most important parameter that determines the positive outcome of the educational process, and the overall ease with which it is reached [60]. As a proposal for further study, the task could be set to experimentally test and confirm the thesis that higher values of the motivation parameter significantly reduce the energy invested in achieving the ultimate goal of the teaching process. This rather engineering view of the system under analysis would find its empirical support in a carefully designed system of basic concepts and tools for their evaluation.

The inclusion of students in the role of evaluators, which is incorporated into the CLSW model, arose from the idea of VFN.

The idea of VFN is incorporated into the CLSW model in terms of the realization of independent evaluation of student works by other students with elements of VFN.

As with VFN, which implies well-prepared and structured literature and learning guidelines, in the CLSW model, instructions are made available to students (which are available and posted on the application website) on the use of the application, the method of assessment, and all the rules that should be followed during the evaluation process of student works. Students are allowed to see the works of other students, the used literature, as well as reviews of other students and evaluators. Based on their knowledge of a certain field, the student in the role of evaluator chooses the work they want to evaluate and can use all the listed literature, previous reviews, information about the reviewers, the number of posted reviews of a certain reviewer, and the reviewer's rating given by other participants in this process. All this information is given in order to make it easier for the student to work on the evaluation of other students' work and create a more comfortable environment for them to work in terms of easier access to relevant information. As with VFN, the teacher is always available to the students for any additional information, and at the beginning of the process, the teacher will hold a lesson in which they will give detailed guidelines for the work and answer the students' questions.

3. Collaborative Learning

Collaborative learning is a teaching approach that incorporates group learning. It implies that two or more students work together to solve a problem or learn new information. This strategy pushes students to synthesize knowledge rather than memorize it. Students can collaborate on projects to learn [61]. Students gain group skills by defending their opinions, refining their ideas, listening, and communicating [45].

Students actively develop knowledge in communication with other students [47], working in pairs, small groups of four students (reciprocal instruction), or the whole class.

A group of young programmers must learn a new framework and then build a piece of the program using it. Each coder must learn and execute their own code. At the same time, each person contributes to the group's success [62]. They are responsible for their team's performance, but they are not responsible for their own resources or structure. Because there is no leader, the group must self-direct.

Collaboration and practical approaches were also extensively researched. For the purposes of this paper, "network learning" is defined as the intuitive and emotional benefits of collaboration in order to investigate the impact of collaborative learning and self-assessment on self-regulation [44]. The International Association for Studying Cooperation in Education's Internet resources now attract professional attention (IASCE).

To learn collaboratively, students use a set of concepts and practices [63]. These models provide educators and students ideas for boosting student-to-student communication. The point is that the skills and attitudes children develop via peer engagement will help them in lifelong learning and other situations.

Individual accountability, positive interdependence, and collaboration as values are some of the collaborative learning strategies. Collaboration tends to improve cognitive and emotional outcomes.

Online environments such as discussion boards, email, and social networks may need new collaboration skills [64].

Group autonomy is a basic idea. Students usually rely heavily on professors. However, this encourages them to initially approach their peers for aid or feedback. To adopt the lifelong learning paradigm, students must the provide support and criticism formerly reserved for instructors. Participation in these activities allows young people to learn and socialize. When students help each other, teachers may assist with existing talents [47].

This may be more important in IT situations than in classrooms since teachers are less likely to be available for immediate help. So, instead of giving up or waiting hours or days for help from their teachers, students may contact their classmates.

Aiming for maximum student contact in collaborative learning encompasses both aspects. First, small group activities increase student-to-student interactions. Less than half of the group interacts in similar ways.

Higher-order cognitive talents improve student-to-student relationships [65]. Collaboration is "magic" when students interact with each other. Students' attention, learning, and processing depth increase [66]. Having more quality student interactions is beneficial.

Students can communicate in unique and interesting ways with one another thanks to various features designed to facilitate peer-to-peer contact. These features should be innovative and engaging in order to pique students' interest. Students may find the ability to connect with peers in this manner to be a valuable resource, whether for academic collaboration, social interaction, or other purposes. With diverse applications, IT allows all group members to participate equally. Asynchronous network communication, unlike face-to-face discussions, allows students to exchange ideas without competing for attention. Additionally, using colors encourages equal participation. A visual presentation, table, text, or group member chosen at random to give their perspectives are shown. The program also tracks the prevalence and quality of divergence within groupings.

Individual responsibility encourages people to do their fair share in organizations as long as participation is equal, allowing all group members to play vital roles. Individual accountability thus opposes equal participation. Students should contribute 100% to their organizations [48]. Individual responsibility can be aided through collaboration theories and IT. For example, groups can allocate and track work. This program may help educate peers and lecturers on who completes group duties. Including peers in the grading process is one of two solutions. The alternative option suggests students studying together, but grading each other themselves, e.g., after working together on a set of online issues, they work on another set of comparable problems on their own.

Positive interdependence encourages student sharing and makes them feel connected to their teammates. It can also drive students to learn for their team's sake. Cooperative thinking and attitudes extend from small groups of students to whole generations, educational institutions, cities, and nations.

4. Blockchain in Education

One possible way to evaluate the value of blockchain is to compare it with other collaborative learning approaches in terms of their effectiveness, efficiency, and security.

Effectiveness: Blockchain can be evaluated for its effectiveness in facilitating collaborative learning by comparing it with traditional approaches such as face-to-face interaction, online forums, and social media. Research has shown that blockchain-based educational systems can enhance the effectiveness of collaborative learning by providing learners with secure and transparent access to information, enabling peer review and feedback, and promoting a sense of community among learners [67].

Efficiency: Blockchain can also be evaluated for its efficiency in terms of cost, time, and resources. Compared with traditional approaches, blockchain-based educational systems can reduce costs by eliminating intermediaries, increasing the speed of transactions, and reducing the time and effort required to verify and authenticate data [68].

Security: Finally, blockchain can be evaluated for its security in terms of data privacy, integrity, and authenticity. Compared with other collaborative learning approaches, blockchain provides a high level of security by using cryptographic techniques to secure data and transactions, making it difficult for unauthorized users to tamper with data or gain access to sensitive information [69].

This decentralized database enables transaction verification. A peer-to-peer network of computers distributes a duplicate data copy, a digital register (digital ledger) [70]. unified blockchain protocol (UBP)—all nodes obtain updates to their local copies. Once recorded and validated by all network nodes, a transaction cannot be implemented. Mining confirms transactions by using some of the same consensus techniques that nodes use to agree on a new block. The anonymity of a blockchain guarantees exceptional security. No one can validate a blockchain transaction or digital event [71].

Blockchain technology has the potential to transform the way collaborative learning is conducted. Figure 1 depicts a blockchain transaction representation suitable for use in a collaborative learning environment. It demonstrates how blockchain can be used to manage and validate student evaluations in order to ensure a fair and transparent assessment process.

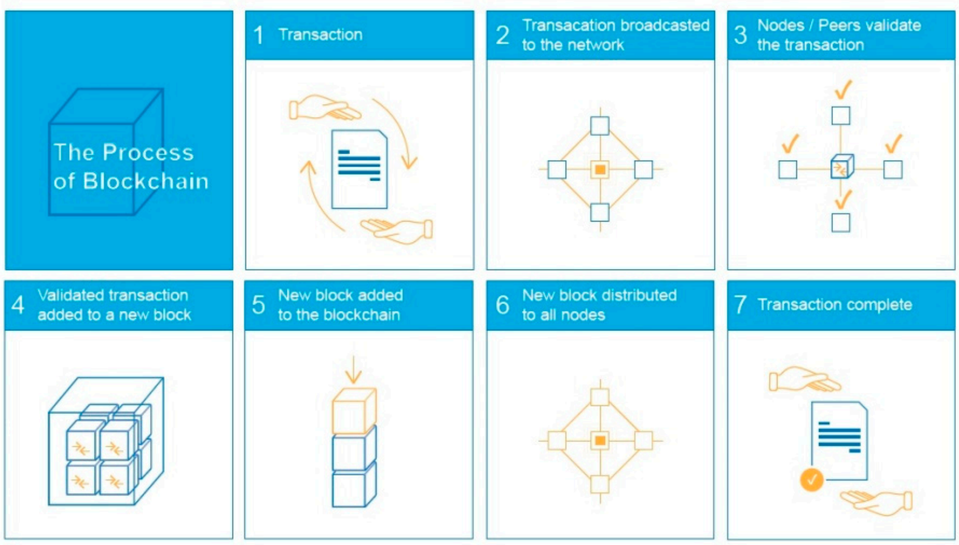

Figure 1. The process of blockchain used in proposed model.

Blockchain technology has the potential to transform the way collaborative learning is carried out. Figure 2 shows a blockchain transaction representation that can be used in a collaborative learning environment. It demonstrates how blockchain can be used to manage and validate student evaluations, resulting in a fair and transparent evaluation process. The numbers in Figure 2 represent different stages in a collaborative learning process and blockchain technology can be used to track and verify student evaluations at each stage, resulting in a fair and transparent evaluation process.

Figure 2. Blockchain transaction representation in collaborative learning.

The Figure 3 depicts various types of blockchain networks based on their permission model. Blockchain networks can be public or private, with different levels of permission for network participants. Understanding the differences between these models is critical for determining which type of blockchain network is appropriate for a specific use case or application. In the proposed model, public with permission blockchain network is used.

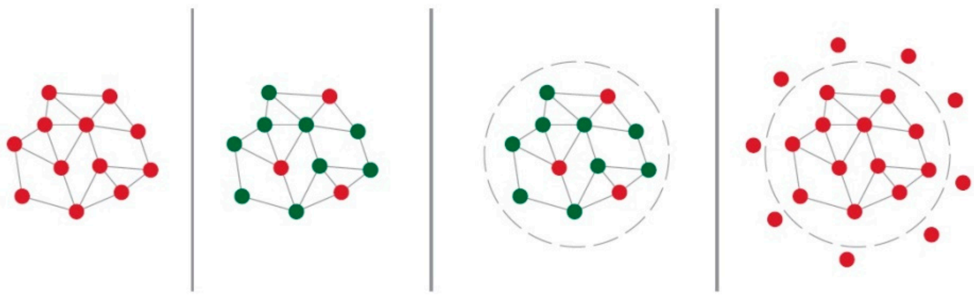

Figure 3. Blockchain network types by permission model (public without permission, public with permission, private with permission, private without permission).

By incorporating blockchain technology into collaborative learning, smart contracts can be created and executed. These contracts, depicted in Figure 4, offer a safe and decentralized method of enforcing agreements between students. The blockchain smart contract keeps a tamper-proof record of all transactions and ensures the transparency and accuracy of the evaluation process.

Figure 4. Smart contract representation in collaborative learning.

Students can participate in the digitization and blockchain technology deployment in higher education and gain confidence in utilizing current technologies important for future professions. Security, decentralization, transparency, and immutability are all advantages of blockchain technology [72]. It also eliminates forgery and reduces fraud risk [73]. In addition to banking [74], blockchain technology is used in commercial operations [50], health [75], tourism [76], energy [77], government [78], and education [42,79].

The blockchain system's central authority elimination is a key feature. All key data entries in a blockchain are encoded using cryptography. Cryptography protects data and records. Each layer of a blockchain has its own purpose. Each layer adds additional components to the blockchain.

The blockchain-based collaborative learning app was created to boost the value of student interactions via technology. With the advent of Web 2.0 [72] and cloud-based tools such as Google Docs, Popplet, and Prezi, more users can collaborate on shared documents.

Project-based collaborative learning is intended to facilitate student learning [80] and assist them in accomplishing project goals (e.g., learning a specific topic or acquiring cooperation skills). Cooperative activities provide a comparable but distinct aim to support measures. For example, gaining new topic knowledge may be the goal of the activity. To do this, the teacher may have students participate in a peer teaching process. To establish a certain form of student involvement, instructional assistance is used. Although few instructional frameworks can do so, they enable a more precise process design [81].

The quality and efficacy of their reports depend on individual student contributions and critique. With technology, students' comments are visible at once. Cloud computing also allows students to work discreetly on tablets, phones, and computers from anywhere.

In thinking, students need to express themselves verbally (thinking aloud). This permits the other group members to watch and learn (recognition modeling). Additionally, as the group accumulates thoughts, new themes may emerge. During the argument, students must directly relate their concepts with examples (development). Students who cannot express themselves may have knowledge gaps. In this case, collaborative learning can help fill the gaps. Students must also reconcile cognitive differences arising from conflicting opinions on the problem.

4.1. CLSW Model

In order to find new research frontiers and subjects, the CLSW approach uses a rigorous literature review.

This model (Figure 5) starts by listing all network participants. Then, HEIs professors provide homework, seminar papers, and projects to students. This study's technique engages seniors or students in higher-level courses in collaborative learning, student work, and project evaluation.

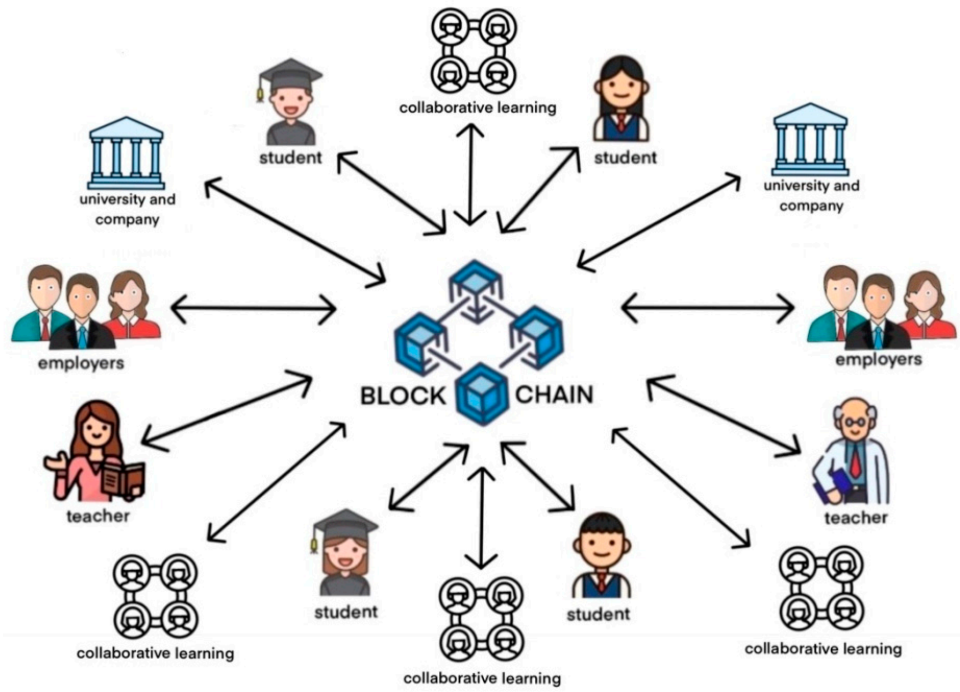

Figure 5. CLSW model.

On each seminar paper and project, another student assesses it quantitatively and descriptively using a pre-defined assessment form. Therefore, anyone may recommend and evaluate a seminar paper or project. Students should assess their peers' work. Teachers put restrictions on topic evaluations. Serbian HEI accreditation limits experimental student groups to 35. Hence, recommending and evaluating the evaluator's work becomes a part of the learning process. Pre-exam readings include other students' seminar papers and projects.

A seminar paper or project is an opportunity for students to learn about the disciplines examined in the course, to better link the accepted forms of information, and to learn about employed technologies and structures. Collaborative learning helps students develop skills. A student-evaluator must also continually exhibit interest in the evaluation process to obtain respect from instructors and classmates.

Student evaluators can build reputation:

- based on practical work assessments of instructors;
- depending on the students' grades who can remark on the evaluation.

This is based on the project and assessment grades of other students.

The capacity to learn new material is more important than a student's reputation as an evaluator. The instructor creates the knowledge grade. Building a reputation is vital for job hunting. Keyword discovery requires reputation to boost future evaluator selection. In addition, instructors' reputation is affected. Unlike traditional information testing, this method accurately assesses students' knowledge and skills. The student wants his talents, i.e., reputation, recognized by specialists.

Student job performance and other assessments will be known to employers. Reviewers may also be involved in student work and projects [38]. The keywords should relate to the seminar paper or project topic. It will be saved for each reviewer. This increases university–business collaboration. Thus, corporations may pick personnel "at the source."

4.2. Modeling Blockchain Networks

The permissioned blockchain-based evaluation mechanism has a restriction on the system nodes. The system owner selects the participants and nodes. Few technology platforms can meet the model's participant authorization network criteria. Additionally, each system member is validated as a peer from a university (or organization). This also complies with data protection laws.

Teachers provide tasks swiftly and automatically assess students, followed by collaborative learning with evaluation (filling out the evaluation form). This is critical for big colleges. An endorser must be able to specify the number and kind of endorsers necessary to validate a transaction. The teacher and student also have copies of the ledger and uploaded smart contracts. As a consequence, approval is achieved by executing intelligent contracts and transferring results across networks.

The blockchain maintains system transactions and is used by all parties. The system participant management layer is the initial relational layer. This section establishes access points, responsibilities, and privileges. Transactions are tier too. The blockchain database then matches the evaluator to the topic material. Finally, the teacher sets a task.

The student should know how to solve difficulties and evaluate other papers. The teacher and student agree on assignments. It is excellent for the learner. A student loses reputation if no consensus is achieved.

The self-managed distributed timestamp server for database evaluation should be accessed directly through the system's integration layer to ensure interoperability among enterprises and a blockchain-based evaluation system. By ensuring that data is accurately and reliably transferred between different systems, this approach could help improve the efficiency and accuracy of the evaluation process. The second block evaluation block sequences are chained.

5. Evaluation

During the 2021/22 school year at the Toplica Academy of Professional Studies—Department of Business Studies, Blace, as part of two study programs for Taxes and Customs and Finance and Accounting, an experiment was conducted with the application of the CLSW model. Students and professors from these two study programs, which were chosen as representative, proposed questions for the questionnaire.

5.1. Research Subject

Blockchain is a relatively new concept, which has become known to the wider public in the last couple of years with the affirmation of bitcoin currency and its application in economy and business. This type of technology finds its application effectively in many other economic branches, as well as in education. The subject of this research is focused on the application of blockchain technologies in education, i.e., dedicated to the views of experts related to the potential application of blockchain technologies in education in Serbia. Given the expected low level of information and knowledge of these technologies and their application in education, the subjects of analysis were the attitudes and opinions of lecturers at higher education institutions in Serbia. The reason for this choice of approach lies in the fact that low information and inexperience in the use of these technologies does not provide the possibility of empirical research, user satisfaction, evaluation of efficiency, etc., but it is possible to approach the evaluation of potential benefits and evaluation of usefulness.

5.2. Aim and Objectives of the Research

The goal of the subject research is to examine the attitudes of the teaching staff related to the potential application of blockchain technologies in education in Serbia. The specific goals relate to mapping the benefits that the potential application would bring and who would be the end user of those benefits, but also detecting the problems that the application of blockchain technology would solve. In this way, it can be roughly concluded whether there is a preference for the introduction of these technologies among professional staff in education.

Some of the research tasks are:

1. Determine familiarity with the term blockchain technology.

2. Examine the level of knowledge, attitudes related to democratization, decentralization, transparency, mobility, and permanence of education based on blockchain technologies.
3. Examine opinions on the impact of preventing manipulation and misuse of educational data and certificates.
4. Examine the relationship between traditional and future methods, based on blockchain technologies, forms of teaching and learning, the ways of their implementation, and the advantages and disadvantages that accompany them.
5. Examine attitudes related to the time certainty of the application of blockchain technologies in education.
6. Determine the benefits that are recognized as the dominant reason for the adoption of blockchain technologies.

5.3. Methods, Techniques, and Instruments

Of the research techniques that were used for this type of research, the most appropriate was a technique in the form of a survey or questionnaire to collect the necessary data. The research instrument is a survey questionnaire intended for lecturers of higher education institutions in Serbia.

The random sampling method was used to ensure the sample's representativeness. Toplica Academy of Professional Studies keeps a database of teaching staff members, including email addresses. To obtain a representative sample, email addresses were drawn at random from this database. By doing so, the researchers ensured that the sample used in the study was representative.

The authors took the following steps to ensure the validity of the questionnaire used in the survey: the questionnaire was designed with a clear understanding of what they wanted to measure. The questionnaire was prepared in a clear and concise manner, using appropriate language that the target population can easily understand.

The basic instrument of the research was a survey questionnaire filled out by the respondents. The questionnaire was composed of closed-ended questions, to which answers were offered through three- and five-level scales, with the aim of reliably confirming or rejecting the attitudes and opinions of the respondents. The data collection technique involved the distribution of the electronic version of the survey questionnaire created on the website https://docs.google.com, accessed on 25 July 2021. The results of the survey were, through the created account, available exclusively to the creator of the survey. This online questionnaire was anonymous. A total of 130 questionnaires were filled out. This number of respondents served as a representative sample on which the research was conducted. It is important to note that all respondents were of legal age and the conditions for completing the survey were clear to them.

The research is applicable, as it has a practical focus on problem solving and implications for practice related to the potential application of blockchain technologies in education. Based on the collected data, the data were analyzed on a quantitative, but also on a qualitative, level. The descriptive method was used in the research analysis.

5.4. Research Sample and Organization

The sample included a total of 130 respondents in higher education institutions in Serbia, i.e., Toplica Academy. Dynamically, the research was conducted during July 2021 via an online questionnaire posted on the Google platform at the link, which was targeted to respondents via email and the Viber application: https://docs.google.com/forms/d/11Wx2kfpzE2SGiLjEv5pXB2FJOhNCBqP7q-eg8LdalsQ/edit#responses, accessed on 25 July 2021. Layout of an online survey of the application of blockchain technologies in education is presented on Figure 6.

Figure 6. Layout of an online survey of the application of blockchain technologies in education.

5.5. Analysis and Discussion of the Obtained Results

This paper analyzed the collected data using certain statistical techniques and methods. The tabular presentation and analysis of the research results followed the appropriate order in terms of the applied statistical analyses, which preceded the analysis of the collected data in the form of appropriate statistical tests. Accordingly, the following methods and techniques were used in the research:

1. Descriptive statistical analysis of the demographic and psychographic characteristics of the respondents in order to calculate the most important indicators of the frequency distribution.
2. The chi-square test was used to test the significance of the difference in the frequency of observed characteristics.

By applying these statistical methods, it was possible to reach conclusions about the acceptance and/or rejection of the set hypotheses. The data, which were collected from the respondents, were processed in the statistical package SPSS 20.

Starting from the determined subject, goals, and objectives of the research, a hypothetical framework was defined, which consisted of basic and several special hypotheses.

The general hypothesis, H0, from which this research is based is: There is a statistically significant difference between the demonstrated willingness of teachers to contribute to the application of blockchain technologies in Serbian higher education institutions and their demographic characteristics (gender, age, and level of education). The theoretical support of the general hypothesis defined in this way stems from the appreciation of numerous approaches to the importance of the blockchain system in collaborative learning. This approach actively involves students in analyzing and synthesizing information and concepts, rather than using rote learning and memorization of facts and figures. One of the more important contributions of the development of collaborative learning is the educational approach of using teams to optimize learning through joint work. Collaborative learning in e-education uses small groups of students in class, encouraging them to maximize their own and each other's learning.

Based on the analysis of the related literature, three specific hypotheses were defined that can be operationalized/disaggregated as follows:

Hypothesis 1 (H1). *Are differences in the gender of teachers statistically significant for the introduction and application of blockchain technologies in higher education institutions*?

Hypothesis 2 (H2). *Did the differences in the level of education significantly affect the readiness of teachers engaged in higher education institutions of Serbia to apply the model of collaborative learning and evaluation of student works based on blockchain technologies*?

Hypothesis 3 (H3). *Does the application of blockchain technologies that enable connection with partner higher education institutions statistically significantly differ depending on the age of the respondents*?

The main feature of the assessment of the impact of demographic characteristics of teachers on their readiness to apply blockchain technologies in higher education institutions of Serbia is that it is not a quantitatively measurable phenomenon and therefore can only be expressed in the form of frequencies. Therefore, the testing of this hypothesis was carried out with a non-parametric, i.e., chi-square test. The essence of this type of test consists of determining the significance of the difference between the original and theoretical frequencies of the phenomenon being tested, which enables appropriate conclusions to be drawn. In this way, one of the aims of this paper was realized, namely an objective assessment of the complex role of the modern teacher in the accelerated development of modern education. Therefore, the application of the chi-square test made it possible to check the correctness of the assumption expected in a specific situation in a larger number of modalities of observed features.

For the purposes of testing the first special H1 hypothesis, the chi-square test of independence was applied. Using the chi-square test, it was examined whether evaluations of student works and projects based on blockchain technologies in e-education differ statistically significantly between male and female respondents. The statistical significance of this test was above the threshold value of 0.05, as a result of which it was concluded that there was no statistically significant difference ($\chi^2 = 2.142$, df = 2).

By looking at the crosstabulation table, it can be concluded that the male respondents are extremely ready to use blockchain technology because they believe that, through collaborative learning and participation in the evaluation of the works of their colleagues, students contribute to a better evaluation of both student project works and the quality of the educational process in Serbia. In the case of female respondents, there was also a significant openness to this possibility that can be improved through collaborative learning based on blockchain technologies, analogous to the process of evaluating the results of scientific research work.

Based on the results, which were obtained using the chi-square test, it was determined that there were no statistically significant differences between the readiness of teachers engaged in higher education institutions of Serbia to apply the model of collaborative learning and evaluation of student works based on blockchain technologies and different levels of their education ($\chi^2 = 2.077$, df = 2).

Respondents with completed basic academic studies cited the fact that blockchain technologies in this case can be used to develop a secure platform for storing and exchanging data on student projects and works, student evaluators, practice reviewers, and evaluations as the most frequent reason. Once the student evaluation data are recorded, they cannot be denied or changed by any party.

Additionally, the application of blockchain technologies enables participation in the evaluation of student works to become part of the career development process. Evaluations and evaluated projects can be made available to interested employers. The employer would have information about the results of the students' practical work and how the project was evaluated by others. In addition to student-evaluators, a practical reviewer can be provided for student papers and projects. In order to select a competent evaluator, the evaluator's competencies will be mapped in relation to the topic of the seminar paper or project using key words and graphs. Review quality information for each reviewer will also be stored.

Using the chi-square test, it was also examined whether the application of blockchain technologies, which enables connection with partner higher education institutions, statistically significantly differs between respondents depending on their age. The test results (χ^2 = 2.106, df = 2) indicated the existence of a statistically significant difference between the age groups.

Table 1 presents the results of testing the general H0 hypothesis and it can be summarized as follows.

Table 1. Status of the tested, special, H1 hypothesis and associated additional hypotheses (Source: authors of the paper, own work).

General Hypothesis	Status
H0: There is a statistically significant difference between the demonstrated willingness of teachers to contribute to the application of blockchain technologies in Serbian higher education institutions and their demographic characteristics (gender, age, and level of education).	Confirmed
Additional Hypotheses	Status
H1: Are differences in the gender of teachers statistically significant for the introduction and application of blockchain technologies in higher education institutions?	Confirmed
H2: Did the differences in the level of education significantly affect the readiness of teachers engaged in higher education institutions of Serbia to apply the model of collaborative learning and evaluation of student works based on blockchain technologies?	Not confirmed
H3: Does the application of blockchain technologies that enable connection with partner higher education institutions statistically significantly differ depending on age of the respondents?	Confirmed

The Figure 7 show three different curves which represent the chi-square test for three degrees of freedom 2, 4 and 6. The test was used to investigate the impact of demographic characteristics on teachers' readiness to use blockchain technologies in higher education institutions.

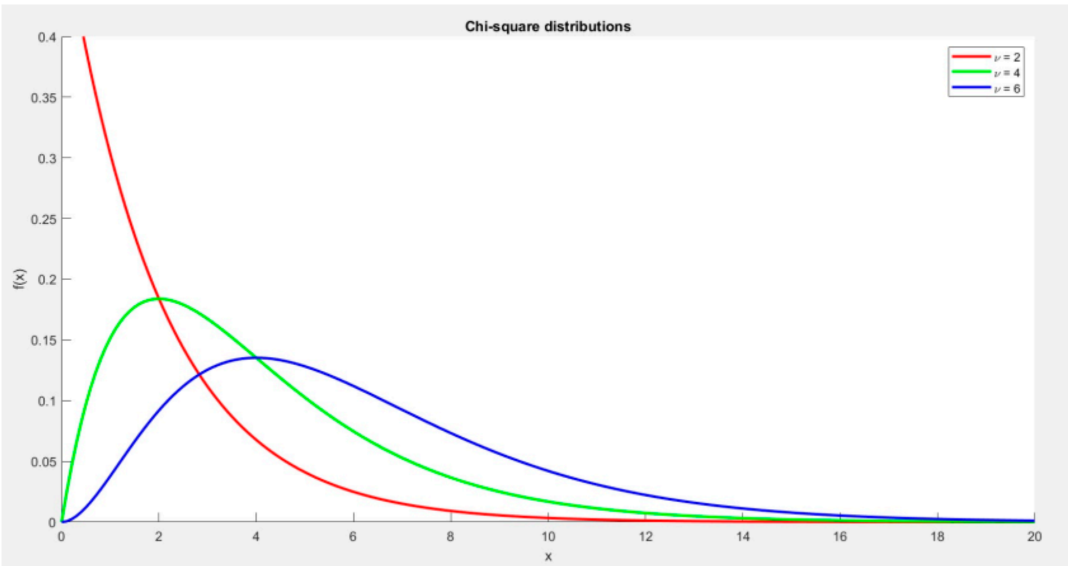

Figure 7. The impact of teachers' demographic characteristics on their readiness to use blockchain technologies.

6. Discussion

The general hypothesis H0 was verified by testing the auxiliary hypotheses H1, H2, and H3. The chi-square test was used to test the correctness of the supplementary hypotheses. Using this test, it was examined whether there is a statistically significant difference between the demonstrated willingness of teachers to contribute to the application of blockchain technologies in higher education institutions of Serbia and their demographic characteristics. Based on the fact that two of the three supplementary hypotheses are confirmed, it can be concluded that the general hypothesis, H0, is accepted.

This study sought to investigate teachers' willingness to contribute to the implementation of blockchain technologies in Serbian HEIs, as well as the potential effects of demographic characteristics on this willingness. The study's findings show that there is a statistically significant relationship between teachers' demonstrated willingness and their demographic characteristics, particularly gender and age.

This study discovered that male teachers are more willing than female teachers to contribute to the application of blockchain technologies in higher education institutions. This could be due to a variety of factors, including differences in technology experience and perceptions of its utility.

In terms of age, the study discovered that younger teachers are more willing than their older colleagues to contribute to the application of blockchain technologies. This could be because younger teachers grew up in a digital age and are more comfortable with technology, as well as being more open to new ideas and approaches.

This study also investigated the potential advantages of implementing blockchain technologies in higher education institutions. It was discovered that the use of blockchain technologies allows for participation in the evaluation of student work as part of the career development process. This is especially advantageous for students because evaluations and evaluated projects can be made available to interested employers, providing them with valuable information about the outcomes of students' practical work and how projects were evaluated by others.

Furthermore, the study discovered that by incorporating collaborative learning into e-education, better evaluation of student work is enabled, project-oriented learning is encouraged, and the educational process's quality is improved. Students gain new knowledge, skills, and competences through collaborative learning and participation in the evaluation of their colleagues' work, which contribute to a better evaluation of student work and the quality of the educational process.

This study has provided light on the potential benefits of implementing blockchain technologies and collaborative learning in Serbian higher education institutions. It also emphasizes the importance of taking demographic factors into account when planning for the implementation of such technologies, as different groups of teachers may have varying levels of willingness to contribute to their implementation.

The application of blockchain technologies allows participation in the evaluation of student works to become part of the career development process. Evaluations and evaluated projects can be made available to interested employers. The employer would have information about the results of the students' practical work and how the project was evaluated by others. In addition to student-evaluators, a practical reviewer can be provided for student papers and projects. In order to select a competent evaluator, the evaluator's competencies will be mapped in relation to the topic of the seminar paper or project using key words and graphs. Review quality information for each reviewer will also be stored.

By introducing collaborative learning into e-education, better evaluation of student works is enabled, project-oriented learning is encouraged, and the quality of the educational process is improved. Through collaborative learning and participation in the evaluation of the works of their colleagues, students acquire new knowledge, skills, and competences and contribute to a better evaluation of student works and the quality of the educational process.

Students have the possibility of mutual project collaboration, where they must act as a team in order to understand the concepts presented to them. By defending their positions, reframing ideas, listening to other points of view, and articulating their points of view, students gain a better understanding as a group than they could as individuals. Teams of students have the opportunity to solve certain tasks together, set problems, or cooperate in mastering new concepts.

Using collaborative learning combined with a multi-frontal teaching method supported by blockchain technologies is a promising approach to enhance the learning experience and outcomes. However, there are several limitations and challenges that need to be considered.

One of the primary challenges is the technical aspect. The adoption of blockchain technology in education requires a certain level of technical expertise and infrastructure. Additionally, blockchain technology is still in its early stages, and there are several technical issues that need to be addressed, such as scalability, interoperability, and security [82].

Another challenge is the pedagogical aspect. Collaborative learning and multi-frontal teaching methods require significant changes in teaching practices and strategies. Educators need to be trained to use these methods effectively and to create a supportive and inclusive learning environment [83].

The adoption of this approach also poses challenges. The adoption of collaborative learning and multi-frontal teaching methods supported by blockchain technology requires institutional support and resources. Moreover, learners and educators who are accustomed to traditional teaching methods may resist change [84].

The ethical and legal implications of using blockchain technology in education also need to be considered. There are several issues related to data privacy, ownership, and security that need to be addressed, and educational institutions need to develop clear policies and guidelines to address these issues [85].

Finally, the cost aspect of adopting this approach is also a challenge. The adoption of blockchain technology in education can be expensive, and the maintenance and upkeep of the blockchain network require ongoing resources and investment [86].

Overall, while using collaborative learning combined with a multi-frontal teaching method supported by blockchain technologies has the potential to revolutionize the learning experience, careful consideration of the limitations and challenges is necessary to ensure successful implementation and adoption.

According to the findings, using blockchain technology in Serbian HEIs has a number of benefits. It allows students to take part in the evaluation process, incorporating it into their professional development. It also provides employers with information about student projects and how others rated them, which can be helpful during the hiring process.

It is also suggested that collaborative learning be incorporated into e-education, which can improve project-based learning and the overall quality of the educational process. Students can work together as a team to gain a more comprehensive understanding of the concepts presented to them. By defending their positions, listening to opposing viewpoints, and articulating their own ideas, they can gain new knowledge, skills, and competencies.

7. Conclusions

Finances are an issue for many educational institutions, especially in low-income and developing countries. New technologies require significant technical and instructional resources. Additionally, blockchain technology is often costly and energy intensive. This model's solutions may help. Governmental institutions may be requested to take a more active role in formulating data protection policy and funding. A green blockchain consensus mechanism [87] is another alternative for a more eco-friendly CLSW architecture.

Increasingly, businesses are focusing on existing and future employee capacities in light of I4.0 digitalization and labor need. A reputation service overview, i.e., the top students at the source, is defined as an employer's obligation. Professionals may play a crucial role. Experts can help identify current difficulties and faults in proposed solutions.

They can help teachers adapt educational courses to market demands. Dual education systems are already in place in many countries, and may be a suitable starting point for increased collaboration between HEI and companies and wider implementation of the recommended model or particular principles from this project.

To assess student work, authors propose a blockchain-based model. The article describes a new blockchain-based collaborative learning and assessment mechanism for student work that improves student work evaluation, project-based learning, and overall educational quality. Data integrity is ensured via blockchain [88,89]. This is a new methodological innovation. Teachers report more efficient work and faster project completion using the recommended paradigm. The authors' next study will disclose the findings. Hence, future research will have more data sources. The project's faculty and partner HEIs will conduct more research on integrating the established model with formal learning systems. A more open basis is preferred.

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