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Empowering E-learning through blockchain: an inclusive and affordable tutoring solution

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ABSTRACT

This study presents an innovative approach using the Ethereum blockchain to democratize access to tutoring services, advancing educational technology by bridging the affordability gap for learners with limited financial resources. This solution enables low-income learners to access tutoring services without significant expenses by eliminating intermediaries through smart contracts. Learners can directly book tutoring services based on fees and evaluations, ensuring a fair and accessible experience. The findings show that this approach reduces tutoring expenses and improves trust and accountability through transparent transactions and feedback mechanisms. The proposed system demonstrates how blockchain technology can foster a more equitable and efficient educational landscape, offering personalized support to all learners regardless of their economic background.

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1. INTRODUCTION

The advent of online learning has significantly reshaped the educational landscape, offering a more accessible and flexible approach to education [1]. This paradigm shift has enabled learners from varied backgrounds and circumstances to engage with educational material on their terms, thereby democratizing access to learning. Online education platforms facilitate a broad spectrum of courses and subjects, allowing for personalized and self-paced learning experiences [2]. In this evolving landscape where learning is more accessible and tailored to individual needs, peer-to-peer learning stands out as an essential strategy, especially in situations where formal education might not be feasible, like in informal educational setups or unconventional learning environments.

Peer-to-peer learning is becoming increasingly important especially when face-to-face learning may be limited for one of the following reasons: learner mobility limitations, courses that are easily taught at a distance (coding and language), in pandemic situations (such as COVID-19) [3], or for learners from low socio-economic backgrounds [4]. In support of this trend towards peer-to-peer learning, institutions are taking proactive measures. When seeking to employ a tutor, a third party which can be a school or a university is responsible for interviewing candidates who applied for tutoring positions and making sure that they satisfy all criteria needed to be eligible to work as qualified tutors. The third party is also the only party that decides on the tutoring fee, which is usually fixed. The tutoring fee that the third-party fixes is sometimes high and represents a problem for learners with limited financial resources. Therefore, there is a

pressing need for the establishment of an inclusive educational environment that offers free or affordable tutoring to address the needs of this group of learners. The solution involves building a tutoring system that utilizes blockchain technology to remove intermediaries and offer tutoring services to learners with low fees and ensure high-quality tutoring. The solution uses mechanisms of control and verification such as the smart contract that the blockchain technology provides, therefore only qualified tutors are authorized to join the network.

Blockchain technology is transforming the education sector by improving security, transparency, and efficiency [5], [6]. Official blockchain is an open, complementary database. Each participant can write and read the information. It securely stores and exchanges student data, reducing the risks of manipulation. It also records and verifies academic credentials [6], creating an unchangeable ledger of achievements. Blockchain decentralized educational processes, eliminating the need for central administrative bodies [7]. This integration streamlines procedures and ensures the integrity and privacy of educational records. Overall, blockchain offers accessible and reliable educational services. The incorporation of blockchain technology into the educational sector is very promising. In this paper, a novel approach to managing and delivering educational services like tutoring based on Ethereum blockchain is presented. The purpose is to use blockchain technology in an educational context as a distributed ledger of transactions used for enhancing transparency, security, and efficiency in transaction management. Blockchain, through its decentralized and tamper-proof system, facilitates educational transactions like scheduling and booking tutoring sessions, as well as fee payment, eliminating the need for traditional intermediaries. This not only reduces administrative costs but also improves access to tutoring services, making them more affordable and widely available.

The article is organized as follows: section 2 covers the context and problem statement, discussing challenges in peer-to-peer e-learning systems and providing an overview of blockchain technology and its educational applications. Section 3 describes the development of our blockchain-based peer-to-peer tutoring system, including its architecture, system actor interactions, and implementation. Section 4 presents the results of deploying the "*TutoringSystem*" smart contract, focusing on tutor and learner registration interactions. Finally, section 5 summarizes the findings and suggests future research directions.

2. PROBLEM STATEMENT AND BLOCKCHAIN TECHNOLOGY IN EDUCATION

2.1. Problem statement

This paper examines peer-to-peer learning within the context of e-learning, with a specific focus on peer tutoring [8]. Peer learning involves learners of similar levels assisting each other, which supports independent learning [9]. This method deepens understanding of key concepts and encourages active engagement, moving beyond the limits of traditional classroom teaching [10]. Initially developed for face-to-face education, peer learning has proven adaptable across various formats, including in-person, hybrid, and online environments [11]. It has been evidenced that peer learning boosts competencies such as communication and clinical skills, while also enhancing knowledge, time management, confidence, and accountability. Particularly, peer tutoring is steadily gaining popularity in many higher education institutions as a prevalent instructional approach where students teach their peers as part of the learning process [12], [13].

The transition to peer-to-peer tutoring introduces a unique set of challenges and opportunities. Conventional systems commonly depend on centralized entities, like educational institutions, to facilitate the tutoring process. As peer tutors may face challenges due to insufficient knowledge, potentially affecting trust within the tutor-tutee relationship [9], centralized entities are responsible for verifying tutors and ensuring their reliability [14]. This is crucial for establishing a trustworthy eLearning system and ensuring that peers are adequately prepared for eLearning delivery. Additionally, centralized entities handle tasks such as scheduling tutoring sessions, managing payments, and overseeing the entire tutoring process. However, this centralized approach may lead to reduced efficiency, increased costs, and limited access, especially for individuals from disadvantaged socio-economic backgrounds.

Blockchain technology, with its decentralized nature, presents a promising solution to these challenges. Through a distributed ledger, blockchain technology provides a reliable and unchangeable record of all transactions [15], including the organization and fulfilment of tutoring sessions, without relying on a central authority. By adopting a decentralized approach, the reliance on a single entity is minimized, resulting in potential reductions in transaction costs and improved accessibility for both learners and tutors. Moreover, blockchain 's smart contracts automate agreements and payments in tutoring, ensuring transactions are fair and efficient. The use of cryptocurrency in this system speeds up and simplifies international payments, making them faster and more accessible across geographical boundaries. The efficiency of the blockchain leads to transparency [16] and security, creating a reliable educational setting where all transactions, including tutor credentials and evaluations given by learners, are recorded and stored in a ledger, ensuring that only qualified tutors participate, and guaranteeing a high-quality tutoring service.

In summary, removing the intermediary in our blockchain tutoring system solves numerous issues found in traditional tutoring arrangements. It democratizes access to high-quality tutoring, lowers costs, and increases trust and transparency, making it a compelling solution for the evolving landscape of e-learning and peer-to-peer education

2.2. Blockchain technology overview

Blockchain functions as a decentralized database, maintaining records in a public ledger accessible to all participants involved in transactions or digital events. Users can record, send, and share data according to predetermined rules. Initially developed to support the Bitcoin cryptocurrency protocol [17], blockchain technology has since evolved into various iterations, from cryptocurrency and Bitcoin version 1.0 to smart contracts version 2.0, and now to an advanced form of peer-to-peer (P2P) collaboration known as "Blockchain 3.0". This latest iteration finds application in diverse sectors including supply chain management, voting systems, finance, healthcare, and more.

Blockchain technology operates on three fundamental principles: consensus, immutability, and decentralization. Consensus ensures compliance with protocol rules and fosters trust in transactions through algorithms governing registry entries. This transparency creates a unified vision among participants in real-time. Immutability guarantees that recorded transactions are permanent and resistant to alteration. Finally, decentralization eliminates the reliance on trusted third parties. Transactions occur directly between parties in a peer-to-peer manner, with data registered, stored, and managed in a distributed manner.

Various categories of blockchain exist, such as private, public, hybrid, and consortium blockchains, and which differ in their distributed rights [18]. Public blockchains are permissionless, allowing all participants unrestricted access to read, send, receive, and validate transactions. In contrast, private blockchains are governed by a single trusted entity, controlling access and rights for participants. Hybrid blockchains combine features of both, useful when balancing confidentiality and public availability of data. Consortium blockchains involve pre-selected nodes in consensus protocols, often used for collaborative efforts among institutions or companies, providing a partially decentralized approach

In this research context, the implementation of peer-to-peer tutoring through private blockchain technology emerges as the most suitable solution. Here, the educational Institution Authority, whether a school or university, serves as a central authority responsible for pivotal functions. This includes deploying smart contracts to enforce essential regulations and validate transactions, as well as authenticating the identities of learners and tutors within the system. Moreover, the authority regulates access to tutors with the necessary skills, ensuring the maintenance of quality standards in tutoring services. Furthermore, the utilization of private blockchain seamlessly aligns with other critical objectives of this solution. The immutable ledger inherent in blockchain facilitates the creation of a chronological record of tutoring sessions, tracks student attendance, monitors progress, and evaluates tutors' service quality. Additionally, it offers universal and secure access for learners worldwide seeking tutoring services, while enabling the provision of very low transaction fees, ensuring cost-effective and efficient transactions across the platform.

2.3. Blockchain technology in the educational sector

Blockchain technology has emerged as a transformative force across various sectors, including finance, banking, healthcare [19], [20], energy, smart grid technology [21], education, ambient intelligence [22], internet of things (IoT) [23], [24], and numerous other industries. Research highlights its integration with educational technology to address associated challenges [25], [26]. Blockchain can provide a secure and transparent framework for storing and exchanging student-related data, enhancing data integrity, privacy, and accessibility, ultimately contributing to more efficient educational infrastructures [25].

Enrolling students in upcoming semester university programs is a crucial university operation, requiring transparent and secure verification and storage of academic credentials. Blockchain technology offers a solution by providing a tamper-proof and unchangeable record of student data and achievements (diplomas, certifications, and records). Each student's information can be recorded on the blockchain as a transaction, ensuring permanence and verifiability. During enrollment, students submit administrative documents for various purposes, but the risk of document manipulation persists. Blockchain addresses this challenge by preventing administrative document falsification. For instance, Meyliana *et al.* [27] proposes using blockchain for enrollment records to enhance the security and reliability of university operations.

2.3.1. Accreditation process

Kamišalić *et al*. [4] emphasized that blockchain is enabling many opportunities in the educational field. For example, using blockchain may help institutions simplify the accreditation process by verifying the institution's proposals making it easier for governments to verify their accreditation [4]. This has the potential to result in a more streamlined and transparent accreditation process for both educational institutions and

governments. Khan *et al.* [22] proposed a solution called BlockMoodle which represents the integration of Ethereum blockchain technology into the Moodle educational platform.

2.3.2. Exchange programs

Universities are not permitted to deliver student information to third parties. However, students applying for an exchange program are required to verify the validity of their documents. Furthermore, these records are archived using varying standards and languages, making the sharing of information about students and their achievements among universities a challenging endeavor [28]. To address these issues, Kamišalić *et al.* [4] suggests utilizing blockchain technology to manage student exchange programs more conveniently, avoiding time-consuming administrative procedures. Similarly, Daraghmi *et al.* [29] introduces UniChain, a decentralized system designed to securely manage and distribute electronic academic records (EARs) across multiple institutions, providing a solution for efficient and secure record-keeping. For instance, students may pursue their education in one or more institutions during their program of study, especially if they apply for an exchange program. The issue is the distribution of a student's academic records across diverse and heterogeneous institutional databases, making it challenging for both students and institutions to access a comprehensive and unified overview of the student's records. Using blockchain in this case has the potential to ensure a more efficient verification of academic credentials [16], as well as improve transparency, data privacy, and accuracy. Furthermore, blockchain may be used to enable institutions to verify if the student has indeed completed a degree and be sure of the validity of provided documents [30]. This is particularly crucial as the academic accomplishments and educational qualifications of applicants are becoming more vulnerable to falsification, with many universities and institutions delivering certifications and diplomas on paper.

Blockchain is a decentralized ledger not requiring a central authority in order to perform actions or exchange data. In higher education, this technology can highly enhance transparency but also the security of various academic tasks and administrative workflows and processes, such as student records management and payment [31]. For instance, Kabashi *et al.* [6] described many possible applications and use cases of blockchain technology in Higher Education institutions and proposed a blockchain academic and career record system. Shakan *et al.* [28] proposed an Ethereum-based system enabling educational institutions to provide authentic information about students' academic achievements to third parties. They present a prototype called UniverCert, utilizing a consortium blockchain architecture based on Ethereum to enhance the verification and security of academic records. The platform aims to address issues such as the vulnerability of academic documents to unauthorized alterations and the lack of detailed information on academic performance in official records.

2.3.3. e-certification

As stated in [32], smart contracts are described as software programs capable of functioning autonomously within a blockchain when predefined conditions are met. Once these contractual conditions are satisfied, the associated actions are executed automatically, leading to the fulfillment of the smart contract. This capability has the potential to eliminate the need for user involvement, allowing transactions to be executed automatically. Both [32] and [33] have emphasized this potential by proposing the utilization of an Ethereum blockchain-based smart contract for verifying digital certificates distributed to participants. Another pivotal aspect of e-certification concerns the transferability and portability of credentials issued by institutions, which are subject to authentication by third parties. Blockchain technology facilitates the exchange of educational data between institutions, enhancing reliability and security. However, Elgado-von-Eitzen *et al.* [34] pointed out that it is interesting to take into consideration international regulations such as the General Data Protection Regulation in Europe (GDPRE) while exchanging students' records.

Another benefit of blockchain technology is its potential to address issues related to security, privacy, and access control when sharing educational records with other institutions. Ocheja *et al.* [35] proposed a platform that facilitates the transfer of student's data and academic records between institutions. They introduced UniverCert, a platform designed to monitor academic performance, generate educational certificates, and ensure authenticity. The solution encompasses student registration, document validation, and ensuring the authenticity of educational records. In addition, UniverCert ensures data transfer between universities.

3. METHOD

This section explores the architecture of the blockchain-based peer-to-peer tutoring system, emphasizing its structural components and design principles. It defines and examines the roles and interactions of the various actors within the proposed tutoring scenario. Additionally, it outlines the practical steps and technical considerations involved in the implementation phase.

3.1. Blockchain-based P2P tutoring system architecture

The architecture of our system utilizes a private Ethereum blockchain [36], depicted in Figure 1. It showcases the deployment of the *TutoringSystem* smart contract and its interactions among tutors, learners, and educational authority actors. This design ensures smooth and secure communication, fostering a trustworthy peer-to-peer tutoring environment.

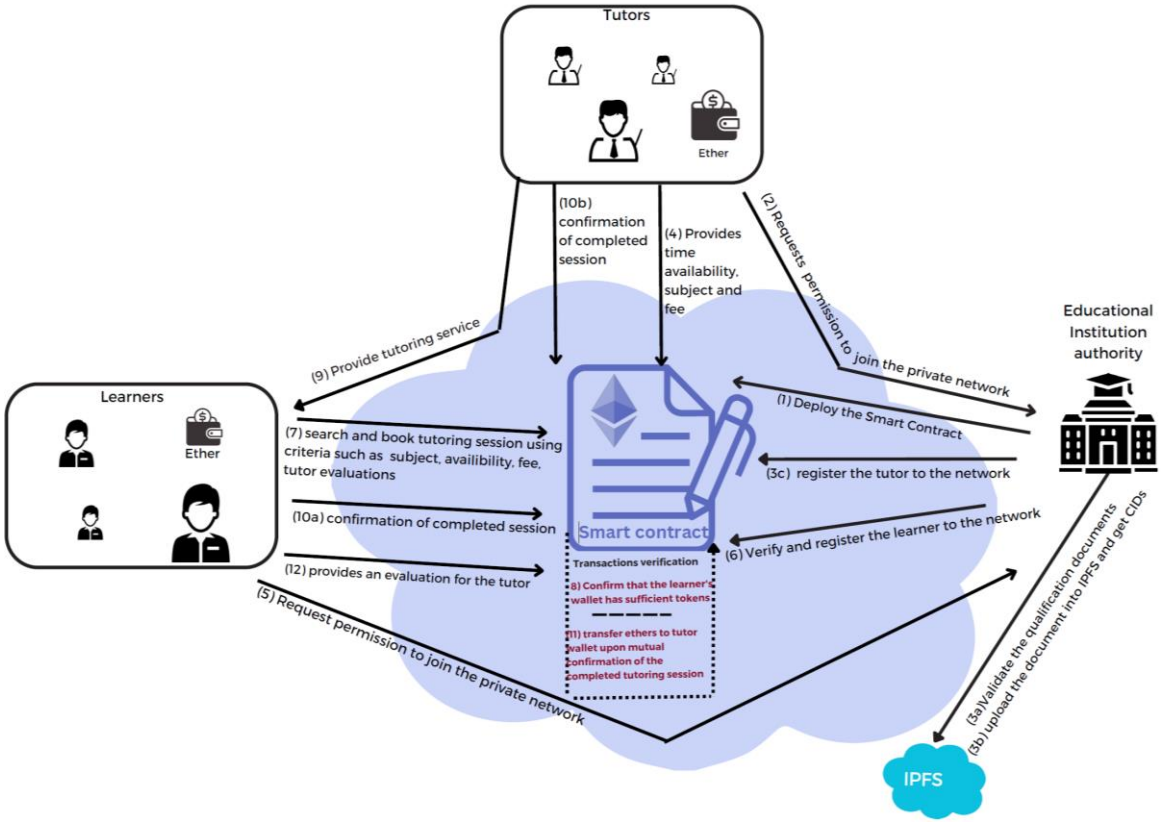

Figure 1. The architecture of the tutoring system

3.2. Actors and scenario in the proposed tutoring system

The initial phase of creating the blockchain-based tutoring system involves developing a fundamental prototype designed to showcase core functionalities, with provisions for future enhancement through the integration of robust security measures. The system revolves around three primary actors: the educational institution authority, learners, and tutors. The educational institution authority assumes a central role in deploying and maintaining the smart contract. This responsibility entails overseeing various processes, including the management of the tutor registration procedure and the verification of their qualification documents, subsequently registering eligible tutors into the network. To validate the qualification documents of tutors, the educational institution authority employs the interplanetary file system (IPFS) [37]. IPFS serves as a decentralized file storage system, leveraging a distributed network for file storage and retrieval. Documents undergo encryption before being stored in IPFS, resulting in the generation of a unique content identifier (CID) for each document. This CID facilitates seamless retrieval and verification, ensuring convenient access and validation of documents [37]. Additionally, the authority is tasked with verifying student IDs and enrolling valid students as learners within the network, ensuring the credibility and authenticity of participants within the educational ecosystem. When it comes to Tutors, they represent the second actor in the system, offering tutoring services and actively engaging in various system actions. Tutors register within the system, set availability and hourly rates, and monitor booked sessions. They conduct tutoring sessions, receive evaluations from learners contributing to their overall reputation, and receive tutoring fees in Ether for their services. As for the learners, they represent individuals seeking tutoring services and actively engaging in various system actions. Learners register within the system, browse available tutors, and book tutoring sessions. Following the receipt of tutoring services, learners submit

tutoring fees in Ether and provide feedback, along with ratings after each session, to evaluate tutors. Through the collaboration of these entities, the blockchain-based tutoring system facilitates transparent, secure, and efficient exchanges of tutoring services within an educational ecosystem. In Figure 2, a sequence diagram illustrating the interaction among system actors.

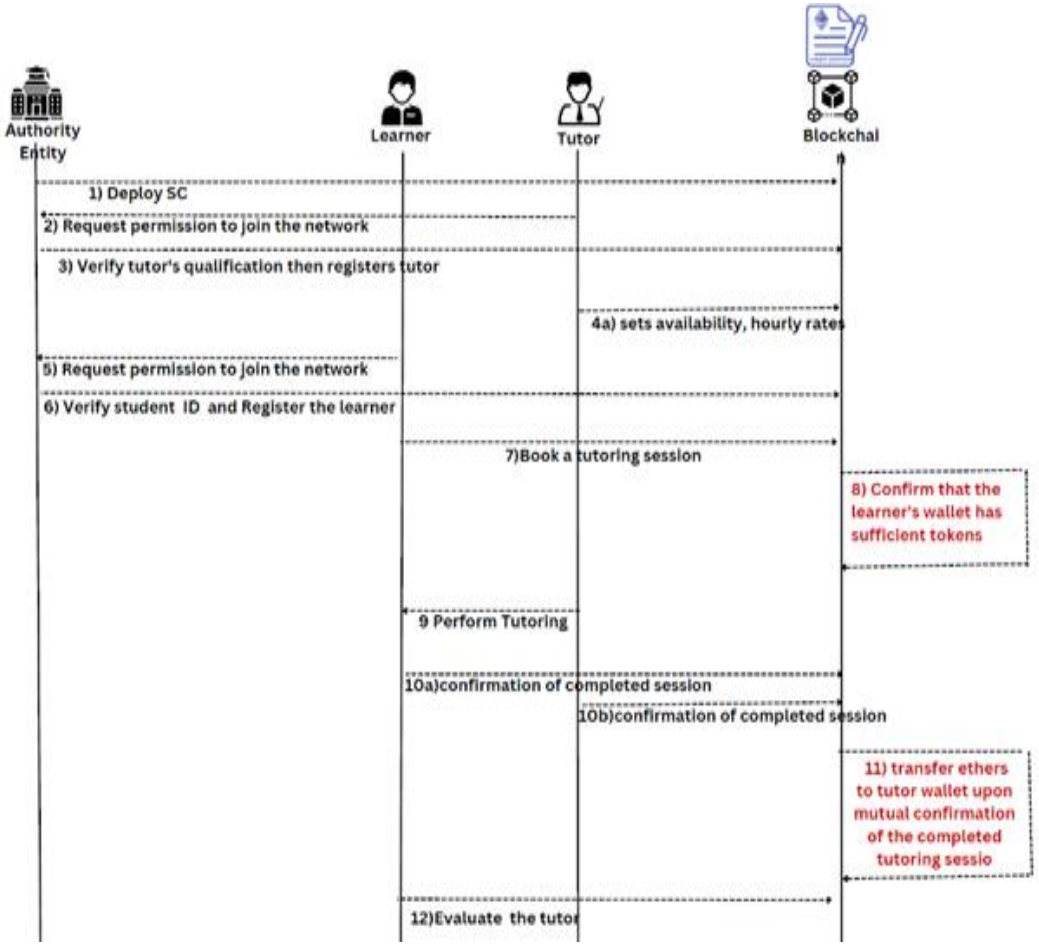

Figure 2. The sequence diagram of the tutoring system

3.3. Implementation

3.3.1. Developing smart contract logic

The core of the solution is a smart contract. The smart contract, *TutoringSystem*, is written in solidity and implemented using the Remix IDE. Remix IDE is an online platform for creating, compiling, and deploying smart contracts in a local testing environment. This enables the automation and oversight of various aspects of the tutoring system. Key responsibilities and features include:

3.3.2. Tutor registration

After deploying the smart contract, individuals aiming to tutor can register on the Ethereum network using the *RequestTutorRegistration* function. This function is only available to users not yet registered as tutors. Algorithm 1 outlines the tasks performed by the *RequestTutorRegistration* function.

Algorithm 1. Request tutor registration

```
Output: Tutor address or Error
#Check if the sender is a non-registered tutor
If the sender is a non-registered tutor:
    Execute the Transaction to request tutor registration on the Ethereum blockchain
    Return the tutor's address
Else:
    Return an error indicating that only non-registered tutors can make this request
    Cancel Transaction
```

Upon receiving a registration request from the individual seeking to become a tutor, the educational institution authority uses the *RegisterTutor* function. This function collects personal details like name and qualification documents. Only the educational institution authority can access this function. Its role is to ensure the applicant is not already a tutor, validate the documents, and officially register the applicant as a tutor. This registration transaction is then recorded on the blockchain. Here's the Algorithm 2 for the *RegisterTutor* function.

Algorithm 2. Register a tutor

```
Input: Tutor Address, tutor Name, qualification Documents
Output: Success or Error
   If the sender is the educational authority:
     If the tutor is not already registered:
       If qualification Documents are valid:
         Register the tutor with the provided information.
         Mark the tutor as registered.
         Add the tutor's address to the list of registered tutors.
         Execute the transaction to register the tutor on the Ethereum blockchain.
         Return Success
       Else:
         Return an error that qualification Documents are not valid
     Else:
       Return an error indicating that the tutor is already registered.
Else:
     Return an error indicating that the sender is not the educational authority.
     Cancel transaction
```

3.3.3. Learner registration

On the learner's side, the preference is to initially establish a private network, ensuring that only students with a valid ID from the institution are eligible for tutoring services. Consequently, a student can commence the registration process on the Ethereum network by triggering the *RequestLearnerRegistration* function, which prompts the input of their student ID. Algorithm 3, outlines the task performed by the *RequestLearnerRegistration* function.

Algorithm 3. Request learner registration

```
Input: Student ID
Output: Learner address or Error
If the sender is a student with a valid ID:
     Execute the Transaction to request learner registration on the Ethereum blockchain
     Return the learner's address
Else:
     Return an error indicating that only students of the institution can make the request
     Cancel Transaction
```

Upon receiving a registration request from a student seeking a tutoring session, the educational institution authority invokes the *RegisterLearner* function which requires the student's personal information such as their name. Exclusively available to the educational institution authority, the *RegisterLearner* function verifies that the applicant is not currently registered as a learner. Once confirmed, the applicant is officially designated as a learner. Algorithm 4, outlines the task performed by the *RegisterLearner* function.

Algorithm 4. Register learner

```
Input: Learner address, general information
Output: Success or Error
If the sender is the educational authority:
   Retrieve learner information from storage Using learner address
   If the learner is not already registered:
        Set the learner's general info to the provided ones
        Mark the learner as registered.
        Add the learner's address to the list of registered learners
        Execute the transaction to Register the learner on the Ethereum blockchain
        Return Success
   Else:
        Return an error indicating that the learner is already registered
        Cancel transaction
Else:
     Return an error indicating that the sender is not the educational authority
     Cancel transaction
```

3.3.4. Tutor session preferences input

Once a tutor is successfully verified and registered on the Ethereum blockchain, they can input their session preferences, including session time, subject expertise, and tutoring fee. Our smart contract named *TutoringSystem* includes a function called *ProvideSessionAvailability*, which is exclusively accessible to registered tutors. This function assists tutors in setting their availability and hourly rates. Algorithm 5, outlines the task that the *ProvideSessionAvailability* function performs.

Algorithm 5. Provide session availability

```
Input: Daytime, qualified Subjects, tutoring fee
Output: Success or Error
If the sender is a registered tutor:
   Retrieve the information associated with the sender (Address).
   If the sender is a qualified tutor with a valid CID:
      if session is in the tutor list of availabilities:
      Return an error indicating that the session is already available
      Cancel transaction
   Else:
      Generate a New ID for the New session
      Create a New tutoring Session object
      Mark session as not booked
      Add the New tutoring Session object to the tutor's availability list.
      Execute the transaction to add the New Session in the Ethereum blockchain
      Return Success
Else:
      Return an error indicating that the tutor must be validated before enhancing their
      profile
      Cancel transaction
Else:
      Return an error indicating that the tutor must be registered
      Cancel transaction
```

3.3.5. Book a tutoring session

Learners can access all available sessions, enabling them to book sessions at a low cost or even for free using the *BookSession* function, specifying the session ID. Once a session is booked, it is immediately marked as reserved, triggering a direct notification to the tutor, enabling them to confirm the booking and prepare for the session, in addition, the session will be marked booked. Additionally, to ensure the secure transfer of funds to the tutor upon session completion, the tutoring fee is transferred from the learner's wallet to the smart contract account upon booking the session. In the event of a session cancellation, a refund will be issued to the learner's wallet.

3.3.6. Payment for tutoring services

After the session concludes, both parties mark it as completed through the blockchain platform using the *CompleteSession* function, triggering subsequent actions such as payment processing and evaluation submission. The smart contract automatically processes payment for the tutoring session based on predetermined terms, transferring funds from the Smart contract account to the tutor's account via the *ProcessPayment* function. Algorithm 6, outlines the task performed by the *ProcessPayment* function:

Algorithm 6. Process payment

```
Input: Session ID
Output: Success or Error
Retrieve the addresses of both the tutor and the learner associated with the tutoring
session ID
If the address for either the tutor or the learner is not valid:
     Return an error
     Cancel the transaction
Else:
     Retrieve payment amount based on the session ID
     Transfer payment amount from the smart contract account to the tutor wallet.
     Execute the transaction to transfer funds from the SC account to the tutor wallet
     Return success
```

Upon completion of the payment process, learners gain the ability to assess the tutoring service through the *EvaluateTutor* function. This feature allows learners to rate the tutor's performance based on their session experience, which contributes to the tutor's reputation on the platform. These evaluations provide valuable feedback and help maintain quality standards across our tutoring system.

4. RESULTS AND DISCUSSION

In this section, we explore the outcomes of successfully deploying the *TutoringSystem* smart contract and examine the interactions it facilitates. We demonstrate how our system manages tutor and learner registrations by rejecting attempts from non-authority nodes. Additionally, we illustrate our system's prevention of duplicate registrations from previously registered tutors and learners, ensuring operational efficiency and data integrity.

4.1. Smart contract deployment

The educational institution authority is responsible for deploying the compiled smart contract. To assess the deployment and behavior of the contract, remix's virtual blockchain is used. This simulated environment provided a convenient and efficient means of testing the deployment process and evaluating the smart contract's performance before contemplating its deployment on the live Ethereum network. Figure 3 illustrates the successful smart contract deployment.

This achievement represents a significant advancement, indicating that the SC code is now operational on the Ethereum network. The deployment of the smart contract marks the execution of the first transaction on the Ethereum blockchain, initiating the creation of the Genesis Block or Block #1 as shown in Figure 3. After deployment, the *TutoringSystem* smart contract is ready to undergo testing and interaction.

Figure 3. Successful smart contract deployment

4.2. Interaction with SC: tutor registration

A non-educational institution authority node's attempt to register a tutor will result in rejection, as illustrated in Figure 4. Likewise, if a tutor who is already pre-registered attempts to register again, the transaction will also be rejected, as shown in Figure 5. When a qualified and non-registered tutor requests registration, the educational authority validates it on the blockchain. Figure 6 shows two successful tutor registrations transactions: one in block #8 and the other in block #28.

Figure 4. Rejecting tutor registration attempts by non-authority nodes

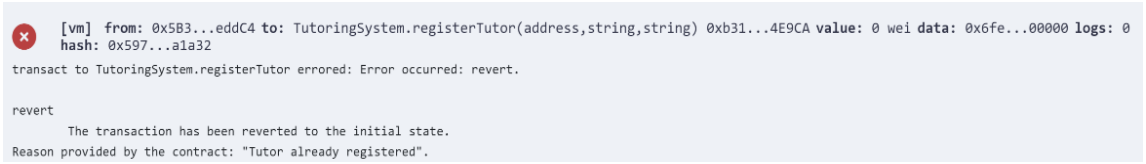

Figure 5. Rejecting duplicate registration from pre-registered tutors

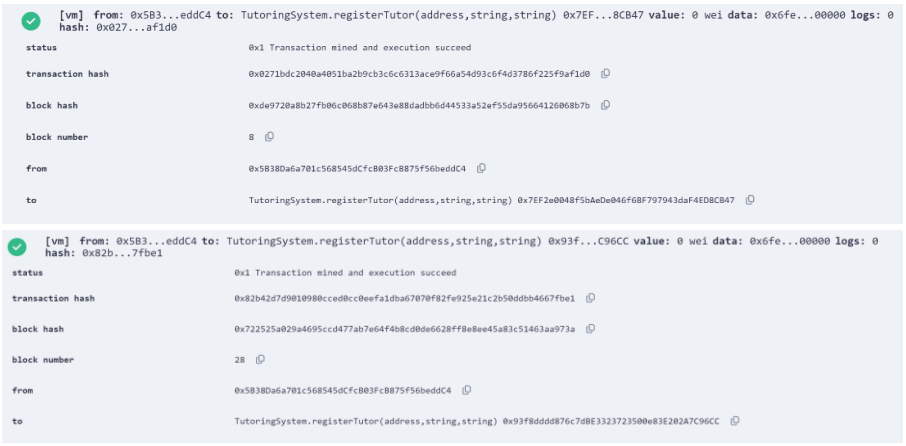

Figure 6. Validating tutors registrations by educational institution authority

4.3. Interaction with SC: learner registration

If a non-educational institution authority node attempts to register a learner, or if a pre-registered learner tries to register again, the transaction will be rejected as shown in Figures 7 and 8. When a non-registered learner requests registration, the educational authority validates it on the blockchain. Figure 9 shows two successful learner registrations transactions: one in block #14 and the other in block #26.

Figure 7. Rejecting learner registration attempts by non-authority nodes

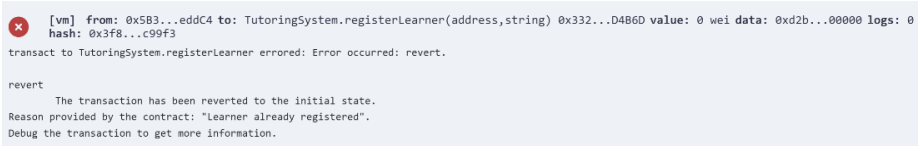

Figure 8. Rejecting duplicate registration from pre-registered learners

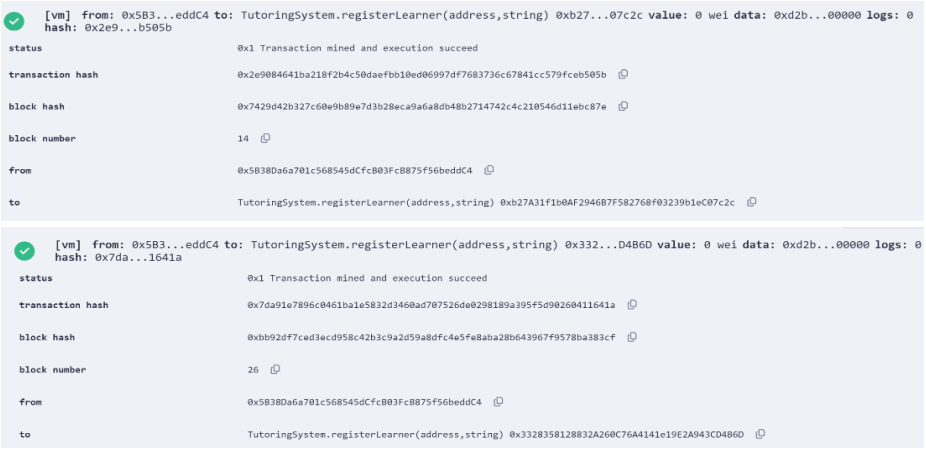

Figure 9. Validating non-registered students as learners by educational institution authority

5. CONCLUSION

This article introduces a novel blockchain-based approach to delivering tutoring in E-learning. Our Ethereum solution is based on a smart contract to enhance tutoring activities. By removing centralized intermediaries, our system creates a decentralized, low-cost, secure, transparent, and immutable marketplace for learners to connect with tutors. Qualified tutors can efficiently register, set their availability, and receive payments after sessions. Learners can register, schedule affordable tutoring, make payments, provide feedback, and help improve tutors' ratings. This study showcases blockchain's innovative application in education, especially in peer-to-peer E-learning, overcoming economic barriers and ensuring credibility through decentralized verification. It confirms blockchain's potential to revolutionize peer-to-peer E-learning, providing more inclusive, accessible, and affordable tutoring solutions.

In addition to developing a frontend application for the tutoring system, it is vital to bolster the security of our smart contract for secure transactions. Future research will focus on addressing challenges like integrating blockchain with existing educational systems, ensuring data privacy, and enhancing user engagement.

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