BLOCKCHAIN IN EDUCATION: STUDYING SMART CONTRACTS TO CREATE A DECENTRALIZED SYSTEM

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Abstract: Recently, blockchain technology has been actively studied and used by both researchers and practitioners. This is due to its unique features, such as decentralization, security, reliability, and data integrity. The article is devoted to the possibility of introducing blockchain technology into the educational environment through smart contracts. To achieve this goal, the following tasks were set: to study blockchain technologies for their applicability in the educational environment; to justify the need for using smart contracts in the educational process; to develop an algorithm for implementing smart contracts for storing educational information and using it for further analysis. The Ethereum platform was chosen for the development of smart contracts. The program code of the smart contract was compiled in the Remix compiler.

Keywords: blockchain technology in education, smart contract, decentralized systems, blockchain technology, Ethereum Virtual Machine(EVM), Remix IDE.

A blockchain is a hack-proof protocol that creates an immutable digital data structure for tracking transactions between participants in a public or private peer-to-peer network. Although blockchain is widely used in business and finance, it also finds significant applications in education. This technology has the potential to revolutionize the educational system by providing affordable and low-cost learning options, changing the relationship between institutions and students, and securely storing digital curricula and papers. Traditionally, hard drives were used for storing such data, but they are susceptible to damage or hacking. Blockchain ensures enhanced security [1].

Smart contracts play a vital role in the educational domain.[2] They can simplify tracking student progress by automatically verifying each task and issuing the next one until the entire program is completed, providing teachers with tools to give more accurate and reliable grades. Blockchain also streamlines the accreditation process, making it more transparent and accessible for students with the necessary permissions. Additionally, it can issue immutable digital higher education diplomas, improving existing certificate verification systems, which often suffer from performance, speed, and reliance on centralized authorities.

While numerous diploma verification systems are still under development, facing issues like data management and dependence on the consensus algorithm, blockchain offers a promising solution [3].

This research presents a unique approach to implementing blockchain technologies in the educational environment by focusing on learning and writing smart contract code. Unlike many existing studies that mainly compare operational platforms and their functionalities, this work provides original smart contract code adapted for educational processes. It aims to explore the practical aspects of using smart contracts, opening new opportunities for automating certification processes and managing educational data, making a significant contribution to the use of blockchain in education.

Now, let's discuss the key features of various existing approaches to creating smart contracts. Anton Vashkevich, in his work "Smart contracts: what, why and how" (2018), examines the main concepts and risks associated with smart contracts, emphasizing their potential for automation and transparency.[4] Alexander Tabernakulov and Jan Koifmann, in "Mastering Ethereum: Building Smart Contracts and dApps", offer a practical guide to developing smart contracts on the Ethereum platform, including code examples and testing aspects.[5] Andreas M. Antonopoulos and Dr. Gavin Woo, in "Blockchain: IBM Limited Edition", discuss the potential of blockchain for business and the importance of secure smart contract development.[6] Manav Gupta, in "Applications for Systematic Smart Contracts on Blockchain", explores systematic approaches to creating smart contracts and their application in various industries.[7] Alvina Sevde Elnara et al., in their systematic literature review on blockchain-based systems for academic certificate verification, analyze solutions for verifying academic certificates using blockchain, highlighting their advantages and disadvantages.[8] Finally, Fisnik Dalipi and his colleagues explore the use of blockchain technologies in education and data verification, focusing on the challenges and opportunities associated with their implementation.[9]

Smart contracts are self-executing contracts with the terms of the agreement directly written into lines of code. They run on the Ethereum blockchain, which is a decentralized platform that enables developers to create decentralized applications (DApps). Ethereum's smart contracts are executed by the Ethereum Virtual Machine (EVM), a computation engine that processes smart contracts and ensures they operate as intended. Solidity is the primary programming language used to write smart contracts for the Ethereum platform. The development of smart contracts for educational systems uses Solidity and the Remix IDE to create, deploy, and manage contracts on the Ethereum blockchain. Solidity is a statically typed programming language specifically designed for writing smart contracts, compiled into bytecode and executed on the EVM. The main components of a contract include a pragmatic expression, state variables, constructor, functions, modifiers, events, and inheritance.

There are several methods for developing a smart contract, one of which is using the Remix IDE, a powerful open-source tool that allows you to develop smart contracts directly from the browser.[10]

First, you need to open the Remix IDE[11] in a browser and create a new file with the .sol extension, which will be used to write code in the Solidity language. The contract begins with the announcement of the Solidity version and the contract itself. The Assignment structure is defined inside the contract, representing the assignment. It contains the following fields:

- **id**: The task ID.
- **content**: The content of the task.
- **isMarked**: A flag indicating whether the task has been evaluated.
- **grade**: The assessment of the task.

Next, the assignments array is defined, which will contain all the tasks. This Solidity[12] smart contract provides basic functionality for managing educational assignments. Users can submit their assignments, and teachers can rate them. The contract ensures that each task can only be evaluated once.

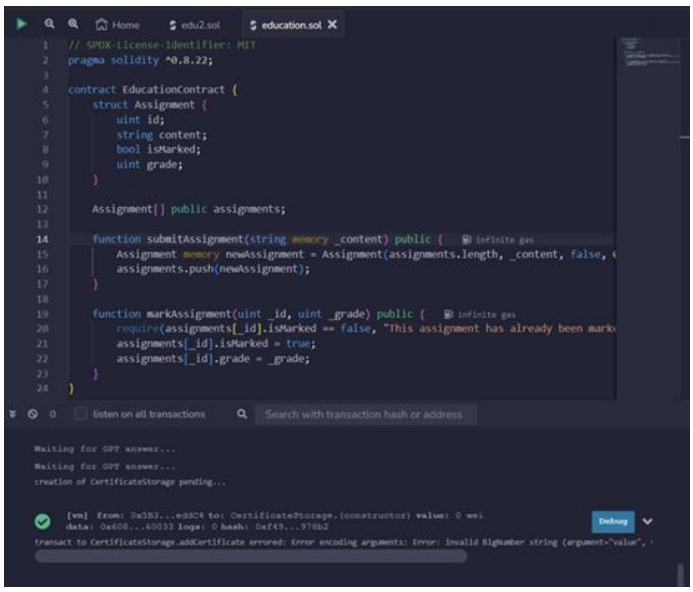

Figure 1. Smart contract code for job management in the Remix IDE

In this smart contract, there are only two functions:

1. **submitAssignment()**: This is a public function with no return value (void) that allows users to submit tasks. When this function is called, a new task is created and added to the array of contract tasks.

2. **markAssignment()**: This is also a public function with no return value (void), which allows teachers to evaluate submitted assignments. When this function is called, the task is marked as evaluated, and the score for this task is set.

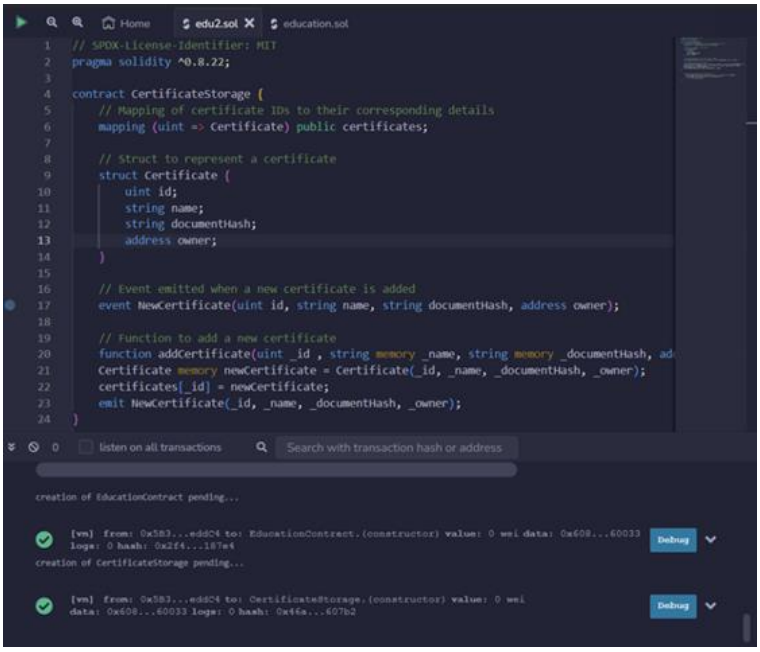

Figure 2. Smart contract code for certificate management

The following smart contract represents a certificate management system, providing secure and efficient storage of certificate data. It includes the following main functions:

- **addCertificate**: Allows you to add a new certificate to the repository.
- **certificates**: Allows you to get information about certificates by their ID.

Calling the addCertificate function allows you to add a new certificate to the repository. Example: In Remix IDE, the user calls the addCertificate function with arguments for the ID, certificate name, document hash, and owner address. The function creates a new certificate with the specified data and saves it to the repository. To get information about a certificate by its ID, you can use the certificates function. Example: The user calls the certificates function with the certificate ID. The contract returns information about the certificate, including its name, the hash of the document, and the address of the owner.

This smart contract demonstrates how blockchain technology can be used to securely and transparently store certificate information, providing quick access and verification for interested parties.

Smart contracts on the blockchain open up new horizons for educational institutions, offering effective solutions for process management and learning. The study clearly identified the tasks aimed at studying the applicability of blockchain technologies in the educational sphere, justifying the need to use smart contracts in the educational process, and developing an algorithm for their implementation in the storage and analysis of educational information. The results of this study emphasize that the integration of smart contracts can significantly increase the transparency, reliability, and efficiency of educational data management, as well as contribute to a deeper analysis of the educational process. In the future, this can lead to a more adaptive and personalized approach to education, improving interaction between all participants in the educational process.

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