Decentralized Platform for Issuing and Verifying Student Achievements

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***Abstract*— The aim of this paper is to present a prototype platform for issuing and verifying of student achievements across different forms of academic engagement, using blockchain technology. The proposed solution leverages smart contracts and NFT standards to represent and store verifiable proofs of student participation and performance. By utilizing decentralized storage and wallet-based identity, the platform enables secure, transparent, and tamper-proof management of student achievements. This paper outlines the conceptual framework, presents a technical prototype built on Ethereum-compatible blockchain, and discusses the potential implications of applying tokenization in higher education for incentivizing engagement, ensuring verifiability, and fostering innovation in e-learning ecosystems.**

Keywords—student, digital badge, Blockchain, NFT, student achievements, employability

I. Introduction (*Heading 1*)

Traditional systems of issuing diplomas and certificates are often complex, vulnerable to falsification, and difficult to verify across institutions, limiting trust and efficiency in recognizing student achievements. These challenges highlight the need for secure, transparent, and verifiable digital solutions.

While digital badges and micro-credentials have been explored in education, most existing approaches rely on centralized systems that lack interoperability and strong protection against manipulation. Limited research addresses how blockchain and NFT standards can comprehensively transform credentialing in higher education.

The aim of this paper is to present and evaluate a blockchain-based prototype platform for issuing and verifying student achievements, using smart contracts and NFTs to ensure transparency, immutability, and verifiability. The expected contribution lies in demonstrating technical feasibility and analyzing its potential to enhance student engagement, employability, and innovation in e-learning.

The paper first outlines the theoretical background, including digital badges, micro-credentials, blockchain, NFTs and student achievement and employability. It then presents the system architecture, functionalities, and implementation of the prototype, followed by discussion of results, limitations, and future directions.

II. Theoretical Background

A. Digital badges and tokenization in Education

A digital badge is an online visual marker of achievement, interest, or affiliation, enriched with metadata that provides context, meaning, and evidence of the activity[1]. The origins of badges can be traced to military traditions and religious pilgrimages, where they functioned as visible symbols of achievement, authority, and belonging. In contemporary settings, their digital counterparts first appeared in video games as indicators of accomplishment, a development that laid the groundwork for the emergence of micro-credentials in education and professional learning as formalized representations of skills and competencies [2].

During the learning process, micro-credentials are most effective when designed to promote collaboration and peer interaction, rather than treating learning as an isolated pursuit[3]. Learners are awarded badges that serve as outward symbols of successful learning experiences. Well-designed badges can stimulate intrinsic motivation by emphasizing effort and improvement rather than performance, while also offering learners greater autonomy and choice. By fostering learner independence, badges support the design of guidance and scaffolding that leads to new, engaging, and personalized learning pathways aligned with individual preferences, abilities, and aptitudes[4].

Although many digital badges are issued automatically through mechanisms such as online quizzes, completed activities, or submitted materials, in many cases their credibility is reinforced by the involvement of subject matter experts. This dual approach allows digital badges to serve not only as markers of participation but also as indicators of content mastery, providing a more accurate reflection of learners' knowledge and skills [5]. Micro-credentials and digital badges allow learners to reflect on their accomplishments, recognize how far they have progressed, and identify remaining gaps for growth. They serve not only as markers of recognition but also as structured tools for continuous development, simultaneously enhancing learners' employability by rendering their acquired skills more transparent, demonstrable, and relevant within professional contexts[3].

B. Blockchain and NFTs in Educational Context

The issuance of diplomas in universities often involves complex administrative workflows, which can be streamlined through the adoption of digitally signed documents. To preserve legal validity and prevent unauthorized alterations, these digital diplomas must incorporate trusted digital signatures issued by certified authorities [6]. To ensure the necessary transparency and security in the management of digital diplomas and digital badges, blockchain technology is increasingly being applied. Its fundamental characteristics—such as decentralization, immutability and traceability [7]. Blockchain security is ensured through mechanisms such as hash chaining, which makes altering previous blocks extremely difficult, and incentive structures for miners that uphold network integrity. In Proof of Work, one of the most common protocols, miners expend computational resources to add blocks, discouraging malicious behavior by making attacks costly and inefficient[8].

Blockchain provides key advantages such as enhanced security, trust, and transparency, which hold significant potential for e-learning systems. Several blockchain-based initiatives in education demonstrate how these properties can transform learning by enabling more transparent, secure, and efficient educational experiences[7].

Non-fungible tokens (NFTs) are blockchain-based records that verify the ownership of unique digital assets and offer several contributions to education, including the issuance and management of certificates, the protection of rights, impact beyond the classroom, and privacy control [9]. They are particularly suitable for diplomas, recognitions, and certificates, as they enable secure verification of academic credentials and achievements. The main advantage lies in the use of blockchain tokens, which reduce the risk of falsification while ensuring the reliability of student records and credits. In addition, NFTs provide an effective means of tracking students' learning progress and preserving educational data securely [9][10].

C. Student Engagement and Achivements/Employability

In the context of higher education, student satisfaction has become a key priority for policymakers, as it positively influences academic performance. Beyond formal qualifications, employers increasingly demand a balanced combination of hard and soft skills. Therefore, higher education institutions must integrate employability skills into their curricula to ensure graduates are equipped for the labor market[11]. Faculty performance is often assessed through their competencies and skills, reflecting the demands of the teaching profession as both challenging and influential. Faculty performance is closely tied to student engagement, as effective teaching practices and adherence to competency standards foster critical thinking, self-direction, and responsibility. By integrating innovative methods and providing meaningful learning choices, educators can enhance engagement and support students' development into well-rounded individuals [12].

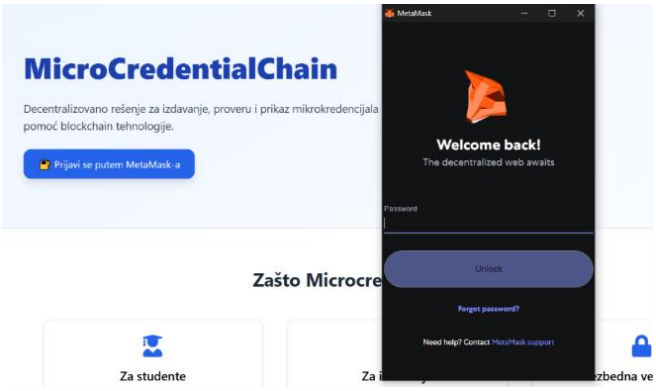
Employability encompasses the integration of knowledge, skills, personal traits, and social resources that enhance an individual's ability to secure and sustain meaningful employment [13]. Employability is a critical issue for students, influenced by factors such as academic achievement and self-concept [14]. Achievement motivation has a positive effect on students' academic performance, which in turn enhances employability, suggesting that academic performance may mediate the relationship between achievement motivation and employability[13].

III. Prototype of the Platform

A. System Architecture

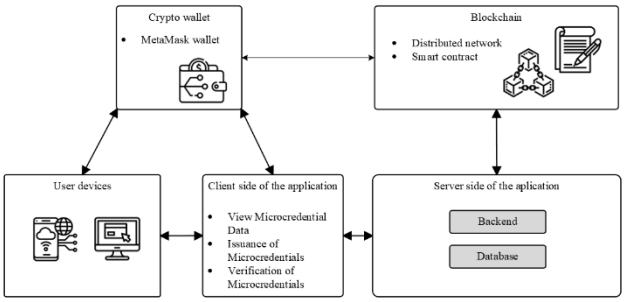
The proposed platform is designed as a decentralized application (dApp) deployed on an Ethereum-compatible blockchain (e.g., Sepolia testnet). The architecture integrates four main layers:

- **Frontend:** A React-based web application with Tailwind CSS, enabling intuitive interaction for students and issuers.
- **Smart Contracts:** Solidity contracts implementing the logic for credential requests, issuance, and verification, following the ERC-721 NFT standard.
- **Storage:** Off-chain storage via IPFS (through Pinata) to host credential metadata and visual certificates, with tokenURIs linking NFTs to this content.
- **Wallet Integration:** MetaMask for authentication, transaction signing, and decentralized identity management.



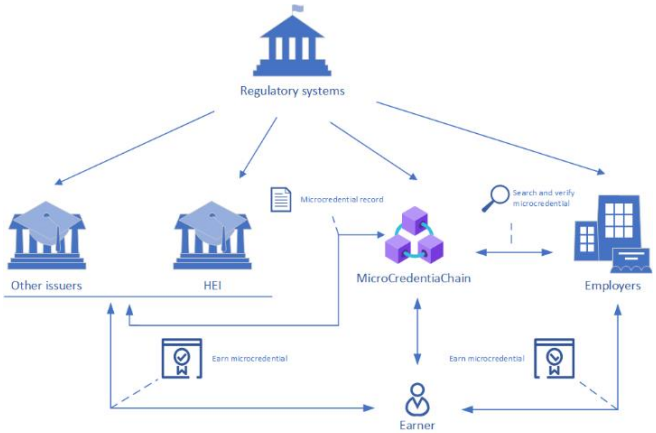
1 Authentication with MetaMask

This layered architecture ensures security, transparency, and verifiability of all issued student achievements.



B. *Core functionalities and processes*

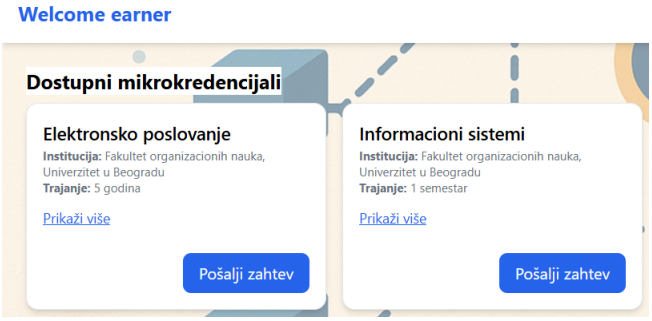
The platform is designed to support the interaction of three primary stakeholder groups: students, issuers, and verifiers. Students, referred to as earners, can connect their digital wallets via MetaMask and submit requests for recognition of their academic or extracurricular achievements. Once their requests are approved, they receive tokenized achievements in the form of NFTs that are permanently stored in their wallets and accessible via tokenURI links. Issuers, typically universities or professors, authenticate themselves through verified wallet addresses and manage pending requests. They are responsible for uploading certificate images and metadata to IPFS and for issuing NFTs using predefined smart contract functions. Verifiers, such as employers or accreditation bodies, do not need direct access to the system. Instead, they can validate the authenticity of credentials by accessing tokenURI metadata on the blockchain, ensuring trustless verification without intermediaries. This division of functionalities enables seamless interaction across different actors within the ecosystem.



2 Stakeholders

The interaction between actors follows a structured three-phase flow.

- **Request Flow:** The student selects an achievement type, submits a request, and links metadata to IPFS.



3 Requesting digital certificate

- **Validation and Issuance:** The issuer reviews the request, uploads certificate data, and issues an NFT credential via the contract.

4 Issuing of digital certificate

- **Verification:** Any third party retrieves the credential metadata via tokenURI and confirms authenticity using blockchain explorers or the frontend.

5 Displaying Metadata via IPFS and token URI

This process ensures that all interactions are transparent, verifiable, and permanently recorded on-chain. By structuring user interactions in this way, the platform supports both inclusivity and accountability across the ecosystem.

C. Smart Contract Implementation

The smart contract serves as the backbone of the system, guaranteeing trust, transparency, and immutability in the issuance of credentials. Students initiate the process by submitting credential requests, which are recorded on-chain and associated with a specific issuer. Authorized issuers can then approve requests and mint NFTs that are directly tied to IPFS-hosted metadata. The contract includes mappings that track ownership of credentials, credentials issued per institution, and the status of requests. Strict authorization rules are enforced so that only the designated issuer is allowed to mint a credential, thereby preventing unauthorized issuance. Furthermore, once minted, tokens cannot be altered or revoked, ensuring immutability of the academic record. This technical foundation provides a high degree of security while simplifying verification for external stakeholders.

```
   pragma solidity ^0.8.24;
   import
"@openzeppelin/contracts/token/ERC721/extensions/ERC721
URIStorage.sol";
   import "@openzeppelin/contracts/access/Ownable.sol";
   contract MicroCredentialNFT is ERC721URIStorage,
Ownable {
       uint public tokenCounter;
       uint public requestCounter;
       struct Credential {…}
   function issueCredentialFromRequest(uint requestId)
public returns (uint) {
           CredentialRequest     storage     req     =
requests[requestId];
       require(!req.isIssued, "Vec izdato");
         require(req.issuer   ==   msg.sender,   "Niste
ovlasceni za ovaj zahtev");

       uint tokenId = tokenCounter;
       _safeMint(req.earner, tokenId);
       _setTokenURI(tokenId, req.tokenURI);

       credentials[tokenId] = Credential(
           req.{Credential}
       );
   function getCredentialsByOwner(address owner) public
view returns (uint[] memory) { … }

   function   getCredentialsByIssuer(address   issuer)
public view returns (uint[] memory) { … }

   function getRequestsByIssuer(address issuer) public
view returns (uint[] memory) { … }

   function getCredential(uint tokenId) public view
returns (Credential memory) { … }

   function getRequest(uint requestId) public view
returns (CredentialRequest memory) { … }
   } }
```

D. The platform

The prototype was developed as part of the Web3 Hackathon 2025, serving as a proof of concept for applying blockchain to student engagement. The implementation combines several widely adopted technologies. Smart contracts are written in Solidity and rely on OpenZeppelin libraries for secure NFT functionality. The frontend, developed in React, offers an intuitive interface for both students and issuers, while ethers.js is used for interaction with the Ethereum blockchain. MetaMask enables wallet-based authentication and decentralized transaction signing, replacing traditional username-password systems. Storage of credential metadata and certificates is provided by IPFS through Pinata, ensuring decentralized and tamper-resistant access to data. This technological stack demonstrates the feasibility of integrating blockchain into educational ecosystems and illustrates how tokenization of student engagement can be realized in practice.

IV. Disccusion and Conclusion

The development of the prototype highlights the potential of blockchain-based tokenization as a novel approach to recognizing and incentivizing student engagement. By integrating decentralized storage, smart contracts, and wallet-based authentication, the platform addresses several limitations of traditional recognition systems, such as lack of transparency, vulnerability to fraud, and difficulties in verification across institutions. The tokenization of student achievements introduces a new layer of trust and permanence, enabling credentials to be shared and validated without intermediaries.

One of the most significant advantages of the proposed system lies in its capacity to motivate students by transforming participation and achievements into verifiable, digital assets. These assets not only serve as permanent proof of engagement but also carry symbolic and potentially economic value in broader educational and professional ecosystems. For issuers, the platform simplifies credential management, reduces administrative overhead, and provides auditable records of student activity. Employers and third parties benefit from immediate, trustless verification, which can streamline recruitment and evaluation processes.

However, the prototype also reveals a set of practical challenges that must be addressed before large-scale adoption. The reliance on blockchain infrastructure raises concerns regarding transaction costs (gas fees), network scalability, and energy consumption. Moreover, institutional adoption depends on regulatory acceptance and alignment with existing educational frameworks for accreditation and certification. From a user perspective, wallet-based authentication may present barriers for students and educators with limited familiarity with Web3 technologies. Thus, additional research and user testing are necessary to ensure usability, accessibility, and compliance.

Looking ahead, there are several opportunities for further development. The prototype could evolve into a governance model based on decentralized autonomous organizations (DAOs), where universities and accredited institutions participate in collective decision-making. Integration with

existing micro-credential frameworks, such as those promoted by the European Union, could enhance interoperability and recognition across borders. Finally, the tokenized achievements could be extended beyond higher education to lifelong learning, professional development, and citizen science initiatives, thereby creating a broader digital ecosystem of trust and recognition.

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