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PAPER

Blockchain-Based Mobile Learning Management Applications: An Intensive Examination and Future Research Opportunities

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ABSTRACT

Instant access to information without reliance on desktop or notebook computers has been made possible by the increasing development of mobile technologies and the Internet. Blockchain technology is garnering significant interest from researchers, academics, and practitioners due to its unique properties, including data reliability, security, and transferability, as the use of information technology continues to increase over time. The financial, healthcare, and supply chain management sectors have all been impacted by the rapid development of blockchain technology. Because of its special qualities, such as decentralisation, dependability, and security, this technology has recently also been used in education. To provide readers with a complete understanding of the current state of affairs, including its benefits, drawbacks, existing applications, and possible future applications in other academic disciplines, this study aims to present an extensive assessment of the literature on blockchain technology in education. The current application of blockchain technology in education is described in the study along with its benefits and drawbacks. The main objectives of using blockchain technology in education were systematised as a result of the findings: identifying students, assessing the university's level of accreditation, arranging the educational process, encouraging lifelong learning, protecting intellectual property, paying tuition, providing student loans, verifying the validity of the issued education document, helping with adult professional education, and ranking universities when they receive grant funding.

KEYWORDS

mobile learning, Blockchain technology, education management, healthcare, institution, academics

1 INTRODUCTION

The new technology known as blockchain was first presented in 2008. Originally, it was used to record Bitcoin transactions in a peer-to-peer ledger [1]. The goal was to

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remove all middlemen and enable direct user-to-user transactions. The blockchain was created as a self-governing network of peer servers in order to do this. The following is what each network node does:

- conserves a copy of the communications ledger;
- adds an admittance to its journal upon receiving consensus from other nodes;
- announcements any user transactions to the other nodes in the network; and
- Commonly verifies that the ledger it maintains matches the ones across the entire system.

Practitioners and academics are becoming more aware of the vast possibilities of the underlying technology behind Bitcoin as its popularity continues to rise. It was discovered that the special qualities of blockchain, such as rigidity, openness and reliability, were beneficial not only for cryptocurrencies but also for a wide range of other industries. As a result, more and more sectors have seen the development of blockchain-based applications.

Blockchain technology has attracted a lot of attention lately because of its potential to revolutionise a number of industries. The Distributed Ledger Technology (DLT) concept lies at the heart of this expertise. A distributed system called DLT enables numerous people to work together to update and maintain a single database; by doing away with the need for a single source of truth, this method allows for more transparency and data's unchanging nature. Blockchain is the most well-known and well-studied DLT application in terms of both real-world use and scholarly study [2]. Blockchain serves as a decentralised, transparent ledger that guarantees safe recorded transactions and certification over a network of linked computers. Decentralisation, immutability, consensus processes, and secure encryption are its guiding concepts.

The inception of Bitcoin in 2008 marks the beginning of the past of the Bitcoin blockchain. The blockchain knowledge that underpins cryptocurrencies was first introduced by Bitcoin, which was established by Satoshi Nakamoto, a pseudonym. But blockchain's potential soon outstripped its original application. Blockchain has developed over time and now finds use in a number of sectors outside of finance. Because of its transparency and security, it is being investigated in several fields, including e-learning, open banking, logistics control, healthcare, and safety analysis.

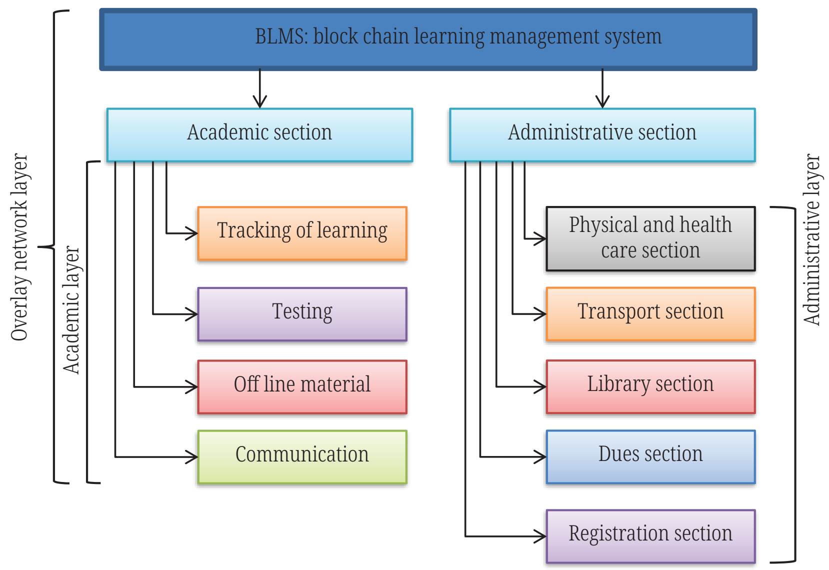

Fig. 1. Blockchain-based solution for learning management

Decentralised ledger technology is integrated into blockchain-based learning management systems to increase the dependability, security, and openness of educational records. Conventional LMS systems sometimes depend on centralised servers, which are susceptible to limited interoperability, data breaches, and tampering. By guaranteeing safe credentialing, immutable record-keeping [3], and student ownership of data, blockchain can address these problems in Figure 1.

The remainder of the paper is organised in this manner. Section 2 looks at the characteristics of blockchain technology and how it might be used in the e-learning industry, as well as relevant research and the field's constraints. We outline the research approach in Section 3. We provide the results of answering the research questions in Section 4. The discussion is introduced in Section 5, and the limitations of our review are rounded up, and some future research areas are presented.

2 RELATED WORKS

This section of the research will describe the e-learning industry, its drawbacks, and how blockchain technology might help overcome them. We will look at the key characteristics of blockchain and investigate several researches pertaining to e-learning initiatives based on blockchain technology.

Additionally, the Open Web Application Security Project issued a list of the top 10 threats for mobile devices and collected data on security flaws. The dangers fall into the following categories: poor client code quality, code abuse, hacking, insecure data storage, insecure interaction, insecure authorisation, absence of cryptography, insecure permission, and inappropriate platform utilisation [4]. Both developers and users can learn from real-world instances of mobile app safety vulnerabilities. One example was a security vulnerability in Amazon's Ring Neighbours app that revealed users' exact whereabouts and residential addresses when they posted publicly, even though the messages were initially intended to be public but not location-specific. Another incident involved the Slack mobile app, which caused users to change their security passwords after unintentionally logging user credentials in plain text on devices. Before being fixed, vulnerabilities in SHAREit, a well-known Android file-sharing application with over 1 billion installations, allowed malicious code to run on smartphones for a long time. Furthermore, up to 100 million customers' personal information is at risk due to 13 Android apps that employ unreliable cloud providers.

Blockchain is a novel transaction technology that functions as a distributed computer network-managed digital data storage system linked by cryptography. Blockchain contains data that may be validated by another server. Some participants in the blockchain network can reach a consensus regarding the splitting process's share status and exchange transaction data between computer networks. Every member of the computer network does not need to rely on a trustworthy central point for the process to function [5]. With blockchain technology, a transaction no longer needs to rely on a single server because it is duplicated throughout the current network. As a result, blockchain ensures storage security by offering unaltered storage. To avoid third-party interference and alteration, the blockchain implements a procedure for adding or changing transactions without erasing transaction data. Blockchain has emerged as the foundation of modern cryptocurrencies based on its dependability characteristics. Since each block on the public ledger represents a system that is interconnected, any attempt to alter data in one block must also alter data in adjacent blocks.

By adopting Education 4.0, which encourages creativity and originality and maintains the flexibility to respond to the implications of Industry 4.0, where machines are interrelated and capable of autonomously communicating and cooperating throughout the manufacturing and production processes, educational institutions, and universities in particular, bear the burden and have the opportunity to produce graduates prepared to navigate the challenges of the new era. The blueprint for education's future, where students anticipate learning experiences that mirror and improve their daily lives and where human and artificial intelligences collaborate through a symbiotic web to question and generate new possibilities [6], is at the core of Education 4.0. Since Industry 4.0 seeks to equip engineers to manage digital technologies, Engineering Education 4.0 is particularly important to accomplishing this aim in a highly sophisticated and globally interconnected environment.

The first step is to forecast students' academic performance at the conclusion of a four-year course [7]. The second is examining children's development and integrating it with the outcomes of forecasts. Based on their achievement levels, he divided the students into two groups: poor performance and high achievement. Based on his research, educators need to focus on a small number of classes that exhibit particularly high or low performance in order to give prompt warnings, support underachievers, and offer direction and chances for high performers. Artificial intelligence has the ability to expedite handling documents and provide all the facts required for human decision-making, stopping human error. The history of document management began with the invention of the filing cabinet at the close of the seventeenth century. Paper documents are arranged in boxes within foldable cabinets using a vertical filing system developed by Edwin Granville Seibels in 1898. In the business sector, these cabinets would continue to be the primary method of document storage for the majority of the 20th century.

Since it uses digital technology to support its learning settings, the idea of remote education has led to the development of e-learning, online learning, and mobile teaching and provides flexible means of education. The phrase "ubiquitous learning" or "u-learning" has really been used in literature for "schooling for everyone, everywhere, at all times." But as was already said, proving one's involvement and experience is one requirement for flexible access to education, and "security" in u-learning contexts is another. Technology is attempting to address these two demands that resulted from the freedom it offered in education (as well as possibly some other needs in the future [8]). It is beneficial to have a basic understanding of this innovation, which is also referred to as blockchain technology and is utilised in connection with digital currencies.

The authors have demonstrated the advantages of employing MEC in conjunction within the context of the web of Smart Vehicles, using cloud solutions for the duration of electric vehicle auto-charging [9]. The authors have suggested energy-harvesting models that enable energy savings at the nodes; the mobile nodes must transfer tasks to nearby mobile edge structures. The mobile nodes have also tried to use an edge-centric methodology for multidimensional authentication in order to determine the optimal load distribution between edges and online biometrics patterns. For simultaneous job offloading between a mobile device, the edge network, and the cloud, the authors used a spatial Markov decision process to lower energy use, administration time, and communication cost.

Smart contracts, which some blockchains support, resemble software programs but are stored on the blockchain and run independently by any user on the internet. These smart contracts can read data, record transaction results, and even initiate activities in off-chain networks. Additionally, they can use oracles—hardware or software machines that provide intelligent contracts with external data and/or transmit data to the outside world—to read and write information obtained from the blockchain alongside various sources [10]. To increase trust, every transaction is impermeable and documented in the blockchain. The blockchain network's subjects, or peers, produce and exchange transactions that change the network's state, and reliable documentation of one or more of these events can be found in each block. Before new information may be uploaded to the chain, network peers must concur that it is accurate. The particular blockchain and its objective determine the transactions' substance. For instance, in Bitcoin, the primary data recorded are Bitcoin transactions between accounts.

3 METHODS AND MATERIALS

3.1 Overview of blockchain

These days, there are three widely accepted categories of blockchain systems, each with its own architecture and management.

1. **Public the distributed ledger:** everyone can participate in the consensus-building management, and all transactions are accessible to the general public. Even though this kind of blockchain is extremely unchangeable, it is not very efficient.
2. **Private blockchains** are owned by a single entity, and participation in the consensus process is limited to nodes from that entity. Compared to public blockchains, private ledgers are less immutable but have greater efficiency [11].
3. **Consortium blockchains** combine the two earlier system types in that not all users are affiliated with the same organisation, and that only a predetermined number of users are permitted to take part in the decision-making process. However, in terms of consolidation, consortium blockchains lie in the middle of centralised private and decentralised public blockchains; they share consistency and efficiency with private blockchains. Another name for this kind is a permissioned network.

3.2 When can blockchain be helpful?

One of the most talked-about, if not overhyped, technologies is blockchain. It does not apply to every project. Relational databases are a more reliable and well-established technology that can be used for most tasks. However, there are several situations where blockchain technology can be used. [12] Has provided a fair set of rules for when using blockchain technology into a project may be beneficial. In particular, blockchain could be beneficial if certain circumstances are met [13]:

- To function as a collective ledger, the project will require an identical database;
- Multiple writers will be involved in the creation of transactions that will alter the database.
- Additionally, a copy of the database will be held by the writers, who will communicate transactions among themselves;
- Lack of trust: users refuse to let other users edit their own database entries; disintermediation: several untrustworthy entities want to function without a single, reliable middleman;

- Transaction communication: various users' transactions rely on one another;
- Set of rules: Given the aforementioned situations, it makes logical for the database to have rules that restrict operations;
- Property keep: the blockchain serves as an actual asset registry;
- Authoritative event log: all users have accepted the contents of the blockchain, which serves as the final transaction log.

Blockchain innovation may be a suitable fit for the endeavour if all or most of these requirements are satisfied. Upon reflection, it will become evident that these characteristics are present in many educational use cases.

3.3 Platforms for blockchain

In recent years, several platforms for creating blockchain systems have been created. These include some of the most well-liked ones:

- **Ethereum [14]:** Ethereum includes Ether, a digital token that may be used to purchase "gas", a computational unit carried out by smart conventions (letterings) that are executed on the Ethereum Virtual Machine. The consensus protocol used by Bitcoin, known as Nakamoto consensus, has been changed and is supported by Ethereum. Ethereum is frequently utilized in the growth of peer-to-peer.
- The R3 blockchain technology business created Corda. Corda is an open-source platform for smart contracts and distributed ledgers that was created with commercial needs in mind. Although Corda lacks a native token and is permissioned, it is more customized and designed to meet the demands of the financial services sector, much as Hyperledger Fabric.
- Openchain is open-source CoinPrism developed a blockchain platform for companies wishing to safely and scalable issue and manage digital assets. With enabled smart contracts and partitioned acceptance, users can create several instances under a single authority. Bitcoin can be connected to openchain tokens. Openchain features client-server architecture in place of the more widely used blockchain P2P design. Additionally, since consensus doesn't require a miner, transactions are quick and inexpensive.
- BigChainDB is an open-source distributed database system that aims to combine the advantages of NoSQL databases (spread out storage, permanence, and lack of a corporate authority) with blockchain technology [15]. The immutable transaction information kept in the many NoSQL database nodes (like MongoDB instance) that comprise BigChainDB is synchronized using the Tendermint Byzantine Fault Tolerance consensus technique. BigChainDB can be public, private, or permissioned.

3.4 Positive and negative aspects

- Blockchain functions are comparable to a ledger that uses electronic certificates and fingerprints to store digital documents and transmit data across a computer network. Nonetheless, in the educational setting, it facilitates openness and constantly authenticates. It makes academic and pedagogical metrics accessible using complex cryptology techniques that ensure the system's authenticity.

- For instance, a distributed ledger, the easiest way to describe blockchain software, is a decentralised record that confirms who owns a digital asset. Blockchain applications such as Tutellus and Khan Academy have previously undergone testing. Peer-to-peer learning between students, teachers, and business professional networks is promoted by these platforms. To prepare teachers to offer individualised learning experiences through advances in curricula, teaching strategies, and digital resources, it is imperative to empower them with the necessary abilities for market labour.
- A "hybrid model"—As a result of the disruption of education and the rise of technology, innovative blockchain-based sites such as Khan School, there is now more virtual contact through Zoom, Facebook, Amazon, MOOCs, Google Classroom, and other cutting-edge services, as well as the emergence of Tutellus, Sony Global Educational (SGE), APPII, SuccessLife, TeachMePlease (TMP), GradBase, ODEM, Blockcerts, Papers, and Echolink.

4 IMPLEMENTATION AND EXPERIMENTAL RESULTS

4.1 Developing improved educational resources

All of the features mentioned earlier might be added to systems such as SGE, Edgecoin, and Tutellus. In order to access learning resources, such as virtual reality classes, and other educational services, users can purchase internal tokens on these platforms. They may ask friends to sign up so they can earn tokens. Additionally, when users engage with their work, professors receive more tokens. Blockchain guarantees that students, teachers, and devs can communicate quickly. Blockchain facilities will be a viable option for higher education as learning and collaboration become less dependent on physical location. Ullah and co-workers found that although certain schools employ blockchain technology to maintain final scores and academic standing, others use it to accomplish learning objectives. Grade-based exams and a higher education degree are prerequisites.

4.2 The connection between student engagement, motivation, collaborative work, learning performance and blockchain

A blockchain application should track all interactions between various member categories on a MOOC platform. When a student completes a task exceptionally well, they are eligible to receive credit points. Additionally, educators can receive credit points for every exceptional video or simulated reality course that is released for efficient education and student engagement. These points can be used for vouchers good for savings on educational resources or virtual currency.

To sum up, the platform might provide both free and essentially paid online courses. This technology will guarantee a sustained instructional approach and high levels of involvement between professors and students on the platform. Additionally, rather than teaching pupils content, this method will help them develop competencies. Besides that instead of teaching students STEAM, instead of discipline-specific skills, it will help students create transferable zeros, which will motivate them to solve issues and think like institutions. The platform can encourage critical thinking, teamwork, communication, and creativity in students in this way. When a teacher enters an online classroom and poses a question, presents an issue, or assigns a particular activity for the students to do using their knowledge and abilities, it can encourage critical thinking. The teacher might provide hints to the students if they are unable to answer the challenge. After considering problem-solving strategies, the instructor leads the class to a video or experiential lesson, simulation software, or a particular game where he goes over all of the material. The instructor will provide the lesson at this point. Put another way, by assigning pupils to work in small groups to complete a project or an issue, the instructor can encourage teamwork. Teachers can encourage student cooperation, interaction, and innovation in this way.

Table 1. The process of validating reflexive constructions

Spontaneous Construct	Amalgamated Reliability (>0.7)	Chief Cronbach (>0.7)	AVE (>0.5)	√AVE (>0.5)
V1	0.874	0.872	0.583	0.763
V2	0.889	0.889	0.667	0.817
V3	0.892	0.891	0.582	0.763
V4	0.931	0.925	0.626	0.791
V5	0.936	0.935	0.701	0.837

Table 2. Consequences of bootstrapping

Conduit	New Sampling	Section Mean	Std. Dev.	T Stat	p Values
V1_motivation -> V2ColabWork	1.907	1.908	1.053	12.132	1.000
V2ColabWork -> V3_engagement	1.935	1.937	1.048	20.342	1.000
V2ColabWork -> V5_blockchain	1.655	1.661	1.099	17.628	1.000
V3_engagement -> V4_LernPerform	1.977	1.978	1.023	51.813	1.000

Source: SmartPLS output.

4.3 Methods of research

The authors created a poll that took into account the previously mentioned V1, V2, V3, V4, and V5 factors based on the literature study. Additionally, they examined techniques like MOOCs, AR, VR, gamification and teleconferences from the viewpoint of the students.

The following presumptions form the basis of our analysis:

- ***First hypothesis (H1).*** *Student Collaborative Work (V2) is significantly and favourably impacted by Student Motivation (V1);*
- ***Hypothesis 2 (H2).*** *Higher levels of student involvement in the learning process are linked to student collaborative work (V2);*
- ***Hypothesis 3 (H3).*** *Block chain is used in HE to bootstrap student collaborative work for a large audience (V5); and*
- ***Hypothesis 4 (H4).*** *Student learning outcomes (V4) are positively correlated with student engagement (V3). The learning performances in HE were bootstrapped by student involvement.*

The data was coded, and information was extracted using the correlation matrix, composite dependability, Cronbach's alpha, bootstrapping, and other analytical techniques and applications (refer to Tables 1 to 3) (see Figures 2 and 3). The variables were mined using SmartPLS3. After analysing the data and factors and verifying the reliability of the approach, we developed three regression frameworks on the assumption that this hypothesis was endorsed.

Table 3. Regression coefficient and variables

Intercepts	Standardized	V1_Motivation	V2_ColabWork	V3_Engagement	V4_LernPerform	V5_Blockchain
V1_motivation	Constant					
V2_ColabWork	0.378	0.803				
V3_engagement	1.124		0.837			
V4_LernPerform	0.464			0.895		
V5_blockchain	1.445					0.602

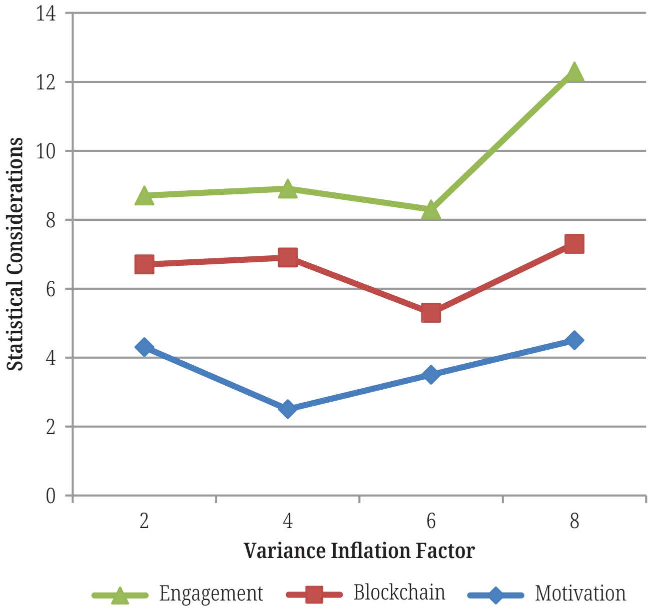

Fig. 2. The process of bootstrapping

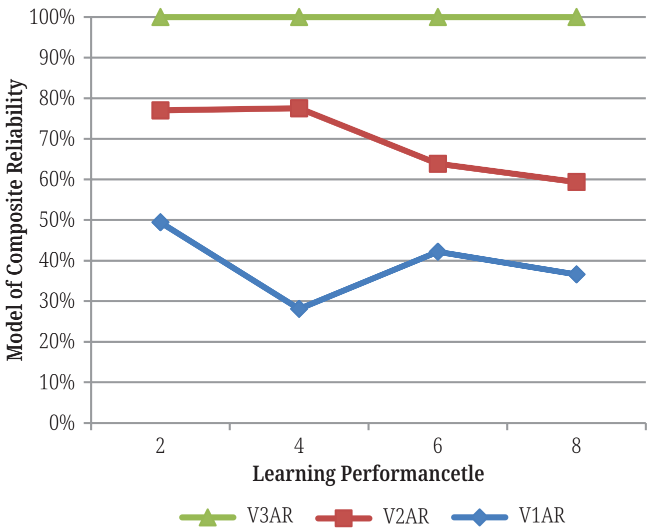

Fig. 3. Model of composite reliability

Finding the significance and impact of student enthusiasm, teamwork, appointment, and blockchain on erudition outcomes was the aim of the study.

The structural model of analysis is displayed in Figure 3. "Student Motivation" is the name of the first variable, V1. We check if factors such as student collaboration, MOOCs, AR, VR, and gamification have an impact on V1 using Cronbach's alpha. "Student Collaborative Work" is the name of the second variable [16], V2. We use Cronbach's alpha to determine whether MOOCs, AR, VR and gamification have an impact on V2. "Student Engagement" is the name of the third variable, or V3.

We examine if student motivation, MOOCs, AR, VR, gamification, and collaborative work have an impact on V3 using Cronbach's alpha. "Learning Performance" is the name of the fourth variable, or V4. We examine if student collaboration, motivation, engagement, MOOCs, AR, VR, gamification and online courses have an impact on V4 using Cronbach's alpha. The variables and corresponding indicators are shown in Table 1. V5, or the fifth variable, is called "Blockchain". A large audience uses blockchain in HE, and we examine if MOOCs, AR, VR, gamification, blockchain infrastructure and video conferences have an impact on V5 using Cronbach's alpha.

4.4 Discussion

The study explores the possible uses of blockchain in higher education institutions (HEIs) while examining the influence of incentive on collaborative work at these organisations.

We will discuss the findings of our research based on survey data, document analysis, or observation, depending on the methodology selected in this paper. Blockchain can offer decentralisation, security, and integrity in addition to invisibility and anonymity.

Additionally, it can be viewed as an agreement-based process that, like an intelligent contract, compensates college campuses, instructors, and trainees. Universities have been able to improve the calibre of their programmes by utilising this technology. Additionally, it allows less knowledgeable people to engage with mentors and colleagues who possess greater knowledge. Lastly, this study aims to advance our present knowledge of blockchain implementations.

Additionally, the significance of documentation authentication must be linked to speeding up the procedure and cutting down on expenses and paperwork. Last but not least, blockchain is a completely inclusive method that enables the integration of the most varying learning levels as well as various backgrounds and individuals. In this sense, blockchain can be linked to the idea of sustainability, particularly in light of the potential for new technology to enhance learning in higher education.

5 CONCLUSION

Blockchain technology is relatively new in the educational space. As a result, an analysis of the most current blockchain research in the field of education was conducted.

According to our study, student collaboration increases with increased motivation, which is mostly brought about by innovative teaching methods and technology. MOOC systems, blockchain technology and virtual reality and augmented reality applications specifically designed for education enable interaction and cooperation between students and/or teachers. Gamification turned out to be a crucial instrument for fostering engagement, creativity, critical thinking, and interactivity. In times of emergency, videoconferences proved to be a useful tool for remote instruction. Any activity in which students cooperate in groups or pairs is considered collaborative. Blockchain may have an effect on how well pupils collaborate.

Given the constraints of the research, we will continue to explore novel applications for blockchain technology. Furthermore, the first HEIs to use blockchain technology did not cover all facilities. Given the limited degree of digital knowledge and the intricacy of blockchain technology, this is currently a drawback.

Additionally, there isn't a digital answer for students' cognitive and socio-emotional growth. We keep looking for answers, mostly in the form of psychological support. We're still waiting on the psychologist's responses.

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