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A Blockchain-Driven Framework for Educational Document Verification in Pakistan

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K E Y W O R D S

Digital Identification

Usability Evaluation

Smart Contracts

IPFS Interplanetary File System

Paperless System

Decentralized Storage

A B S T R A C T

This research work provides a blockchain-based system for digital identification and authentication of educational documents in Pakistan. The suggested model is striving to eradicate the problems that occur continuously like document fraud, long process of manual verification, lack of clarity, and poor interchangeability between institutions. The system that uses Ethereum for smart contracts and IPFS for decentralized storage allows academic records to be accessed with security, unforgeability, and high efficiency. A simple and user-friendly prototype with a web-based interface was constructed which was for students, institutions, and recruiters. To check the usability, the USE questionnaire was used. 204 responses (152 students and 52 recruiters) were gathered. Student participant ages were from 18 to 35 years (81% male, 19% female), whereas recruiters were between 30 and 50 years (70% male, 30% female) as per demographic analysis. The evaluation exhibited dependability for the constructs tested, with Cronbach's alpha values of 0.805 for usefulness, 0.781 for ease of use, 0.809 for ease of learning, and 0.761 for satisfaction. Hypothesis testing identified three positive correlations: usability → satisfaction (β=0.228, p=0.001), ease of use → satisfaction (β=0.188, p=0.000), and ease of learning → satisfaction (β=0.285, p=0.000). Therefore, the system usability factors have a significant impact on overall user satisfaction, as evidenced by the results consistent with the acceptance of blockchain technology in educational document verification. The findings emphasize that the technology, in addition to lowering red tape, builds confidence with the users thereby facilitating the implementation of paperless processes which are of great environmental value. This research shows that the use of blockchain and decentralized storage can make the verification of educational documents in underprivileged areas more open, friendly to resources, and dependable, hence the possibility of expansion to the entire academic world.

1. Introduction

In the contemporary era, people need to be able to ascertain the genuineness and security of their educational qualifications. The situation is critical in Pakistan, where traditional methods are the order of the day [1]. Getting the physical copies of documents is prone to theft, loss, or forgery, and the manual verification of bodies such as the Higher Education Commission is time-consuming, expensive, and with a high level of error [2,3]. These operations are also harming our natural environment, due to deforestation that could have been avoided in large amounts. Both parties face problems when there are students and job seekers on the one hand, and recruiters and institutions on the other, and they need to authenticate the documents. The modern innovations, if put into use, could efficiently replace these processes with virtually

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no human intervention, build trust, and reduce the contamination of the environment as major bottlenecks will be addressed [4,5,6].

Another way is to make use of smart contracts along with decentralized storage alongside blockchain technology. For instance, the research brings in the example of a secure digital identification and verification system suitable for the academic sector in Pakistan [10,11,12,13]. Through the use of the system, it will be possible to get rid of conventional and closed institutions, reduce the risk of unauthorized users, and update the credentials verification system in real-time. The prototype on Ethereum was implemented and evaluated in terms of usability, satisfaction, and efficiency using the USE questionnaire [14,15,16]. The existing research shows that blockchain has the potential to update academic credentialing and, at the same time, fix fraud, and the problem of late arrivals and environmental issues [16].

Online education's worldwide propagation of utilizing e-records has instigated the establishment of reliable and effective systems that cut down the dependency on manual, paper-based verification. The systems, which, although prevalent in some countries, are hardly ever effective, are slow and error-ridden, and are a potential hotbed for forgery of credentials. To address these shortcomings, digital solutions such as web portals, cloud systems, and AI-enhanced platforms have emerged, offering automated credential validation, improved accessibility, and reduced administrative overhead [17,18,19].

Models such as the student number-linked academic systems of Estonia, Miscreeds of Canada, and Europa's of the European Union are a few examples of how online credentials are used to create trust and transparency, which is to a large extent trustworthy. India and Australia have QR code verification systems and academic depositories that are essentially the same type of systems that provide a secure way of digitally verifying the authenticity of documents not only at the time of issuing but also later on as well. But on the contrary, a lot of developing countries like Pakistan still use centralized systems that are not scalable or secure. Blockchain, whose distributed ledger, cryptographic security, and smart contract automation, is a hard nut for any system to break, can be a strong replacement for current solutions. It makes the tamper-proof storage of academic credentials, their instant availability, and decentralized verification possible, thus solving the main problems of managing educational records and providing a scalable solution for nationwide implementation [20,21,22].

Various studies reveal a remarkable increase in the submission of the blockchain technology in the educational ground in command to start a safe system for checking academic records [23]. One instance of this was when blockchain was showcased as a tool to fight fake credentials in universities, while another paper was about the difficulties in the interoperability of academic systems based on blockchain [24]. The most recent work has pointed out how the use of decentralized storage systems could contribute to the openness and scalability of the area. Our research is supported by these findings as they emphasize the need for safety, scalability and designing with the user in mind when utilizing blockchain technology for document verification [23,25].

2. Interoperability and Scalability

The capability of a system to combine and cooperate with present infrastructures in the field of education is one of the major factors that are considered when deploying a system. To ensure compatibility with working standard systems, the prototype is built to be system and API-based interoperation with university databases and governmental verification portals. In order to deal with the aspect of scalability, the given solution like sidechains or rollups to process more transactions at lower fees and with higher efficiency. An idea of a blockchain consortium at the national level for universities might also be considered, which would facilitate the exchange of documents among different institutions without the risk of losing the autonomy.

2.1 Technical Architecture & System Development

The proposed system follows a decentralized architecture leveraging the Ethereum blockchain to ensure secure, tamper-proof, and verifiable academic records, as shown in Figure 1. Users initiate verification requests, which are processed by educational institutes and forwarded to the blockchain via smart contracts. These contracts access data stored in IPFS (Interplanetary File System) and the blockchain ledger to validate records using encryption

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technique. Onceconfirmed, results are sent back to the users thus safeguarding transparency and information integrity.

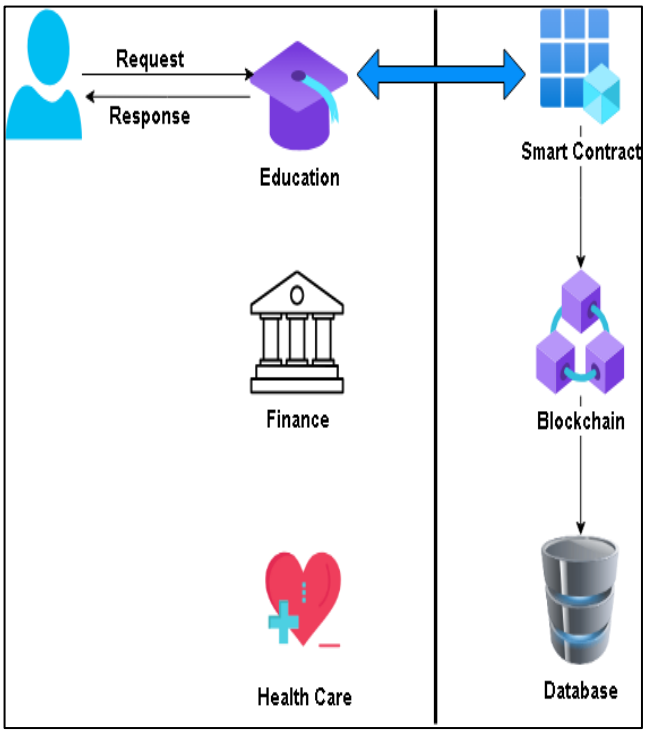


Fig. 1. Building Structure of Proposed System

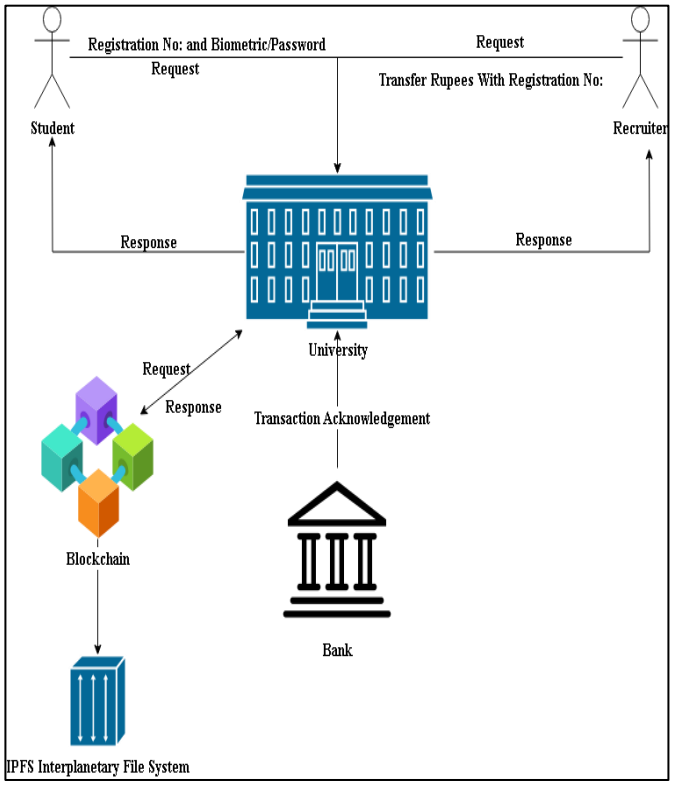
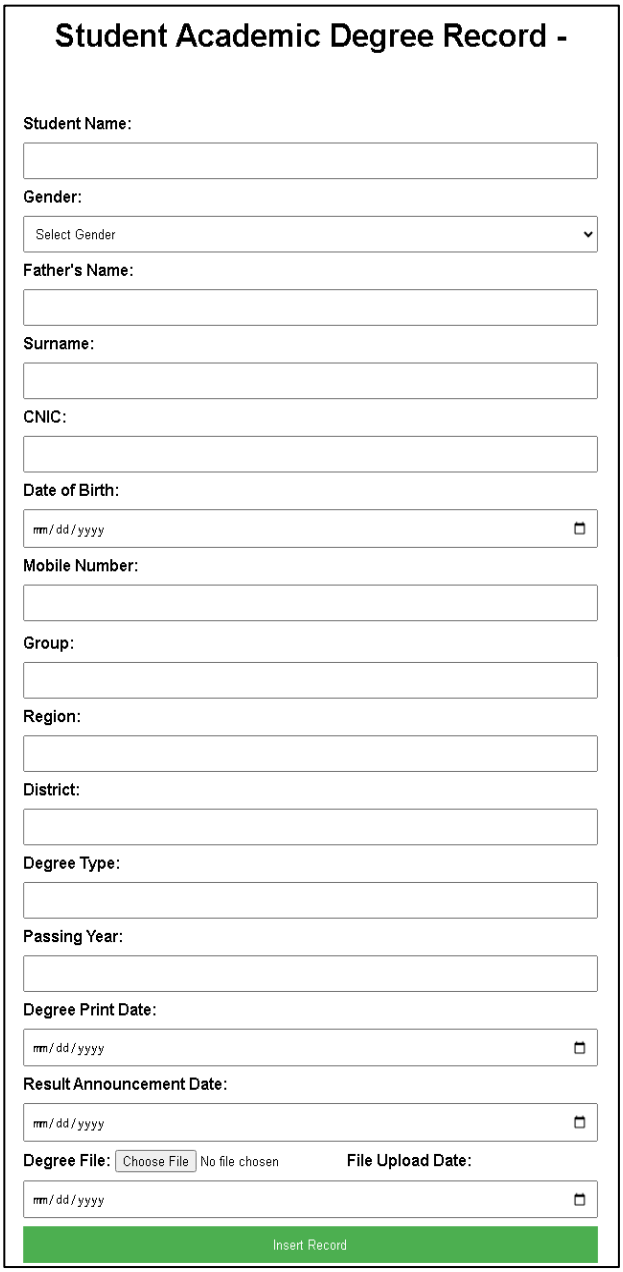


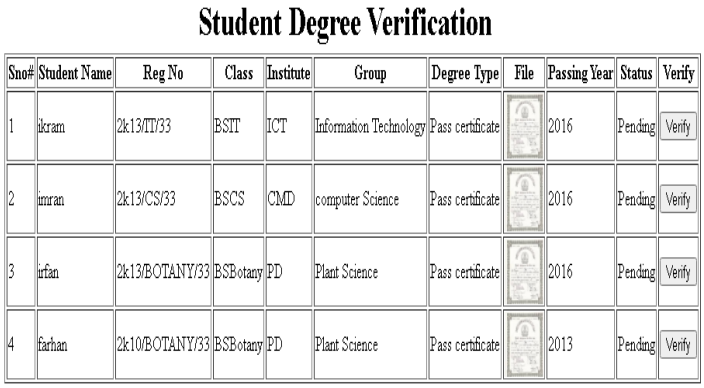
Fig. 2. Working Process of Proposed System

2.2 Process Workflow

The workflow of the system is separated among four mains actors:

- Admin Clerk uploads student details.
- The controller verifies uploaded documents and pushes them to the blockchain.
- Student accesses their verified credentials using their Roll Number or CNIC.
- The recruiter after paying the verification fee, confirmed by the institution, verifies student credentials.





Student Degree Verification

Sno#	Student Name	Reg No	Class	Institute	Group	Degree Type	File	Passing Year	Status	Verify
1	ikram	2k13/IT/33	BSIT	ICT	Information Technology	Pass certificate		2016	Pending	Verify
2	imran	2k13/CS/33	BSCS	CMD	computer Science	Pass certificate		2016	Pending	Verify
3	irfan	2k13/BOTANY/33	BSBotany	PD	Plant Science	Pass certificate		2016	Pending	Verify
4	farhan	2k10/BOTANY/33	BSBotany	PD	Plant Science	Pass certificate		2013	Pending	Verify

Fig. 3. Admin Student Data Entry Panel and Controller Verify Student Records

2.3 Web Application Development

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The front-end of the application is developed using HTML5, JavaScript, CSS, and Bootstrap for responsive web design. The server-side is done with PHP and Node.js technologies. RESTful APIs enable asynchronous data exchange between the app and the blockchain. Web3.js in combination with MetaMask helps users to verify their identity and work with smart contracts on the Ethereum network right in the browser.

2.4 Roles and Interfaces

- Admin Panel: An admin clerk is allowed to create and upload students records.
- Controller Panel: It opens the way for document verification and submission to the blockchain.
- Student Panel: This is a place where students can see their academic records uniquely.
- Recruiter Panel: It is the means by which a third party can verify after a transaction confirmation.

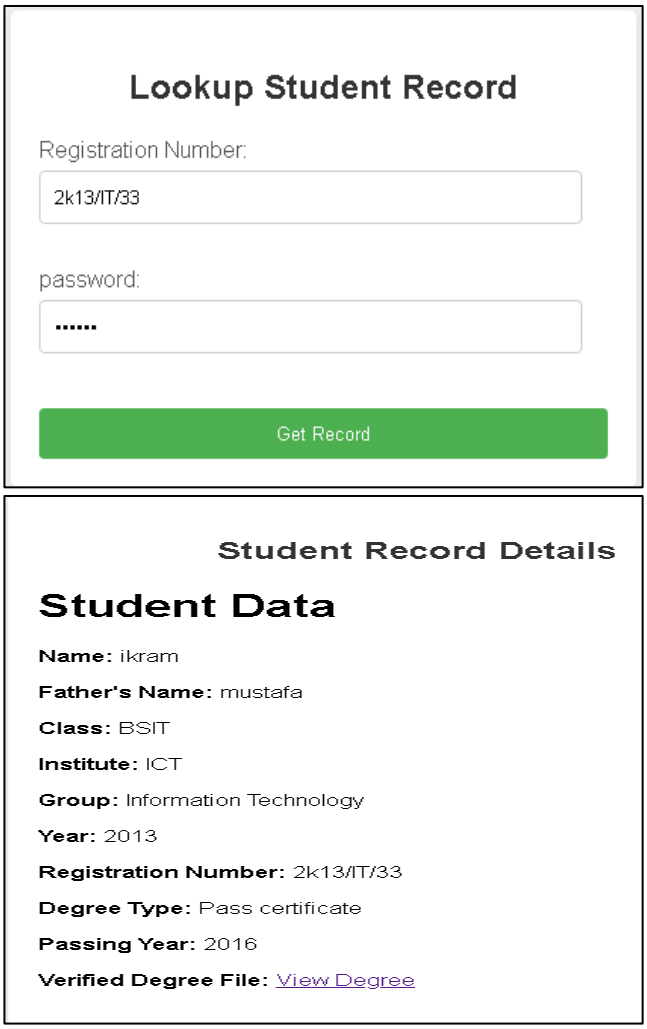


Fig. 4. Students identify their record

A unique interface and specific permission arrangements have been created for each role to safeguard the system's integrity and keep track of user accountability, as shown in Figure 3 and Figure 4.

3. Methodology and Implementation

The methodological framework and implementation details of the proposed blockchain-based digital identification and verification system for educational documents. It includes system development, usability evaluation, and statistical analysis.

4. System Evaluation

In this study, system-level evaluation of the performed blockchain system was done using performance testing with Apache JMeter. Focus performance parameters were response time, throughput, and error rate under simulated load. Alongside the blockchain system, traditional and cloud-based systems were tested as well. In terms of data security and integrity, the blockchain system outperformed the others, but it had a slightly higher response time because of smart contract execution and decentralized validation. The system evaluation report is shown in Table 1 and Figure 5.

Table 1
System evaluation of the Blockchain system

Parameter	Cloud System	Blockchain System
Response Time	1.2 sec	2.5 sec
Data Security	Moderate	High
Immutability	No	Yes
Usability Score	78%	82%

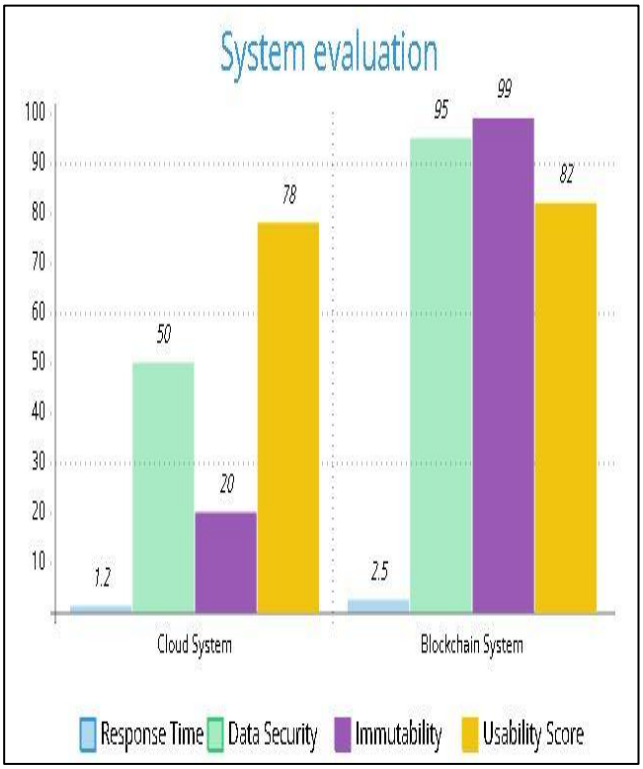


Fig. 5. System Evaluation report of Blockchain system and Cloud System

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5. Usability Evaluation

This study evaluated the usability of a blockchain-based digital identification and authentication structure for educational documents using the USE (Usefulness, Satisfaction, and Ease of Use) questionnaire. A total of 204 valid responses (out of 250 invited participants) were analysed, comprising students (74.5%) and recruiters (25.5%) from various educational and professional backgrounds.

Table 2
Demographic Information of Participants

Group	Count	Age	Gender	Level of Education
Recruiters	52	30-50	70% Male 30% Female	University Level: 100%
Students	152	18-35	81% Male 19% Female	SSC Level: 18% HSC Level: 27% BS Level: 44% MS Level: 11%

5.1 Demographic Characteristics

Participants: Students: The Majority (44%) were bachelor's degree students, with 81% male and 19% female. Recruiters: 70% male, 30% female, all with university-level education. Age Distribution: Students: 18–35 years (digitally literate, comfortable with technology). Recruiters: 30–50 years (varied comfort levels with technology) shown in Table 2.

5.2 Data Analysis

Usability evaluation was conducted using the USE questionnaire. 250 participants (students and recruiters) were invited, and 204 valid responses were collected. Different statistical instruments were used to evaluate the data for skewness, kurtosis, means, and standard deviations. Out of all the features, the customers gave the highest satisfaction scores to data accessibility, verification speed, and the simplicity of the interface.

5.3 Data Validation and Reliability

Data Quality: The responses were complete and there were no duplicates as completeness was ensured by Google Forms.

Normality Tests: The skewness and kurtosis values were within the acceptable range, so together with the data in Table 4 and Figure 7 they confirm the normal distribution.

Reliability: The internal consistency of all the provided ideas was high since Cronbach's alpha for all concepts was above 0.7, as can be seen in Table 3 and Figure 6.

Table 3
Cronbach's Alpha Values

Construct	Objects	Cronbach's Alpha
Usefulness	9	0.805
Ease of Use	10	0.781
Ease of Learning	5	0.809
Satisfaction	6	0.761

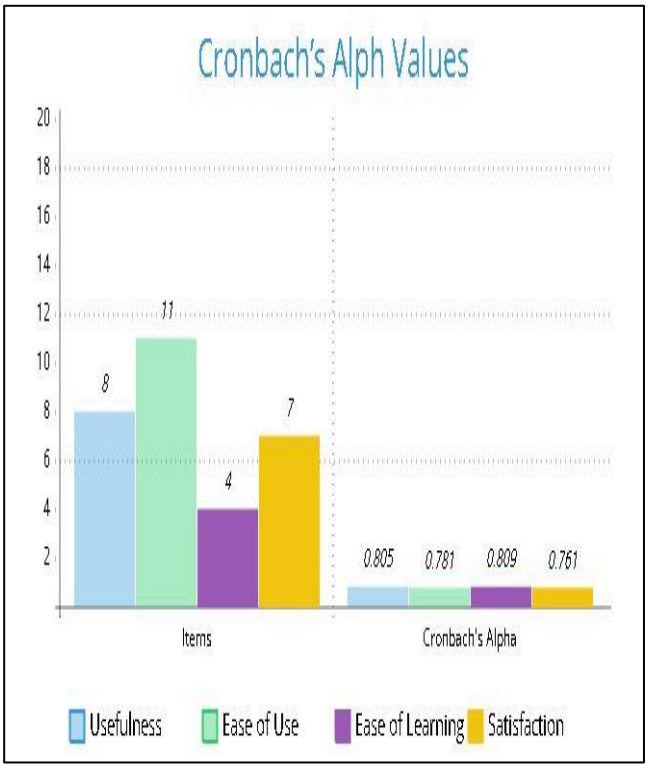


Fig. 6. Cronbach's Alpha Values

A USE Questionnaire (30 items) evaluated the following four constructs:

1. Usefulness (UU) – User's view on how useful the system is.
2. Ease of Use (EU) – How friendly is the interface to the user?
3. Ease of Learning (EoL) – Time essential designed for proficiency.
4. Satisfaction (ST) – The overall experience of the user.

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Table 4

Reliability and Normality Test with Mean Score

Construct	Cronbach's Alpha	Mean Score (1–7)	Key Insight
Usefulness (UU)	0.805	5.41	High perceived value for document verification.
Ease of Use (EU)	0.781	5.36	Intuitive navigation and minimal training required.
Ease of Learning (EoL)	0.809	4.53	Users adapted quickly to the system.
Satisfaction (ST)	0.761	5.09	Positive feedback on reliability and speed.

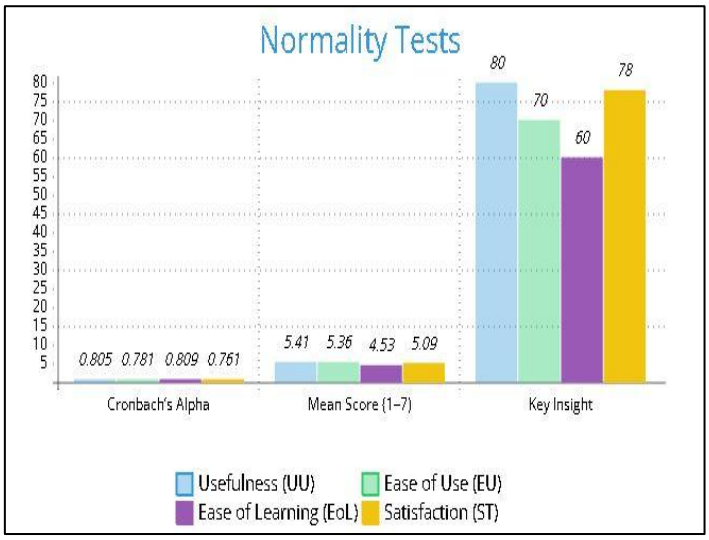


Fig. 7. Reliability and Normality Test Results

6. Statistical Analysis

6.1 Hypothesis Testing:

- H1 (Usefulness → Satisfaction): Supported (β = 0.228, *p* = 0.001).
- H2 (Ease of Use → Satisfaction): Supported (β = 0.188, *p* < 0.001).
- H3 (Ease of Learning → Satisfaction): Strongest effect (β = 0.285, *p* < 0.001).

Table 5

Hypothesis Testing Outcomes

Hypothesis		Unique Sample (O)	Model Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Standards	Outcome
H1	UU->ST	0.228	0.226	0.068	3.372	0.001	Acknowledged
H2	EU->ST	0.188	0.189	0.044	4.295	0.00	Acknowledged
H3	Eol->ST	0.285	0.288	0.061	4.677	0.00	Acknowledged

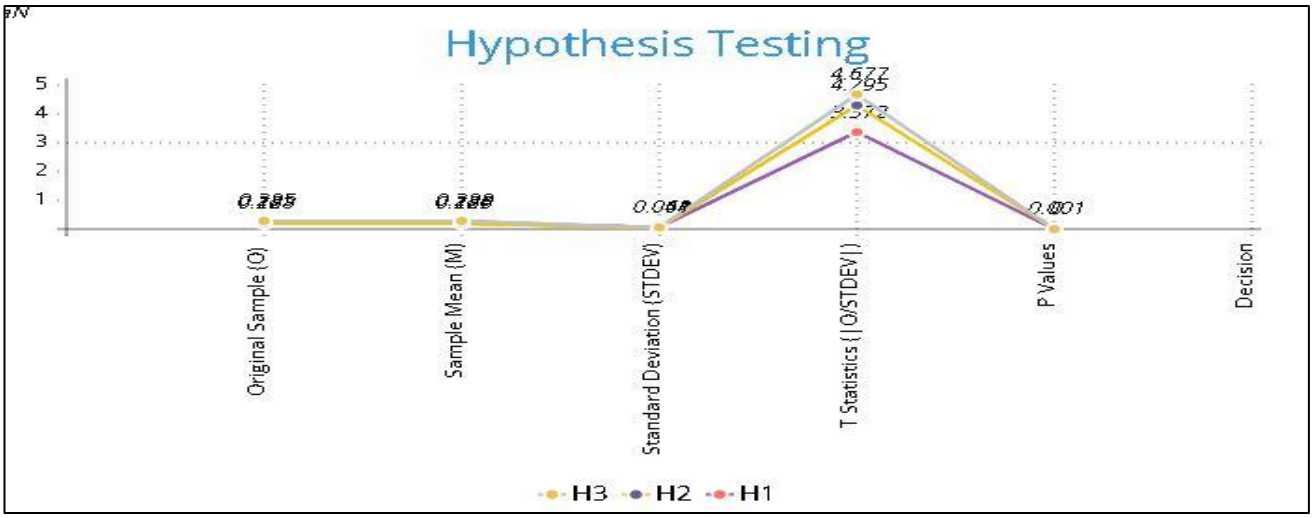


Figure 8: Hypothesis Testing Outcomes

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The statistical parameters of the research have already proven the importance of relationships between the variables that were assumed in the hypothesis. To cite one example, Ease of Learning positively influenced Satisfaction in a statistically significant way ($\beta = 0.061$, $p < 0.001$). Also, Usability and Ease of Use were uncovered to have a statistically significant influence on the general Satisfaction. Hence, these findings are in line with the system acceptance theory and show compatibility between the model's theoretical assumptions and the empirical data, thus, they are significantly strengthening the use of blockchain-based verification as a viable tool to overcome concerns in the field. Table 5 and Figure 8 show the hypothesis testing results.

7. Conclusion

This research introduced a blockchain-based digital verification system for educational documents, ensuring secure, decentralized, and transparent credential authentication. The system enhances efficiency by enabling real-time verification, maintaining tamper-proof records, and reducing administrative burdens. Performance evaluations demonstrated that data was correctly synchronized across multiple nodes and the throughput was stable. Moreover, the solution is capable of integrating legacy data and it is equipped with access control mechanisms, thus raising the level of trust among the stakeholders. The proposed framework is a comprehensive solution to the issues of security, transparency, and operational feasibility.

8. User Feedback

Users gave a number of suggestions during a usability evaluation session. These suggestions mainly concerned the system's user interface simplification of the verification request process and the provision of real-time verification notifications. To revamp the interface based on this input will be the inclusion of dashboard-based navigation, language support, and better mobile access to improve accessibility the changes will thus enhance the usability and adoption rate further.

9. Limitations

Even though the suggested solution has great potentials, it is still hindered by various limitations. Firstly, the deployment of blockchain infrastructure which is a core piece of technology in financial costs might be difficult for educational institutions that are underfunded. Secondly, the adoption may be affected by the technological barriers such as the limited internet access and the lack of IT expertise in the rural areas. Third, the delays at the regulatory and policy level can also slow down the integration with national education frameworks. Lastly, the user resistance to new technologies, particularly among institutions that have been using paper-based verification, is still a potential challenge. While these limitations are major, they also provide avenues for further study and possible targeted measures by the authorities.

10. Adoption Strategies

The involvement of stakeholders and the support of the institution are the major factors which lead to the successful implementation on a large scale. Government approval, especially through regulations that require the use of blockchain technology for verification, can give the adoption a significant boost. Some facilities such as lower verification charges, shorter processing time, and easy compatibility with national databases can be the driving force for educational institutions to use the system. The cooperation with enterprises and accreditation councils will be a source of trust and will extend the range of applications. Besides, training programs for the administrators and the maintenance of the information technology staff will also form part of the prerequisite for the smooth adoption and for the retention of the system in the long run.

11. Future Directions

To expand this work by integrating biometric and AI-based identity verification. Enable cross-border verification via international blockchain consortia. Evaluate performance using larger longitudinal datasets. Optimize the system for mobile platforms and edge computing devices. Develop a national blockchain credential framework in collaboration with HEC and MOFA.

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