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Development of a Distance Education Platform Providing Secure Data Storage and Tamper-Proof Certification: Robust Guard

[1*]Remzi GÜRFİDAN
[1]*Isparta University of Applied Science, Yalvac Technical Sciences Vocational School;*

Abstract:
Distance education is a learning model in which students and teachers carry out education and training activities through internet-based technologies without being in the same physical environment. This model makes it possible to reach wider masses by eliminating geographical restrictions and allows individuals to learn at their own pace and at convenient times by offering time and space flexibility. In the study, challenges such as security of documents, student authentication and exam security in distance education are discussed and it is emphasized that these problems can be overcome largely with blockchain-based solutions. Using blockchain methods, students' exam results and certificates are securely stored and protected against tampering. Performance measurements of the transactions performed on the blockchain are carried out and the upper limits of the prepared infrastructure are tested and determined. These experiments are important in determining the scalability of Robust Guard and its service against intense data flow. According to the experiments, the capacity of the network starts to strain after 60 units of data. The aim of this study is to develop a distance learning platform with secure storage and certification services and to provide a more secure alternative to existing distance learning frameworks.
Keywords: Distance education, secure e-studio, data security, blockchain

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I. Introduction

Moore et al., distance education activities are described as a form of learning where instructors and learners carry out education and training activities in virtual environments using technology-based resources without being physically present. This method of education can reach a wide audience which saves the participants at a distance from the inconvenience of having to be at a specific place regardless of where that place is located; hence students can access learning opportunities at their own pace, anytime, anywhere to continue their education(Michael Moore et al., 2012). It can transform an episodic and demanding education into a permanent and efficient one through use of various technology-based learning resources and materials an idea mentioned by Hodges et al., stating that distance education has been popularly used during past pandemics like COVID-19 and continues to be used today.Education can be attained only in a physical classroom and sometimes at exorbitant costs, plus geographical barriers to education are the main benefits of education: this is distance from the goals of distance learning(Hodges et al., 2020). However, it offers children opportunities to learn at their own pace through repetition. Discipline problems are limited among groups not physically together and they do not engage in activities that disrupt course discipline unlike other cases. This flexibility inexpensive learning resources and easy access to materials make up distance education since an individual can learn from anywhere with an internet connection in their environment that is accessible from where they work or reside.(Means et al., 2009) described flexibility criterion as the ability of students to choose what subjects they study and in what order. In distance education, based on the cost-effectiveness definition both educational institutions and students save significant amount of money; for instance, accommodation plus training costs spent during the training are reduced significantly (Bernard et al., 2004).

In addition to various disadvantages, distance learning also presents document and data security issues. Issues such as student identity authentication, exam security, and certificate verification are the major obstacles that distance learning must overcome (Rowe, n.d.). For a secure and effective distance learning environment, it is essential to prevent identity theft and exam cheating. According toWatson& Sottile, 2010, technological methods such as biometric authentication, security scanners, and proctoring software can help address these issues. The issue of secure data storage is a significant barrier to distance learning, and solutions are needed to securely store students' personal information. Data and course materials to prevent data breaches (Rowe, n.d.).To ensure data security, strong encryption techniques and secure authentication protocols must be used. This is achieved by using distance learning platformsclaims that it is also necessary to verify the user's access authorization. The benefits of distance learning, including its accessibility and flexibility, have made it increasingly popular. If distance learning is to become more reliable and successful, gaps in document verification and data security must be addressed. (Meyer & Barefield, n.d.)argue that technological solutions and security measures can help address these issues in distance learning.

II. Related Works

In their study, Kataev and his colleagues developed a brand-new blockchain-based system for keeping track of student data that are accumulated during a higher education institution's academic program. Every block of created records has four different kinds of student data. These include participation in research, accomplishments in the arts, and intellectual pursuits. The suggested approach suggests utilizing blockchain and integrated machine learning technology, involving the educational institution, students, and possible employers. The work's uniqueness helps to ensure that the system maintains comprehensive and correct data regarding the student's and university's entire learning process, preventing fake degrees, e-portfolio errors, and educational record falsification(Kataev&Bulysheva, 2022).This research comprises an in-depth examination and assessments on the application of blockchain technology in science education. The article's goal is to organize the potential applications of blockchain technology in university operations. The approaches of analysis and synthesis, generalization, and comparison were employed in the article preparation process. The research has led to the systematization of the primary uses of blockchain technology in education, including: managing the institution's accreditation level; identifying students on campus; organizing the educational process; promoting lifelong learning; safeguarding intellectual property; covering tuition costs; granting student loans; and confirming the legitimacy of educational documents issued(Mihus, 2020).Shrivastava and his team propose a system that will not only speed up the verification process, but also increase the security of personal education data and control any kind of misuse. Keeping documents on the Blockchain will increase security and make all data accessible only with a private key and authentication in accordance with that private key. We thus propose a private Blockchain that will be managed by some private vendors, and only these vendors will participate in the consensus. Therefore, proof-of-stake consensus has been used. A private IPFS database server is used to store our documents on the Blockchain(Shrivastava et al., 2019).Wang and his team offer an educational cloud service, a critical infrastructure for the smart campus. State-of-the-art educational clouds are often developed and maintained by individual schools. The isolation nature causes this data to be easily tampered with, leading to malicious tampering and information fragmentation. Blockchain technology is ideal for solving these problems. We present EduBloud, an educational cloud driven by a heterogeneous blockchain architecture, which combines the benefits of consortium, public, and private blockchains. Compared to homogeneous blockchain applications, the system exhibits superior dependability, reduced latency, higher data throughput, and better economic efficiency (Wang et al., 2019).

Han and colleagues describe an innovative blockchain-based approach to protect individuals' official school records and provide an environment that makes it easy to share this information with others. The solution leverages the intricate subtleties of blockchain technology to expedite the production of certification documents by educational establishments, providing unquestionable evidence of achievement or fulfillment. The suggested framework may make it easier to carry out pertinent tasks in the context of higher education after graduation(Han et al., 2018).Puthal and his colleagues' research undeniably shows the influence of blockchain technology on security and privacy. The research conclusively demonstrated that the decentralized nature of blockchain provides a strong protective barrier for data security and protection. It also highlighted the unparalleled potential of blockchain for managing and storing data securely in an educational environment. The writers expressed their strong belief in the benefits of blockchain technology for regulating data access and ensuring its authenticity(Puthal et al., 2018).Kshetri was straightforward in his opinion regarding the potential of blockchain technology to address privacy and security concerns. His strong belief was that a decentralised structure is the most effective defense against unauthorised access and data leaks.Chen's research offered a thorough examination of the advantages and applications of blockchain technology in the field of education. She demonstrated the secure management of educational information, including using blockchain technology for verifying records. Moreover, the research unequivocally demonstrated that blockchain technology guarantees the integrity and security of student information (Chen et al., 2018).Esposito et al. likewise It has been clearly demonstrated that blockchain technology can achieve reliable and secure data storage. They present a strong argument for the decentralized aspect of blockchain, emphasizing how it maintains data security and integrity. They also discuss the additional advantages and various examples of how it can be used in educational record-keeping and authentication(Esposito et al., 2018).

III. Developed Distance Education Platform: Robust Guard

Figure 1 depicts the secure distance learning website. The platform's interface and navigation options are presented in a link bar located at the top of the page. Registered users are required to input a username and password in the login form, located on the left-hand side of the page, in order to gain access to the system. The primary display area presents an overview of the user population, including the number of general users, active users, and inactive users. A list of videos accessible via the platform is provided at the foot of the page. The list comprises the following information for each video: name, ID number, iframe details and course name. Additionally, the platform affords users the ability to edit and delete videos.

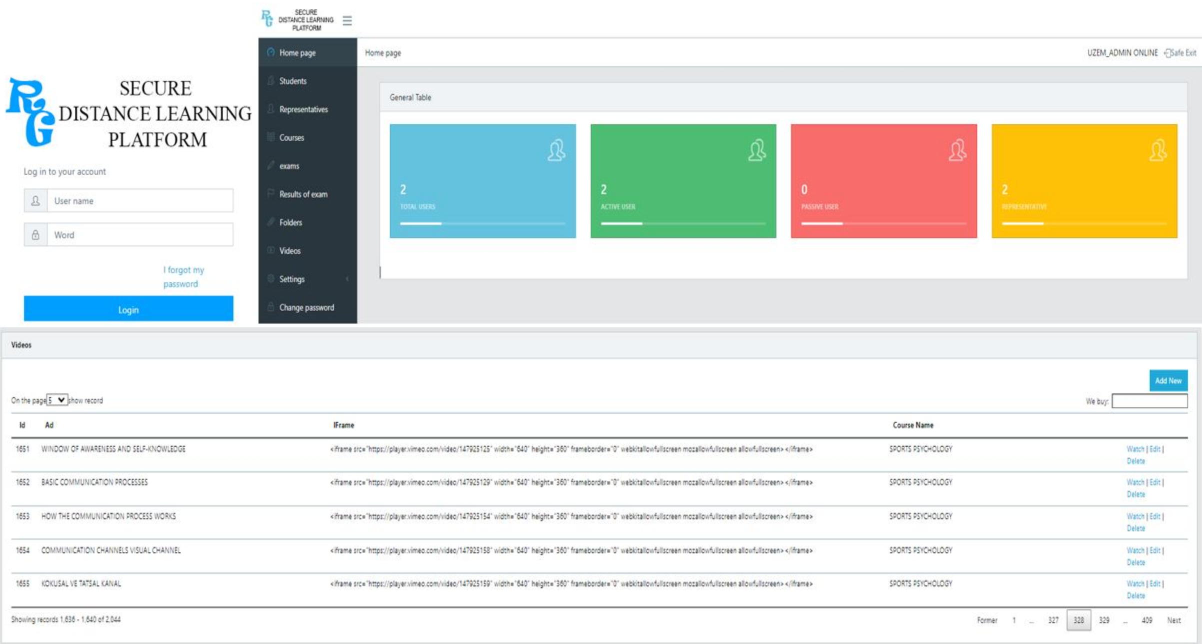

Figure 1.web page images of the distance education platform.

A secure online learning platform's "Documents" page is displayed in Figure 2. An interface for managing course-related papers is available on this page. There is a button to add a new document and a drop-down menu at the top where you can choose how many entries to display. The document list is arranged tabularly, with each row containing the name, ID number, file name, server file name, and course name of the document. The "Edit", "Detail", and "Delete" links adjacent to each document allow users to make changes, examine the document's details, or remove it.Users can quickly identify which courses the documents belong to and locate and manage documents with ease thanks to this format. The range of documents listed facilitates faster access to and editing of the necessary resources for users, particularly in areas like family counseling and educational counseling.

Documents

Add New

On the page 25 show record

We buy:

Id	Ad	Server File Name	File name	Course Name	
1	Student Coaching	def5b39a-c550-4adb-9fd0-3089cfcd9ce8	9-10-2016-21-52-10.rar	STUDENT COACHING AND EDUCATIONAL CONSULTANCY	Edit | Detail | Delete
2	STUDENT COACHING EVRK1	62bea421-bda3-4efb-a09b-f93d6dfcd9f0	10-10-2016-00-44-10.rar	STUDENT COACHING AND EDUCATIONAL CONSULTANCY	Edit | Detail | Delete
3	INDIVIDUAL RECOGNITION TECHNIQUES	6c554afb-7e57-462c-87fd-9ceb4271fea7	10-10-2016-01-33-13.rar	STUDENT COACHING AND EDUCATIONAL CONSULTANCY	Edit | Detail | Delete
4	Contact Document-1	b42d6cf7-eb25-4af4-a843-c08ab3c802fc	7-5-2015-22-28-16.ppt	FAMILY COUNSELLING	Edit | Detail | Delete
5	Contact Document-2	d9362296-3d60-41b7-87dc-c414b94ec6d5	7-5-2015-22-29-37.ppt	FAMILY COUNSELLING	Edit | Detail | Delete
6	Metropolitan	60f180df-bfe6-4992-a1a7-ac07ba11074d	10-6-2015-10-47-04.rar	FAMILY COUNSELLING	Edit | Detail | Delete
7	Objective Test 2	7dc88247-d3c1-469b-9416-8f8b62fbaba1	10-6-2015-10-48-06.rar	FAMILY COUNSELLING	Edit | Detail | Delete
8	Objective Tests 3	2e1bfb81-f913-46b4-8a2f-c39d44bf9705	10-6-2015-10-48-49.rar	FAMILY COUNSELLING	Edit | Detail | Delete
9	FAMILY COUNSELLING	8101ebd5-00d8-478c-9fd5-19f3202844b7	5-6-2015-10-39-48.doc	FAMILY COUNSELLING	Edit | Detail | Delete
10	Family Counseling Theories	2f1de6fb-0dfc-4ef4-842a-9b6c16410a68	9-6-2015-12-26-39.rar	FAMILY COUNSELLING	Edit | Detail | Delete
11	Family Counseling Techniques	5df1314f-8d96-41c4-a804-a6a79586dd0b	9-6-2015-12-27-38.rar	FAMILY COUNSELLING	Edit | Detail | Delete
12	Family Counselors Document 1	ad218411-486f-4186-86c0-3d284724cbc0	9-6-2015-12-32-33.rar	FAMILY COUNSELLING	Edit | Detail | Delete
13	Family Counselors Document 2a	a44f2368-545e-40a3-a472-a2584704c4a6	9-6-2015-13-10-16.rar	FAMILY COUNSELLING	Edit | Detail | Delete
14	Family Counselors Document 2b	b5063977-11ce-49bf-b123-d8d0abd58118	9-6-2015-13-28-43.rar	FAMILY COUNSELLING	Edit | Detail | Delete

Figure 2.Documents page images of the distance education platform.

The "Exam Details" page of a safe online learning environment is displayed in Figure 3. An easy-to-use interface for handling an exam's specific details and content is offered by this website. Basic details including the exam's ID number, name, and linked course name are listed in the top section (Course Name). In this example, the name of the exam is "ROBOTIC CODING EXAM" and the course name is "ROBOTICS AND CODING TRAINING".In the lower section, there is a table where the questions of the exam are listed. In this table, there is information such as ID number (Id), Video-Picture Question Text and Question Text for each question. The "Edit" and "Delete" links next to each question make it easy to edit or delete questions. There is also an "Add New" button in the upper right corner of the page to add new questions.Users can easily evaluate and change the exam content as needed by using the table of questions. For instance, a programming subject is thoroughly described and illustrated in question 376. The purpose of this structure is to better organize the exam's material and streamline students' evaluation procedures.

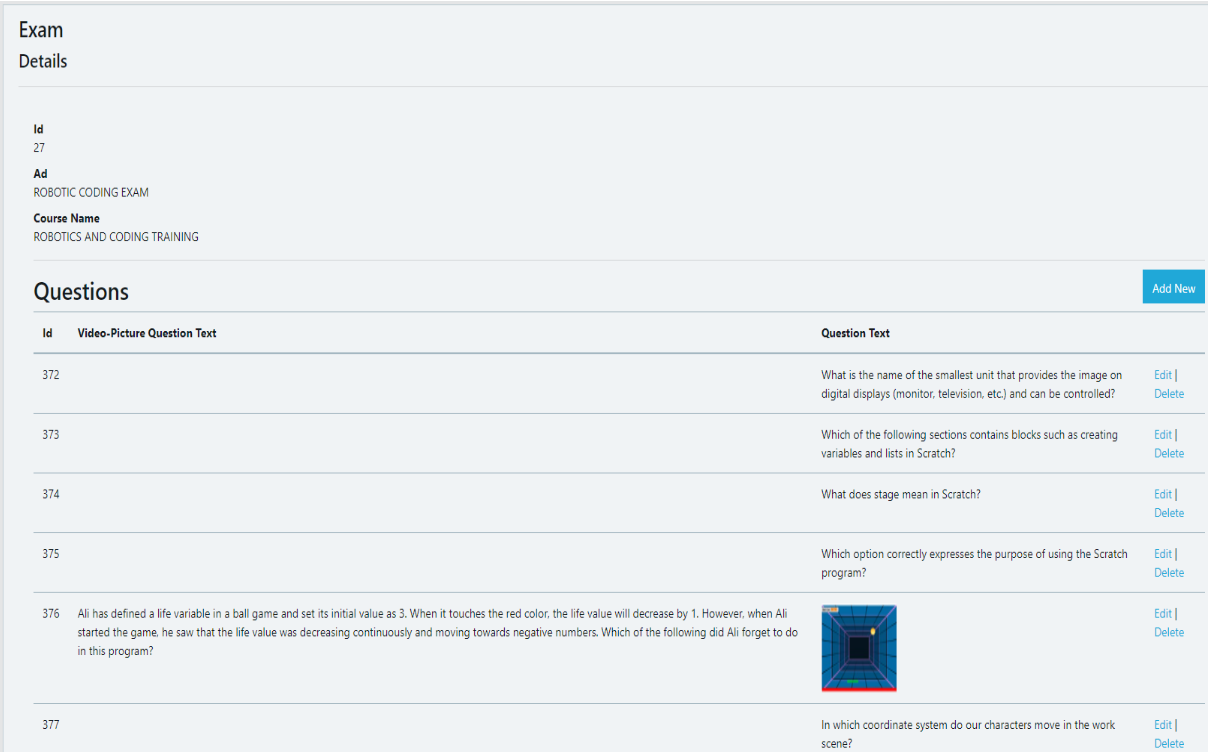

Figure 3. Exam detail page images of the distance education platform.

IV. Secure Data Storage and Certification

Thanks to the blockchain structure, students' exam results and the certificates they receive are stored securely and unalterably. The following steps are taken to establish the security foundations of a secure distance learning platform.

- Set up the blockchain network: The first thing to do is to set up a blockchain network. This blockchain network consists of different nodes and each node is stored in the blockchain. The necessary structures for information exchange and verification between the nodes are then defined. This process provides a decentralised, distributed structure.

Algorithm 1 Create Blockchain_RG Class Code

```
importhashlib
import json
from time import time
classBlockchain_RG:
    def __init__(self):
self.chain = []
self.current_transactions = []
        # --- Genesis block
self.new_block(previous_hash='1', proof=100)
```

- *Block and transaction structure:* Exam results and student certificates are defined and stored in a transaction on the blockchain. This storage process is performed using blocks. Each block is linked to the hash value of the previous block to form a chain. This established structure ensures that the data is immutable and secure.

Algorithm 2 Create a new Block in the Blockchain_RG

```
defnew_block(self, proof, previous_hash=None):
block = {
            'index': len(self.chain) + 1,
            'timestamp': time(),
            'transactions': self.current_transactions,
```

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```
        'proof': proof,
        'previous_hash':  previous_hash  or  self.hash(self.chain[-
    1]),
      }
    self.current_transactions = []
    self.chain.append(block)
    return block
    defnew_transaction(self, student_id, exam_id, score):
    self.current_transactions.append({
        'student_id': student_id,
        'exam_id': exam_id,
        'score': score,       })
    returnself.last_block['index'] + 1
```

- *Data Entry and Approval Process:* Students' exam results and certificates are added to the blockchain network as transactions. These added transactions are first verified and then approved by the nodes. Confirmed transactions take their place as a new block on the blockchain.

Algorithm 3 Data Entry and Hash Process

```
def hash(block):
block_string = json.dumps(block, sort_keys=True).encode()
return hashlib.sha256(block_string).hexdigest()
deflast_block(self):
returnself.chain[-1]
#  --- Usage example
blockchain = Blockchain_RG()
blockchain.new_transaction(student_id="12345",     exam_id="robotics_101",
score="A")
blockchain.new_block(proof=200)
```

- *Access and Security:* All data stored on the blockchain can only be accessed by authorised users. Each user defined in the system logs into the system with a private key and can access the data for which he or she is authorised. This structure guarantees data security and confidentiality.

Algorithm 4 Access, Verify and Cyrpto Process

```
fromuuidimport uuid4
fromCrypto.PublicKeyimport RSA
fromCrypto.Cipherimport PKCS1_OAEP
fromCrypto.Randomimportget_random_bytes
defregister_user(self, user_id):
    key = RSA.generate(2048)
    private_key = key.export_key()
public_key = key.publickey().export_key()
self.users[user_id] = public_key
return private_key, public_key
defencrypt_data(self, public_key, data):
recipient_key = RSA.import_key(public_key)
cipher_rsa = PKCS1_OAEP.new(recipient_key)
encrypted_data = cipher_rsa.encrypt(data.encode())
returnencrypted_data
defdecrypt_data(self, private_key, encrypted_data):
    key = RSA.import_key(private_key)
cipher_rsa = PKCS1_OAEP.new(key)
    data = cipher_rsa.decrypt(encrypted_data).decode()
return data
encrypted_score = blockchain.chain[1]['transactions'][0]['score']
decrypted_score                                   =blockchain.decrypt_data(private_key,
```

```
            bytes.fromhex(encrypted_score))
```

The performance of the blockchain structure varies depending on the type of blockchain used and the number of nodes. In general, blockchain networks offer high transaction security and data integrity, but these benefits come at a performance cost. Verification of blockchain transactions can take time, which can increase the latency of the system. However, for critical applications such as the secure storage of exam results and certificates, this latency is usually acceptable.

V. Discussion and Conclusions

The performance metrics of the block chain structure used in the developed system were measured. The purpose of this measurement is to reveal the time cost of the operations performed while ensuring data security, data integrity and data tamperability. In order to measure the performance and upper limit of the system, a large number of artificial recording information from different nodes were sent to the recording system of the system through the Postman program. Based on the number of jobs performed by the system per unit time, the scalability of the system was ensured, and its upper limit was tried to be determined. The results obtained are shown in Figure 4.

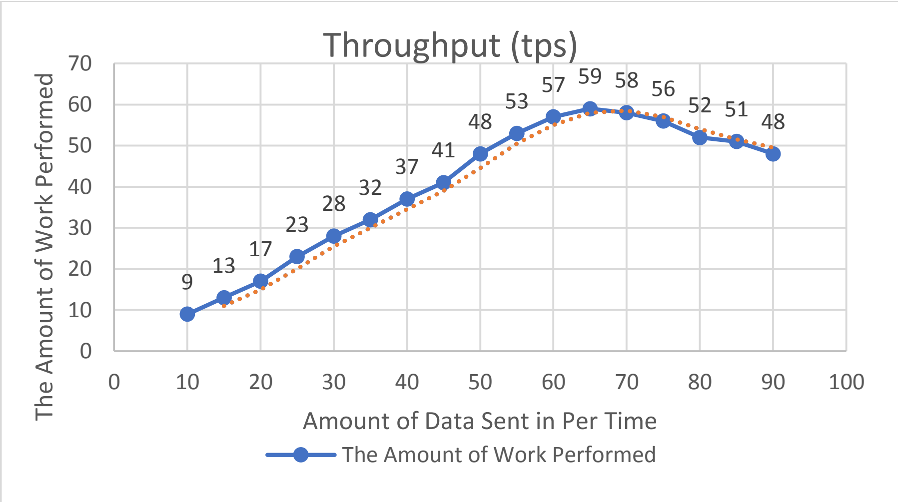

Figure 4. Data Insert Performance of the Robust Guard

This graph shows the throughput of the blockchain network against the amount of data sent in a certain period of time. The curve in blue represents the Amount of Work Performed in relation to the amount of data sent, while the orange dashed line represents the 2-period moving average.

Initial Phase (between 0-20): As the amount of data sent increases, the amount of work performed also increases. This indicates that the network can easily process the data flow at the beginning.

Escalation Phase (between 20-60): As the amount of data increases, the amount of work performed increases rapidly and this trend continues up to 60 units in the graph. This point shows the region where the network works most efficiently and reaches maximum throughput.

Peak Point (around 60): The highest point on the graph is the point where the network reaches the highest throughput value. Here, 59 tps (transaction per second) value is reached.

Decline Phase (after 60): After 60 units of data, the throughput value starts to decrease. This decrease indicates that the network is overloaded, and the performance starts to decrease with the increase in the amount of data. Especially at 90 units of data, the throughput drops to 48 tps.

In general, the blockchain network can efficiently process the data sent at the beginning, but after a certain point (60 units of data), the capacity of the network starts to be strained and the throughput drops. This is an important observation to understand the scalability limits of the network and its resistance to high data flow. Also, by using the moving average (2 per. Mov. Avg.), the trend can be seen more clearly, which increases the accuracy of the analyses.

Given the shortcomings of existing platforms in data security and immutability, this paper proposes a distance learning platform that guarantees secure storage and provides immutable authentication. The blockchain framework offers a practical solution for secure processing and archiving of educational data, as the analysis and performance results show. Especially when it comes to securely storing exam results and certificates and protecting them from unwanted access, security-orientated methods come to the fore. The block chain network can efficiently manage its flow up to a certain limit according to performance metrics. Throughput measurements are an important finding to understand the scalability limits of the blockchain network and its resilience to large data streams. The system performance starts to struggle after 60 units and the capacity of the network in terms of throughput starts to decline.

blockchain-based solutions can significantly alleviate challenges related to exam security, student authentication, document security and distance education. By ensuring data integrity, they prevent data modification or unauthorised access. Thus, technological solutions such as authentication and secure browsers can increase the reliability of distance education processes. Blockchain-based security frameworks of Distance Education platforms enable them to operate in a more reliable, efficient and secure manner. In this way, among other facts, scalability and performance overheads are the most important ones. In this way, the focus should be on developing new approaches and optimisation strategies for a more comprehensive and successful implementation of blockchain technology in distance education.

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