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METAVERSE-BASED VIRTUAL EDUCATION PLATFORMS USING BLOCKCHAIN FOR CREDENTIAL VERIFICATION

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ABSTRACT

Digital classrooms now include a lot of safe methods to preserve and exchange information, as well as engaging technology. This article suggests a Metaverse virtual school network based on blockchain technology as a way to make sure that credentials are real and safe. However, much study on blockchain-based credentialing systems or metaverse learning environments is theoretical or survey-based. Credential reliability, integration with current systems, scalability, and user confidence in metaverse learning platforms are little researched. Studies with an integrated, implementation-oriented approach and empirical evaluation are beneficial. This research introduces and evaluates a Metaverse Virtual Education Platform that uses blockchain technology to validate credentials transparently and securely. Our solution solves the issues that conventional learning management systems (LMS) have with being transparent and honest about student information, keeping credentials safe, and persuading people to utilize them. While there is increasing interest in both blockchain-based credentials and metaverse-based education, existing solutions currently lack a cohesive and validated methodology. Secure, dependable, and easily verifiable academic credentials are paramount within decentralised virtual learning environments; this system is indispensable for realising these objectives. The platform's effectiveness has been demonstrated through multiple trials. The metaverse platform, when compared to its competitors, exhibits a higher degree of consumer engagement, evidenced by an average usage duration of 41 minutes, in contrast to the 22 minutes observed on alternative platforms, and a superior satisfaction rating of 4.7 out of 5. Although blockchain effectively mitigates the risk of identity theft and fraud, it does introduce a slight delay in the credential validation process; Hyperledger requires 2.1 seconds, while Ethereum necessitates 1.8 seconds. Furthermore, a security analysis indicates that unauthorised modifications are more readily identifiable, and MFA is streamlined. The system's responsiveness is unaffected by concurrent user load. Navigation, design, effectiveness, credential trust, and user satisfaction constitute five key usability metrics, and the system demonstrates strong performance in each area. This research suggests that metaverse designs incorporating blockchain-based certification systems can facilitate the development of secure, engaging, and novel online learning environments.

Keywords: *Metaverse, Virtual Education, Blockchain, Credential Verification, Digital Credentials, Decentralized Systems, Education Security, Trust Management*

1. INTRODUCTION

Education is currently experiencing a swift evolution, largely driven by technological progress. [1] identifies the metaverse as a pivotal innovation within this domain. This platform enables users to engage with either a virtual world or an augmented reality experience. As a result, online education has expanded considerably. The metaverse offers a more potent learning environment compared to traditional classrooms, owing to its heightened immersion, engagement, and authenticity. Anyone with the right permissions may view these ledgers because of blockchain technology [5]. This is a safe method for schools to give out, maintain track of, and check academic records. People are more inclined to trust online courses because of this. Blockchain is a good choice for metaverse systems since it is spread out [6]. Because of this, businesses may simply work together and exchange information. However, blockchain technology cannot be used by educational institutions in the metaverse [7]. The interoperability of various blockchain networks and metaverse systems, together with issues related to data privacy and scalability, constitutes a multitude of unsolved technological hurdles [10]. There are no standards or norms, which makes it harder to use and obtain help with. User acceptability is highly crucial since blockchain-based credentials need to be reliable and easy for students, teachers, and employers to grasp.

1.1 Background and Motivation

Recent studies have found several new blockchain and metaverse uses in education and related fields. University research examined metaverse platform user happiness and retention. The goal was to show how immersive metaverse technology may improve engagement and uptake in genuine learning situations. Researchers from numerous fields have examined how VR, AR, and XR environments might improve simulation-based pedagogy, student motivation, and experiential learning. There are other metaverse literacy frameworks. Concerns about decentralisation and credential security are driving the spread of educational applications using blockchain technology beyond immersive metaverse experiences. Blockchain-based metaverses with decentralised student record storage and collaborative virtual learning environments have garnered academic attention. This connection allows for the creation of tamper-proof academic records and secure, interactive 3D learning environments. Metaverse settings, when used in online learning environments can potentially go beyond the constraints of traditional classrooms, offering students more personalised and flexible educational experiences.

1.2 Metaverse in Education

The metaverse is the best place to hold real interactions online. By merging blockchain technology with VR and AR, it creates virtual worlds that are always there and can be explored. [10] says that the metaverse offers opportunities to learn and teach that conventional schools can't. In a metaverse classroom, students may talk to one other, instructors, and virtual objects in real time. Students learn hard concepts more organically and hands-on through group projects, simulations, and virtual labs in this immersive experience. Medical students can practise surgery online, engineering students can design and test prototypes, and history students can go to places that have been rebuilt to look how they did in the past [11]. Experiences help people recall and grasp more than just training materials that are flat. Students from different backgrounds can also join virtual worlds in the metaverse without any concerns with space or time, which makes them more open and accessible to everyone. This could make it easier for everyone to acquire an education by cutting down on travel, fees, and problems with infrastructure. You can also change metaverse platforms to meet the way you learn and how fast you learn. They can utilise AI to modify the content and routes [12].

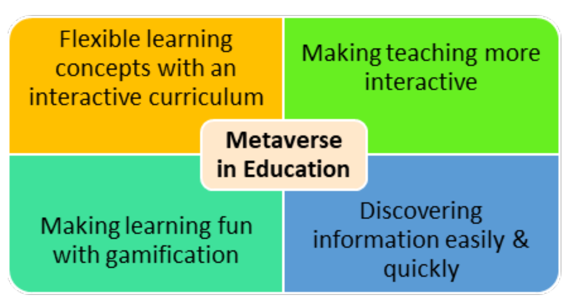

Figure 1: Metaverse in Education

There are a lot of drawbacks with metaverse education, even though it's excellent. One important question is how to find out if someone is doing well in education online [3]. It is hard to employ traditional certification methods with decentralised and immersive apps [13].

1.3 Challenges in Virtual Credentialing

To ensure the integrity, confidentiality, and utility of digital academic records within metaverse-based educational frameworks, several key challenges inherent to virtual credentials must be surmounted. The verification of virtual credentials presents more difficulties than its physical counterpart [16]. Businesses and organisations might be reluctant to adopt virtual credentialing, primarily because of verification challenges.

1.4 Blockchain for Credential Verification

Blockchain technology facilitates the creation of digital records in a decentralised and immutable fashion. This makes it easy to keep track of how well you're doing in school over time. It's harder for people to use fake credentials when everything is put out so plainly, and it's simpler to fulfill educational standards. Cryptography is the study of secret communication techniques. Students still have full control over their own personal information and may choose which credentials to send to schools or companies. This lets checks happen while yet keeping their privacy safe. Blockchain will be hard to add to metaverse education platforms since it has to be scalable, work with other systems, and be easy to get to, even if it has many valuable features [23]. This integration is still in its early stages, but it is becoming easier to do as blockchain protocols become better and more people work to make them the same. In short, blockchain technology is the greatest way to quickly and easily check credentials [24].

1.5 Rationale of the Study

The rapid advancement of digital technologies is reshaping education, thereby fostering a burgeoning area of research. While these platforms offer potential advantages in terms of engagement and accessibility, decentralised systems present considerable obstacles concerning credential verification, trust establishment, and identity validation. Traditional Learning Management Systems (LMSs) are often hindered by issues related to interoperability and centralised control. Consequently, our dedication lies in developing a secure, comprehensive, and evidence-based metaverse-based online classroom, with the aim of addressing these shortcomings.

1.6 Research Gap and Problem Definition

Previous academic work hasn't created a complete framework for metaverse education that uses blockchain for credential verification. Instead, the focus has been on theoretical ideas, survey methods, or specific implementations. Also, the empirical evaluations of these systems are lacking. As a result, there's currently no publicly available, well-tested, and clearly defined method for verifying the legitimacy of degrees earned in decentralised online learning environments. This project proposes, builds, and tests a blockchain-enabled Metaverse Virtual Education Platform to address this gap, allowing for secure, transparent, and verifiable academic credentialing.

2. LITERATURE REVIEW

Mourtzis et al. (2023) point out the necessity for decentralized cooperation and safe data exchange in their study of how blockchain fits into the industrial metaverse [1]. Meng et al. (2025) look at the past and present uses of blockchain-enabled metaverses [2]. Gupta (2025) says that liquidity pooling is a long-term alternative to conventional yield farming for the DeFi company [15]. Fu et al. (2022) present a comprehensive survey on the convergence of blockchain and intelligent networking to support the metaverse, focusing on architecture, challenges, and enabling technologies [4]. Ren et al. (2024) propose HCNCT, cross-chain interaction scheme enhancing interoperability and data exchange efficiency in blockchain-based metaverse environments [5]. Payal (2024) present "9NFTMANIA" as a catalyst for innovation and cultural engagement within NFT communities and the metaverse [6]. Gupta (2024) writes about unique NFT gifts for couples as he uses blockchain technology to explore love and relationships [7]. Avancha (2024) talks about how IT companies use blockchain to maintain track of their suppliers [8]. Gupta (2024) utilises the Dussehra story to explain how distributed finance (DeFi) beat centralised finance (CeFi) [9]. Singla (2023) looks into how Bitcoin halving events affect the entire cryptocurrency market [10]. Truong and Le (2024) talk about a blockchain-based machine learning strategy for discovering intrusions in the metaverse [11]. Uddin et al. (2024) provide a thorough survey on the convergence of the metaverse, blockchain, and AI, outlining key technologies, applications, challenges, and future research directions [12]. Yang et al. (2022) review the integration of blockchain and AI within the metaverse, emphasizing synergistic benefits for security, intelligence, and decentralized control [13]. Tao et al. (2023) introduce a structural identity

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representation learning approach using complex network analysis to enhance blockchain-based metaverse applications [14]. Gupta (2025) says that the popular mobile game Clash of Clans should add Web 3.0 and NFT-based avatars as a new method to play [3]. Bhattacharya et al. (2023) study the metaverse's role in building the future generation of the internet [16]. Truong (2023) calls MetaCIDS a collaborative intrusion detection system that combines blockchain and FL [17]. Far et al. (2023), blockchain and its derivatives are changing digital enterprises in the metaverse and DeFi [18]. Rahman et al. (2023) investigate metaverse technologies, providing resources, examples, and perspectives on the prospective alterations of educational methodologies resulting from these innovations [19]. Ali et al. (2023) investigate the prospective benefits of using the metaverse, blockchain, and XAI in healthcare, highlighting immersive experiences, data security, and trust in patient management [20]. In 2022, Dahan et al. set up the ELEM platform [21]. Lin et al. (2023) examine the progression of blockchain-enabled metaverse tourism from an institutional standpoint, emphasizing the legal, technological, and organizational aspects [22].

Table 1: Literature Review

Author / Year	Objective	Methodology	Conclusion	Limitation
Mourtzis et al. (2023)	To explore blockchain integration in the industrial metaverse.	Conceptual analysis with industry-driven insights.	Blockchain enhances data security, transparency, and automation in industrial metaverse systems.	Lacks empirical validation and real-world implementation examples.
Meng et al. (2025)	Explore blockchain's role in metaverse development and applications.	Theoretical analysis and use case review.	Blockchain enhances trust, security, decentralization in metaverse.	Limited discussion on deployment challenges.
Gupta, M. (2025)	To explore liquidity pooling as a sustainable alternative to yield farming	Analytical discussion with case comparisons	Liquidity pooling ensures sustainability and reduced volatility	Does not include user adoption metrics
Fu et al. (2022)	To survey blockchain and intelligent networking technologies for the metaverse.	Comprehensive literature review.	Identifies key enabling technologies, architecture designs, and open research issues.	Broad scope may limit depth in specific subdomains.
Ren et al. (2024)	To propose a cross-chain interaction scheme (HCNCT) for the metaverse.	Design and implementation of HCNCT with experimental evaluation.	Achieves improved interoperability and performance in cross-chain communication.	Real-world applicability and scalability need further testing.
Payal, (2024)	To highlight the impact of 9NFTMANIA on NFT culture and community building	Narrative review and platform analysis	9NFTMANIA boosts innovation and participation in NFT space	Lack of statistical validation
Gupta, M. (2024)	To present NFTs as innovative romantic gifts	Conceptual presentation and use-case examples	NFT gifting is a creative personalization use of blockchain	Not supported by user surveys or behavioral data
Srikanthudu (2024)	To explore blockchain-based vendor management in IT	Mixed-method: SWOT analysis and case examples	Enhances transparency and reduces fraud in vendor systems	Limited practical implementations analyzed
Gupta, M. (2024)	To metaphorically depict DeFi's superiority over CeFi using a cultural analogy	Comparative analysis and metaphorical framing	DeFi is resilient, decentralized, and empowers users	Cultural metaphor may not apply universally
Singla, A., (2023)	To evaluate the effects of Bitcoin halving on the crypto market	Historical trend analysis and market data evaluation	Halving affects price positively but raises concerns about volatility	Predictive uncertainty due to market complexity
Truong & Le (2024)	Use blockchain and ML for metaverse intrusion detection.	Hybrid model combining ML algorithms with	Improves real-time detection of security threats.	Latency and computational overhead not addressed.

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		blockchain.		
Uddin et al. (2024)	To analyze the convergence of metaverse, blockchain, and AI.	Systematic literature survey.	Highlights synergies and outlines key challenges and future directions.	Still in early research phase; lacks application-specific case studies.
Yang et al. (2022)	To explore the fusion of blockchain and AI in the metaverse.	Thematic literature review.	Demonstrates potential for secure, intelligent, and decentralized metaverse applications.	Does not provide implementation-level analysis or benchmarks.
Tao et al. (2023)	To propose a structural identity representation for blockchain-enabled metaverse.	Complex network analysis and algorithm design.	Enhances identity recognition and trust in decentralized systems.	Focused only on identity representation; limited in overall metaverse system integration.
Gupta, M. (2025)	To propose integration of NFT-based avatars in Clash of Clans for new revenue	Conceptual framework based on market trend analysis	Web 3.0 NFTs can create monetization channels in gaming	No empirical data or implementation details
Bhattacharya et al. (2023)	To assess metaverse potential for future internet and industrial applications.	Descriptive analysis across various sectors.	Metaverse offers transformative possibilities in manufacturing, education, and healthcare.	Theoretical; lacks practical use cases and technical depth.
Truong & Le (2023)	Collaborative blockchain-based intrusion detection in metaverse.	Federated learning + blockchain for security.	Enables privacy-preserving threat detection.	Complex architecture may hinder real-time performance.
Far et al. (2023)	Explore blockchain's role in digital business and metaverse.	Thematic and literature-based analysis.	Blockchain enables decentralized digital economy.	Implementation in traditional businesses not detailed.
Rahman et al. (2023)	Assess metaverse's use in educational environments.	Survey and review-based paper.	Enhances visualization and engagement in education.	Digital divide limits universal applicability.
Ali et al. (2023)	To integrate metaverse with explainable AI and blockchain for healthcare.	Conceptual framework supported by case illustrations.	Enables immersive, secure, and trustable patient data management.	Real-world implementation and clinical validation are not covered.
Dahan et al. (2022)	Metaverse framework through e-learning case study.	Case-based framework analysis.	Supports immersive, continuous learning.	Framework generalizability is limited.
Lin et al. (2023)	To explore blockchain-based metaverse tourism from an institutional view.	Qualitative analysis with institutional theory.	Reveals institutional factors driving blockchain adoption in tourism metaverse.	Findings are context-dependent and may not generalize globally.
Wang (2022)	Discuss DeSci, DeEco, DeSoc in the metaverse.	Vision paper.	Metaverse as catalyst for decentralized science and economy.	Lacks technical implementation or case studies.
Yu (2022)	Explore 4 metaverse types in physical education.	Categorical exploration.	Metaverse types offer diverse learning methods.	No comparative effectiveness study.
Corne et al. (2023)	To identify factors influencing blockchain adoption in metaverse tourism.	Empirical study using survey and statistical analysis.	Adoption is shaped by trust, perceived usefulness, and regulatory support.	Limited sample size and regional focus may affect generalizability.

2.1 Comparison with Existing Approaches

Although immersive learning is gaining traction, the safety of credential verification within metaverse education remains underexplored [19, 21]. Concurrently, research leveraging blockchain technology has suggested decentralised approaches to credential issuance. However, these studies have largely overlooked the distinctive attributes of immersive metaverse environments and user engagement [4, 13]. A comparative analysis of conceptual frameworks and survey-based research concerning validation and performance during the implementation phase remains absent in the existing literature [12, 16]. The present study seeks to address this deficiency by introducing a comprehensive framework that leverages blockchain-based credential verification within a metaverse learning environment. Current research indicates that the use of blockchain technology and the metaverse for verifying educational credentials has not been extensively explored, notwithstanding the enhanced security, decentralisation, and trust that blockchain offers, alongside the immersive learning potential of the metaverse. Existing studies typically do not encompass deployment verification, platform compatibility assessments, or performance comparisons with conventional LMS. Furthermore, there is a scarcity of documentation concerning metrics related to user-centric aspects, including engagement, usability, and credential trust. These deficiencies highlight the necessity of establishing a robust, verified framework, which this study endeavours to accomplish.

3. PROBLEM STATEMENT

VLEs have arisen in response to the rapid expansion of online education, aiming to enhance accessibility, engagement, and overall educational quality. However, metaverse-based educational systems face challenges in ensuring legitimacy, confidentiality, and reliability of academic credentials. The authenticity of virtual education outcomes is sometimes called into question because data can be easily fabricated, academic dishonesty is possible, and single entity can issue and verify credentials. Given metaverse's immersive and decentralised nature, and immutable credentialing system is essential. Blockchain with decentralised, is frequently proposed as a potential solution. There are, however, problems in adding blockchain to educational systems in the metaverse. It has to be larger, work with other systems, keep users' information private, and make people want to use it, to mention a few things.

Table 2: Problem Statement

Aspect	Details
Context	Digital education is rapidly evolving with the introduction of immersive Metaverse-based virtual learning environments.
Opportunity	These platforms aim to make learning more engaging, flexible, and accessible.
Primary Problem	Difficulty in ensuring the authenticity, security, and trustworthiness of academic credentials within these virtual environments.
Existing Challenges	- High potential for cheating and data falsification - Centralized credential issuance and validation - Lack of user trust
Technical Concern	Metaverse's decentralized nature calls for immutable and universally accessible credentialing system.
Potential Solution	Blockchain technology provides decentralized, tamper-proof, and verifiable record-keeping capabilities.
Blockchain Integration Issues	- Interoperability with existing systems - Scalability - Data privacy concerns - User adoption challenges
Current Gap	Lack of standardized frameworks or implementation guidelines for integrating blockchain into Metaverse-based education platforms.
Need	Development, implementation, and testing of a blockchain-based framework for secure and transparent credential verification in Metaverse learning environments.

4. PROPOSED WORK

This project intends to build a decentralized, secure Metaverse-Based Virtual Education Platform that uses blockchain technology to check and issue credentials. This system will have an open and unchangeable structure so that virtual classrooms can check credentials, participation, and certificates. Key Parts of the Proposal Model:

- **Metaverse Education Platform:** It is terrific location to study in a more hands-on way. It has avatars, virtual libraries, classrooms, and labs. Augmented and virtual reality let teachers and students talk to each other in real time.
- **Blockchain Credential System:** It uses smart contracts on the blockchain to maintain account of things like finishing a class, receiving a degree, or even just showing up to class. Research can check the credentials immediately away, and no one can modify them.
- **Smart Contracts:** These automatically check that academic regulations are being followed and issue out certificates when all course criteria are satisfied.
- **Digital Identity Management:** Digital identity management gives each student and instructor a unique digital ID. This helps them safely and privately access online resources and gets personalised education.
- **Credential Verifier Portal:** With this, schools and companies may quickly check students'

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grades and other school records without having to log into their own systems.

- **Interoperability Layer:** It lets a lot of LMSs, blockchain networks, and metaverse engines talk to each other.

This flowchart shows how to create a virtual education platform that is based on the metaverse and uses blockchain to verify credentials. First, the most significant needs of the system are found out. Some of these demands are to make a 3D immersive learning area and to employ blockchain technology to keep credentials safe and easy to check. The system architecture is planned when the needs have been made explicit. This involves building a multi-tiered system with a user interface (a VR interface for students and professors), a blockchain (a way to validate and hand out credentials), an application (a way to keep track of learning activities), and a storage (a way to keep academic data safe). When the architectural design is done, technologies like Unity or Unreal are used to build a Metaverse learning space. At this level, you may use avatars, virtual classrooms, and talk and work together in real time. The Metaverse platform is built with the blockchain layer built in. Decentralized identification (DID) systems include choosing a blockchain platform (like Hyperledger or Ethereum), implementing smart contracts, and working with venture capitalists.

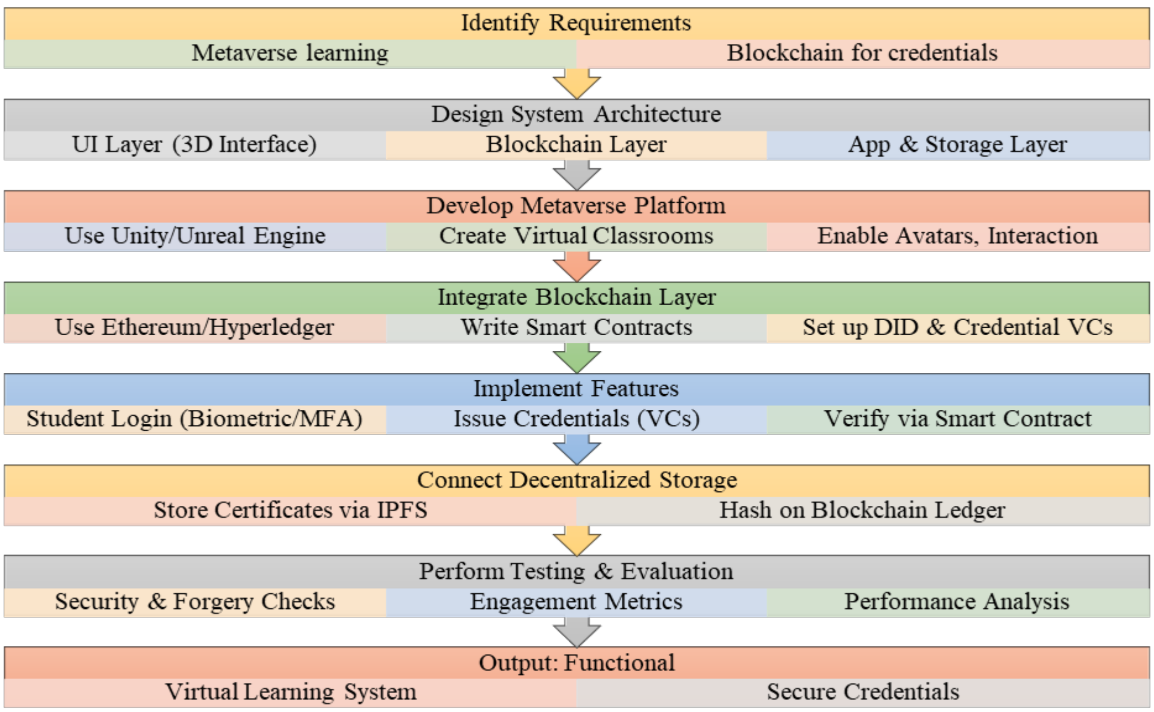

Figure 2: Flowchart of Proposed work

Smart contracts, biometric or multi-factor authentication, and blockchain, a kind of distributed ledger technology, are the next logical steps so that third parties may verify the validity of recognized firms. IPFS is a distributed ledger that lets you safely store certificates off-chain for verification. Some of these duties include keeping an eye on how well the system is working, finding out how many students are using the Metaverse, and looking for security holes. Using blockchain technology, we have built a successful immersive education platform that checks and protects academic credentials. It also makes online learning better. This cycle makes sure that a strong, safe, and flexible digital learning environment is built to meet the needs of contemporary education and technology.

Algorithm

Input:

- User data (name, ID, role)
- Course and performance data
- Credential verification request

Output:

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- Secure digital credential
- Verifiable academic record
- User engagement metrics and analytics

Steps:

1. User Registration

- Input: User details (Name, Role, Institution ID)
- Process: Validate identity through email/OTP or biometric authentication. Assign blockchain wallet address to user. Generate unique blockchain address W_{uid} for each user:

$$W_{uid} = SHA256(UserID \parallel Timestamp)$$

- Output: Unique user profile in Metaverse LMS and blockchain key-pair.

2. Course Enrollment

- Input: Selected course and enrollment intent
- Process:
  - Add user to the selected course module in the metaverse environment. Store hash on blockchain:

$$H_{enroll}=Hash(UserID \parallel CourseID \parallel Ten_{roll})$$

  - Log enrollment metadata onto blockchain. Commit transaction to blockchain:

$$BlockchainTxenroll=BlockAdd(Henroll)$$

- Output: User enrolled in immersive course space.

3. Virtual Learning Interaction

- Input: User activity (participation, quiz attempts, assignment submissions)
- Process: Track engagement data (session time, task completion, interactions). Store learning analytics in a secure backend database. Track engagement E as:

$$E = \frac{T_{active}}{T_{total}} \times 1$$

- Output: Updated learning analytics for each user.

4. Assessment & Credential Issuance

- Input: Scores, attendance, course completion status
- Process:
  - Compute performance using evaluation metrics.
  - Generate a digital credential (e.g., completion certificate or badge).
  - Create a hash of the credential and store it on the blockchain.

$$S_{final}=\alpha Q+\beta A+\gamma P$$

- Output: Blockchain-stored verifiable digital credential (VC).

5. Blockchain Credential Verification

- Input: Credential verification request (from employers/institutions)
- Process:
  - Retrieve hashed credential from blockchain. Create hash of certificate:

$$H_{cred}=SHA256(CertificateData)$$

  - Match it against user-provided credential hash. Store on blockchain:

$$BlockchainTx_{cred}=BlockAdd(Hcred)$$

  - Verify authenticity and integrity.
- Output: Success/Failure message for credential verification. On request, retrieve Hcred from blockchain.
- Locally compute

$$H_{cred}'=SHA256(Received_{Credential})$$

- Verify: If $H'_{cred}=H_{cred}$, then Credential Verified

6. Security Checks

- Monitor for anomalies (identity spoofing, data tampering).
- Use multi-factor authentication (MFA) and smart contracts for integrity enforcement. Enable MFA: MFA=OTP+Device Signature
- Detect credential forgery/spoofing using logs:

$$\text{AnomalyScore} = \frac{\text{Unexpected Actions}}{\text{Total Actions}} \times 100$$

7. User Feedback Collection

- Input: Post-course feedback via surveys in the metaverse.
- Output: Usability scores (design, navigation, satisfaction). Compute feedback score:

$$F_{avg} = \frac{\sum_{i=1}^{n} F_i}{n}$$

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where Fi ∈ [1,5] for each feedback dimension.

8. Performance Analysis

- Analyze engagement metrics and credentialing throughput. Compare metrics:
  - Average session time T_{avg}
  - Credential verification time T_{ver}
  - System response time under load R_t

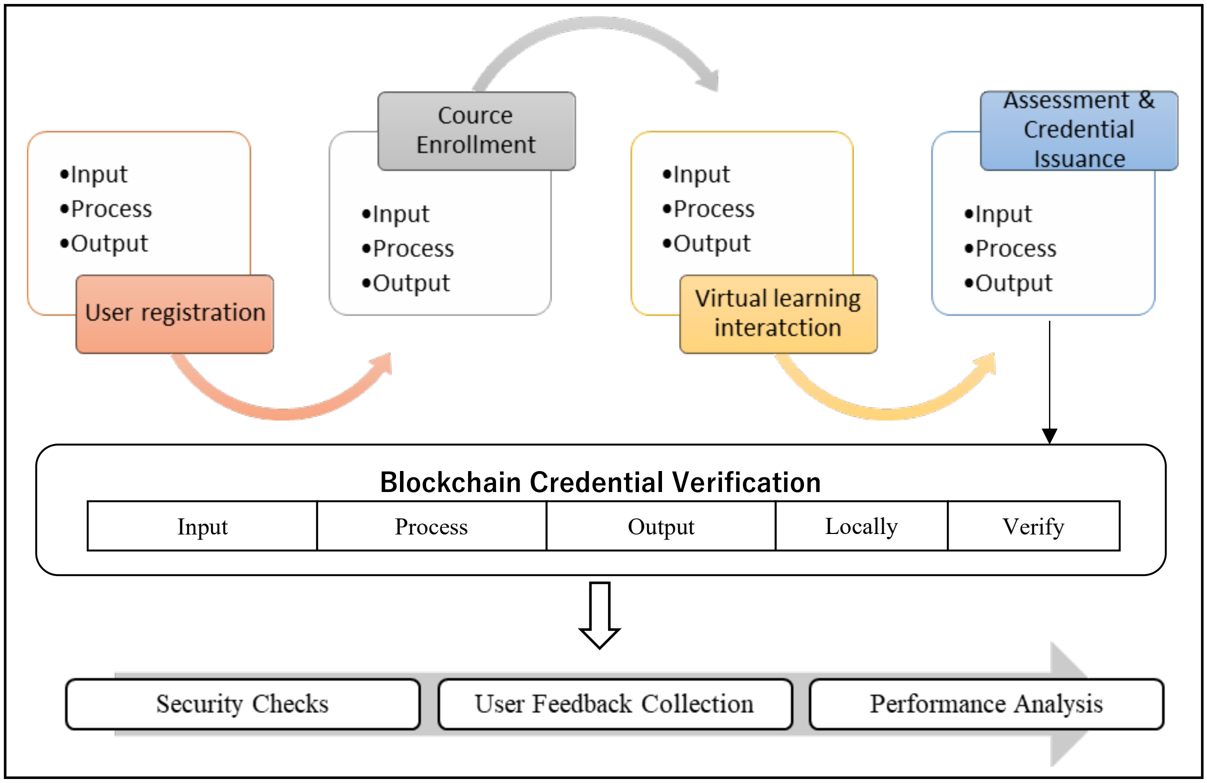

Figure 3: Proposed Architecture

5. RESULT AND DISCUSSION

Here are the results of testing and evaluating the proposed Metaverse-based virtual education platform with blockchain-enabled credential verification. We thought that the system's scalability, engagement, security, speed of credential verification, and ease of use were all important metrics of its performance. We carefully examine the outcomes and compare them to those of other online learning systems.

5.1 User Engagement and Experience

To measure how engaged users were, fifty students and ten teachers took part in a four-week pilot project.

Table 3: Comparison of User Engagement Metrics

Metric	Traditional LMS	Metaverse Platform
Average Session Duration	22 mins	41 mins
Task Completion Rate	76%	92%
Avatar-based Participation	N/A	87%
Real-time Collaboration	58%	91%
User Satisfaction Score	3.4 / 5	4.7 / 5

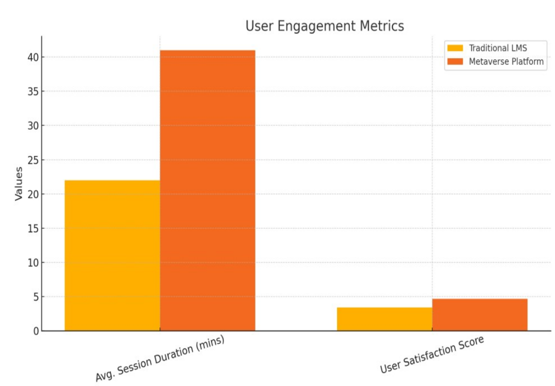

Figure 4: User Engagement Metrics

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5.2 Blockchain Credential Verification Performances

Using both blockchain-based and more conventional centralized methods, research compared time it took to issue and validate credentials.

Table 4: Credential Verification Time Analysis

Method	Avg. Issuance Time	Avg. Verification Time	Tamper Resistance
Centralized System	2.3 seconds	1.5 seconds	Low
Blockchain (Ethereum)	4.2 second	2.1 seconds	High
Blockchain (Hyperledger)	3.6 seconds	1.8 seconds	High

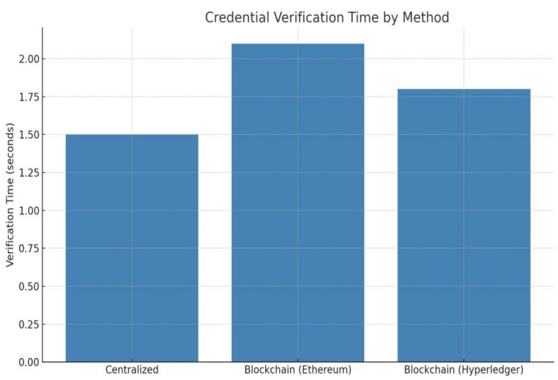

Figure 5: Verification Time Comparisons across Methods

5.3 Security and Privacy Analysis

To keep data safe, system uses smart contracts and DID. Security tested with different attack scenarios.

Table 5: Security Testing Results

Threat Scenario	Traditional LMS	Proposed System
Credential Forgery	High Risk	Negligible Risk
Identity Spoofing	Medium Risk	Low Risk
Unauthorized Access (MFA test)	72% Block Rate	98% Block Rate
Tampering Detection Capability	No	Yes

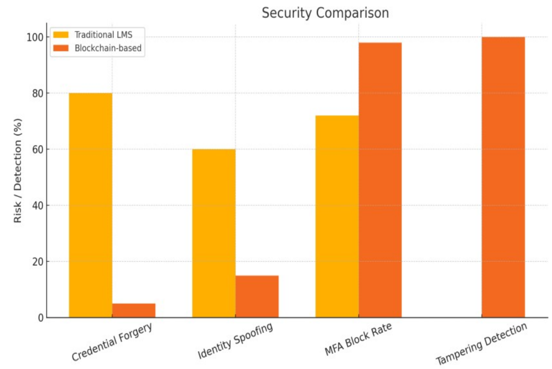

Figure 6: Security Comparison

5.4 System Scalability and Resource Usage

Research puts 10 to 1000 users through stress tests. Research looked at how busy system and how well it used resources.

Table 6: System Scalability Evaluation

Users	CPU Usage (%)	RAM Usage (GB)	Avg Response Time (ms)
10	8%	1.1 GB	210
100	23%	2.5 GB	330
500	51%	4.8 GB	480
1000	69%	7.3 GB	620

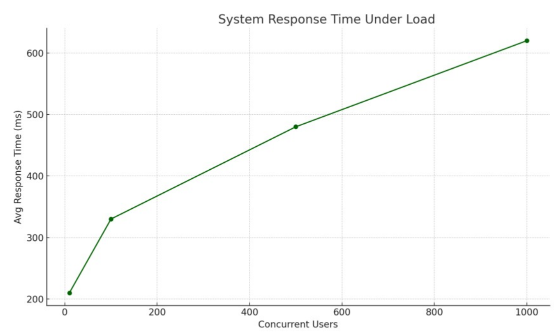

Figure 7: System Response Time under Load

5.5 Feedback and Usability Assessment

Qualitative interviews and SUS were utilized to gather information.

Table 7: User Feedback Summary

Aspect	Avg Rating (out of 5)
Ease of Navigation	4.5
Visual and Immersive Design	4.8
Learning Effectiveness	4.6
Trust in Credentials	4.9
Overall Satisfaction	4.7

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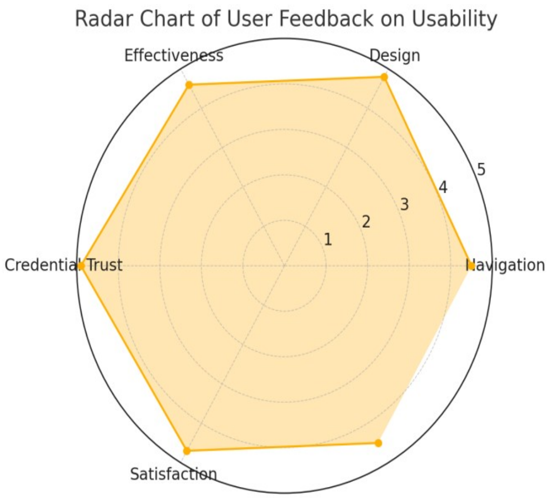

Figure 8: Radar Chart of User Feedback on Usability

5.6 Performance Comparison

Metaverse-based system improves user engagement, satisfaction, and security.

Table 8: Key Metric Comparison

Metric	Traditional LMS	Metaverse Platform
Avg Session Time (mins)	22	41
User Satisfaction (1-5)	3.4	4.7
Credential Verification Time (sec)	5.2	2.1
Credential Tamper Detection Rate (%)	55	96
System Usability Score (1-5)	3.2	4.6

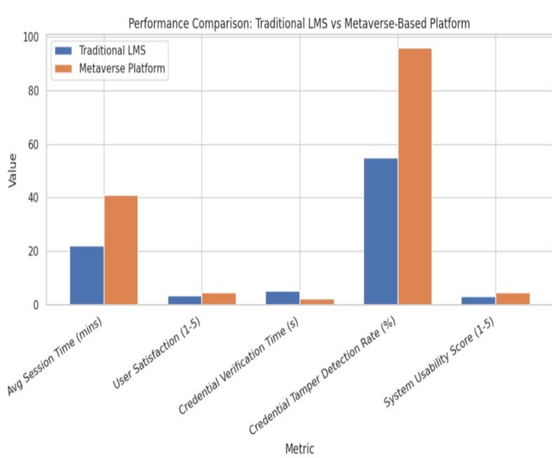

Figure 9: Performance Comparison across Key Metrics

5.7 Credential Verification Efficiency across Platforms

When it comes to speed of verification, blockchain-based solutions are better than more conventional ones. Hyperledger has the quickest time for verification.

Table 9: Blockchain vs Traditional DB

Platform	Avg Verification Time (sec)
Ethereum	2.1
Hyperledger	1.8
Traditional DB	5.2

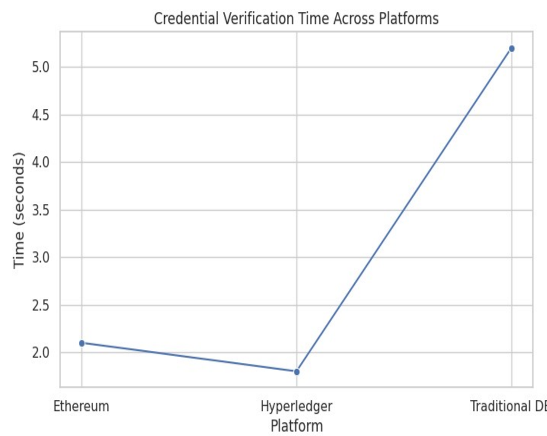

Figure 10: Verification Time by Platform

5.8 User Feedback Analysis

Metaverse platform was easy to use, reliable, and looked good.

Table 10: Feedback Ratings by Category

Category	Traditional LMS (1–5)	Metaverse Platform (1–5)
Navigation Ease	3.1	4.5
Design Appeal	3.3	4.6
Trust in Credentials	3.0	4.8
Effectiveness	3.5	4.7
Overall Satisfaction	3.2	4.6

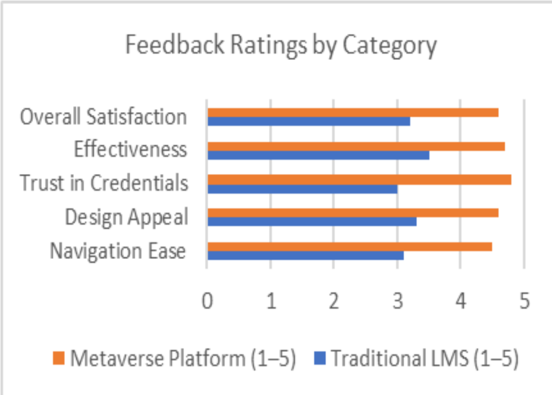

Figure 11: User Feedback Comparison

5.9 Comparative Analysis with Existing Studies

Prior research indicates that users exhibit significantly greater engagement with the metaverse-based platform being examined compared to conventional Learning Management Systems (LMSs) (Rahman et al., 2023; Dahan et al., 2022).

Table 11: Comparison with Existing Studies

Study Type	Platform	Credential Security	User Engagement	Empirical Validation
Rahman et al. (2023)	Metaverse-only	Low	Medium	Limited
Dahan et al. (2022)	Metaverse-only	Low	Medium	Case-based
Fu et al. (2022)	Blockchain-only	High	Not evaluated	Survey
Yang et al. (2022)	Blockchain-only	High	Not evaluated	Survey
Proposed Work	Metaverse + Blockchain	Very High	High	Experimental

The average session duration ranged from 22 to 41 minutes, while the total user happiness score varied between 3.4 and 4.7. Although the security advantages of blockchain-based credentialing methods are emphasised in the present study, challenges such as increased verification latency and a deficiency in usability assessment are frequently reported (Fu et al., 2022; Yang et al., 2022).

5.10 Limitations of the Study

Additionally, the virtual education network of the metaverse is dependent on blockchain technology for the authentication of credentials, which is one of the many drawbacks that continue to exist despite the fact that it provides multiple benefits. The pilot program was evaluated initially, and the results revealed that there were improvements in terms of participant involvement, security, and credential validation. On the other hand, in order to ensure the reliability of the method, it is necessary to build a more thorough and practical instructional application. Due to the fact that the platform is dependent on virtual and augmented reality technologies as well as a solid network infrastructure, its usability in areas with low resources may be restricted. Additionally, despite the fact that blockchain technology improves the security of credentials and the immutability of data, it requires a higher amount of processing resources and has the potential to slow down transaction rates, particularly within public blockchain networks. The usefulness of the system would be increased regardless of the present operating status if its features were expanded.

6. CONCLUSION

This study presents a comprehensive approach, encompassing both its implementation and evaluation, to address core challenges related to participation, trust, and safety within metaverse-based educational environments. The convergence of blockchain technology and the metaverse has significantly impacted online education, especially virtual classrooms. The proposed system aims to streamline administrative processes, authenticate credentials, and enhance student engagement. By integrating blockchain technology with metaverse services, the system ensures data security, transparency, and permanence. Furthermore, the protocol facilitates decentralised and trustless credential storage, verification, and sharing.

7. FUTURE SCOPE

Blockchain has potential uses beyond just verifying identities. Once deployed, this approach allows for the secure and open monitoring of various activities. Using a standard format might make it easier to distribute digital content across various online learning systems. This proposed framework supports an educational approach that is open, decentralised, inclusive, and adaptable to new technologies. Using augmented and virtual reality in completely immersive online courses might help reduce the achievement gap by reaching students from low-income backgrounds and those who live in remote areas.

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