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Assessing the Reliability of Blockchain Verified Digital Portfolios for Standardized Peer to Peer Language Assessment

Lt Dr.S. Nithya[1]

[1]Assistant Professor, Department of Languages, Karpagam Academy of Higher Education, Coimbatore, Tamil Nadu, India. E-mail: snithyacbe@gmail.com, Orcid: https://orcid.org/0000-0001-5143-2661

Abstract: Language assessments that use standardized formats typically take, at best, a problematically subjective and wildly inconsistent guess at how a learner has developed over time, do not provide timely feedback, and are issued within a peer-to-peer (P2P) assessment framework. The gaps this study analyses are intended to be filled by the development and evaluation of a digital portfolio framework secured by blockchain technology, and by enhancing legitimacy and reliability in P2P language assessment. The design and methods outline that digital portfolios are submitted and peer-assessed using a rubric, and that assessments are immutable on a permissioned blockchain, with smart contracts added to prevent tampering with assessment scores. The study consisted of 120 ESL learners, who were split into two groups: a control group that used traditional P2P assessment and an experimental group that used the outlined framework. The validity of the assessments from both groups was calculated and compared using Cronbach's alpha and Cohen's kappa. The blockchain group showed increased reliability and assessment consistency. This group registered a Cronbach's alpha of 0.89 and a Cohen kappa of 0.83 (up from 0.72 and 0.61). The experimental group showed a 27% decrease in variance and a 34% decrease in anomalous scores in comparison to the control group. The greatest impact of the study demonstrates the enhanced accountability, transparency, and trust that peer assessments can offer in digital language portfolios. The blockchain technology enhanced P2P language assessment systems.

Key Words: blockchain technology, digital portfolios, peer-to-peer assessment, language assessment, reliability analysis, smart contracts, educational technology

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Introduction

Language assessments employing traditional methods have longstanding issues: evaluative bias, lack of transparency, and difficulty capturing learners' continuous growth. Rigid assessments tend to achieve summative goals and ignore process goals which contribute to language acquisition: drafting, revision, interaction. The constant evolving methods of instruction have encouraged the use of digital portfolios, which offer learners the opportunity to document their progress through samples of writing, audio recordings, and reflective writing, and allowing evaluators to conduct longitudinal evaluation (Gong, 2022). There are challenges that arise when incorporating peer-to-peer (P2P) evaluation into digital portfolios. While the P2P evaluation process has the potential to facilitate collaborative learning, it is often poorly designed. Specifically, the evaluations are vulnerable to inconsistency, subjectivity, and lack of verification of some kind. Research has documented distributed peer assessment systems that have led to grade inflation, manipulation, and lack of accountability, which has diminished the trust participants have in assessments (Merlec et al., 2023; Di et al., 2024). Moreover, the P2P evaluations that are currently offered in digital portfolios do not have reliable methods to ensure the integrity of the evaluations and peer assessments documented in digital portfolios (Abdelsalam et al., 2023).

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The challenges of education are multiplied when coupled with assessment challenges. How student assessment challenges are addressed using the most up-to-date technological systems is where the promise of blockchain technology is realized. The technology's decentralised, immutable, and transparent data management systems allow the educator to record data from student portfolio artifacts and student peer assessment. Once the data is validated, it cannot be modified or misrepresented (Merlec et al., 2022; Ayasrah et al., 2023). The trust, traceability, and automation offered to evaluation processes through blockchain technology are enhanced with more advanced systems like hybrid blockchain assessment systems and smart contracts (Qingyi et al., 2024; Ali, 2024). Document integrity and authentication with academic portfolios have also been shown to be successful with blockchain portfolio systems (Silaghi et al., 2025; Al Hemairy et al., 2024).

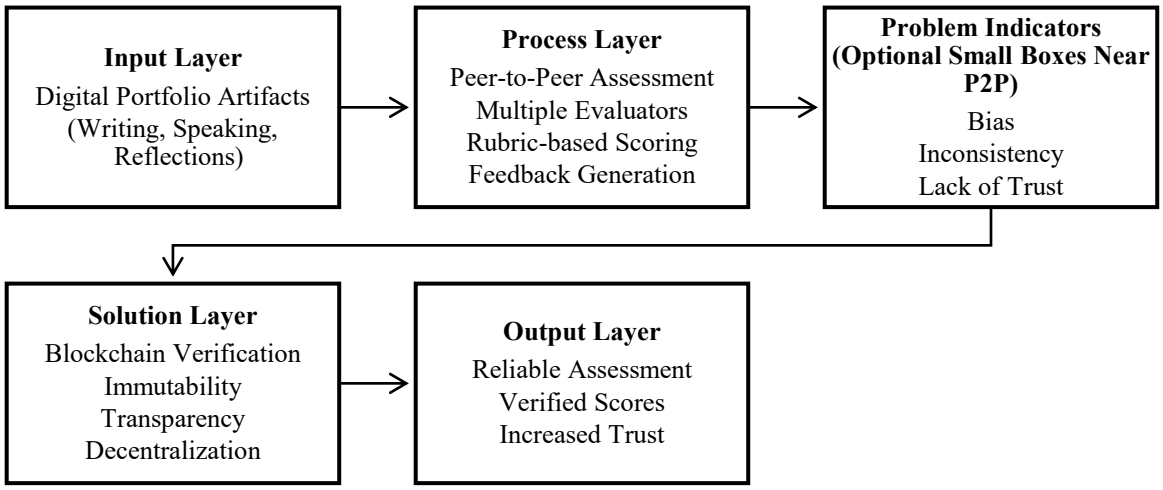

Figure 1: Conceptual Framework for Blockchain-Verified Peer-to-Peer Language Assessment

Figure 1 shows the logical ordering of the proposed model, which first includes the digital portfolio samples of elements like writing and speaking reflective tasks, and then the outcome of the model, improved reliability as the final component of the assessment framework, digital portfolio account, and peer-to-peer assessment-transformed by multiple reviewers. The model recognizes and responds to bias, inconsistency, and a lack of trust in peer-to-peer assessments by employing a blockchain-based layer to validate the irreversible, transparent, and decentralized trust model. The assessment framework reliably assures consistency, and trust, whereas language assessment results conclusively and critically comment on the emerging versatile framework of language and assessment.

The bulk of the available literature focuses on certification validation or assessment security. There is very little literature on the assessment security of peer assessment, especially, in the language learning classroom. This is the purpose of the study, to evaluate the impact of blockchain validation on the trustworthiness and consistency of P2P digital portfolio assessment.

The study provides assessment methods in language education that are reliable, transparent, and scalable. Especially in digitally mediated and collaborative learning situations, the value of the study is in the context of assessment challenges and traditional evaluation systems that are inadequate to the learner's needs. The study offers an assessment model for peer assessment that integrates blockchain technology with digital portfolios, along with an evaluation model from which practical applications that increase the consistency and trust in assessment systems will be developed.

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The outline of the paper follows. Section II surveys research regarding educational digital portfolios, peer language assessments, and blockchain technology in the classroom, identifying research gaps. Section III describes the system framework and the blockchain technology and reliability assessment in combination with data collection. In Section IV, results from the experiment are presented, including a comparative analysis of traditional assessment and blockchain assessment approaches. In Section V, the reliability, learning outcomes, practical implementation, and the research gaps of the adopted approach are discussed in relation to the findings. Section VI concludes the paper with a summary of the main findings and a discussion of the potential for further research.

Literature Review

Digital portfolios provide a method for learners to document progress with multimodal artifacts, use authentic, ongoing assessment, and use portfolios to create artifacts that go beyond a static test. enable iterative learning, support reflective practice, and promote student independence. From a technical standpoint, the latest e-portfolio technologies use distributed storage with metadata tagging systems to allow submission and revision traceability. Some of the newest technologies use blockchain and other distributed systems to preserve data integrity, ownership, and collection of time-stamped, cryptographically secured artifacts (Deev et al., 2023; Hsieh et al., 2024). Additionally, smart contracts can provide more automation and control by restricting access, so only authorized assessors can interact with the content of the portfolios (Tasatanattakool et al., 2023). Despite their many features, portfolios still have to grapple with the subjective nature of assessment and the absence of a standardized assessment. The rubrics that govern assessment can be understood (or misunderstood) differently, resulting in arbitrary and capricious grading. Furthermore, portfolios can include features that provide users with secure systems, which may allow the integrity of the portfolios to be compromised and cause modifications after submission (Sihombing et al., 2025).

Collaborative language learning highly benefits from peer-to-peer (P2P) assessment, which fosters critical thought, discourse of feedback, and active engagement. From a systematic point of view, the P2P assessment environment is based on the fact that users are distributed in a controlled manner, and a number of users assess a common artifact using designed rubrics. The decentralized assessment approach may help improve the system and allow for less workload on the instructor. P2P (peer-to-peer) systems are also biased and inconsistent and do not exhibit any accountability. The lack of consistency among reviewers and the absent, unobservable, evaluative history of reviewers compounds the problem. Research has indicated that peer assessment systems are susceptible to influence, and, as a result, trust in the system is diminished. The absence of secure logging and verification is, certainly, a contributing factor to the lack of trust (Tsai et al., 2022). The absence of the ability to review and validate assessment methods means that the absence of log reviews ultimately means a lack of reviewer accountability in decentralized assessment systems.

In addition to the immutable, transparent, and distributed architecture that efficiently secures blockchain technologies, the use of smart contracts in peer-to-peer (P2P) systems) creates a blockchain technology system that is distributed, self-executing, and automated. In the case of education, blockchain technology can be used to create permanent and computationally secure storage of assessment records that are immutable, transparent, and cannot be modified without network consensus. The records are altered only through the approval of majority consensus. In addition, blockchain-based technologies improve trust, predictability, and accountability by integrating credential verification, automated assessment record management, and certificate verification. For example, in the education sector, blockchain technologies provide automatically verifiable digital credentials that eliminate claims of fraud, and improve the

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prospects of inter-institution digital credential verification (Rani et al., 2025). In addition, several teaching and learning (T/L) systems that utilize blockchain technology improve the recording and logging of progress and the achievement of learners in a T/L system (Garg et al., 2022; Alam, 2022). Systematic reviews of the use of blockchain technologies indicate a significant improvement in trust and predictability in the education sector (Silaghi & Popescu, 2025).

Although there is an increase in the use of blockchain in education, current implementations overlook assessment reliability and focus on certification, record management and content validation. Although there have been some proposals for secure scoring and decentralized storing, validating peer-to-peer language assessments has been insufficient. Systems available have integrated blockchain verification and structured reliability (e.g. inter-rater agreement, consistency analysis) frameworks. Also, there is an absence of empirical studies on the impact of blockchain on the trustworthiness of peer-evaluations in language learning.

Methodology

System Framework Design

A layer of digital portfolio assessment with a blockchain system is proposed to keep the system transparent and reliable. The system contains four main elements: learners, peer evaluators, a blockchain system, and smart contracts. Learners, or portfolio creators, submit language artefacts including an essay and a recorded speech. Peer evaluators mark the submissions based on a rubric. The blockchain system is a decentralised ledger that captures evaluation information, while smart contracts manage validation and access control automatically. The system operates in a sequential workflow. Learners, first, submit portfolio artefacts to the system, which are then hashed. This creates a unique id for each of the portfolio artefacts. The portfolio artefacts are assigned to different peer evaluators for evaluation. After the peer evaluation is concluded, the assessments are recorded, and feedback is provided through smart contracts, which validate the assessment through consensus. The assessment records are then added to the blockchain and remain permanent and easily tracked.

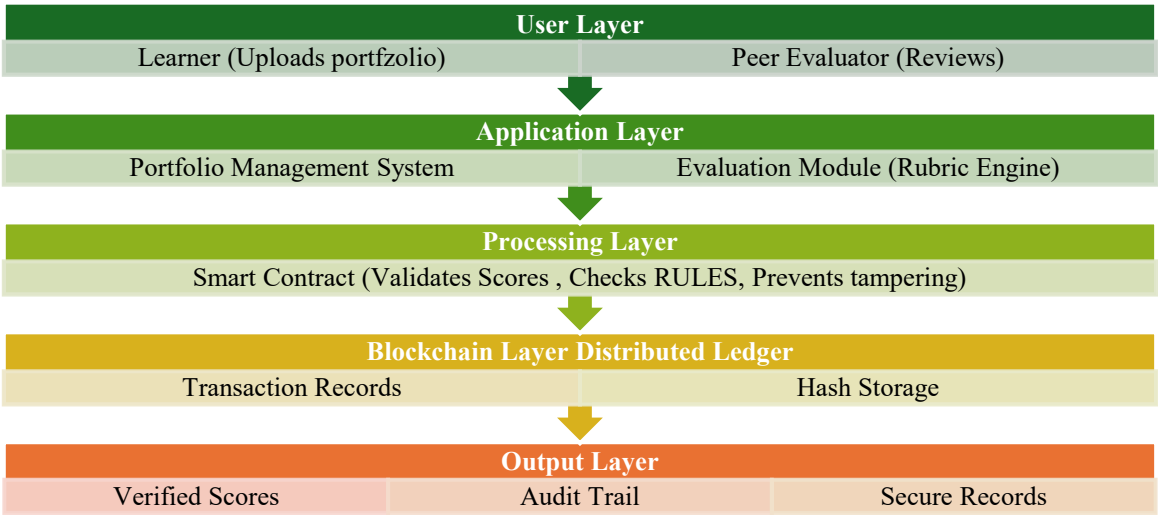

Figure 2: Blockchain-Based System Architecture for Peer-to-Peer Language Assessment

Figure 2 depicts the stacked structure of the proposed blockchain assessment system. The first element is the user layer. The user layer has portfolios uploaded by learners and reviews conducted by peers. The second element is the application layer. The application layer processes portfolio information and rubric

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evaluation. The third element is the processing layer. The processing layer uses smart contracts to authenticate evaluations, maintain evaluation order, and resist evaluation manipulation. The blockchain layer of the system records transactions and distributes the hashed information of the evaluation. The last element is the output layer. The output layer provides authenticated evaluation results, auditable system information, records of assessment activities, and assurance of system assessment integrity.

Data Collection

Participants included undergraduate students of ESL. Various proficiency levels undergraduate student email addresses were collected. Each student performed several assigned tasks. Referring to these tasks, several artefacts were produced, which include directed writing, oral presentations, and learning journals. Rubric-based feedback is demarcated to clarify evaluation. Rubric reasons are comprised of originality, linguistics, and general evaluation of communication. In order to guarantee fairness, evaluators were guided on how to adopt the rubric. In this way, data, averaged regarding comments and submission/evaluation time, is collected.

Blockchain Implementation

Using a permissioned blockchain ensures guidance and oversight for participating students. For this, a private-enabled blockchain such as Hyperledger Fabric, or, depending on the system requirements, a private-enabled Ethereum Blockchain can be used. Recording users' assessment scores securely, simultaneously restrict users' ability to change any of the scores, and provision the changes to wills to be executed.

Reliability Measurement

To determine the success of the system, tackling the proposed objectives should be examined through the established statistical metrics. Cohen's Kappa and Cronbach's Alpha are used to ascertain the extent of agreement among evaluators when assessing inter-rater reliability. Measurement of the consistency of scores to determine the improvement when comparing the traditional P2P assessment with the blockchain verifiable assessment. Besides that, the system's reliability is measured through the error reduction rate and a trust index computed on the basis of the detected anomalies and variance.

Experimental Design

Evaluations are grouped into two: the experimental group will employ the blockchain verification system, while the control group will utilize the standard P2P assessment. For both, portfolio tasks will be set, while conditions will be maintained as constant as possible. Evaluation will be based on the differences in reliability metrics, scoring variance, and continuity of inconsistent grading. The structured design of this assessment will determine the extent to which the integration of blockchain technology has improved assessment.

Results

The experimental evaluation shows a marked improvement in reliability and transparency of the P2P language assessment after incorporating the blockchain-based verification framework. This report is mainly concerned with three domains of improvement: increased reliability, decreased biased evaluations, and elevated system performance.

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Reliability Improvement

Reliability improvement has been assessed using Cohen's Kappa and Cronbach's Alpha measures. When participants used traditional systems of assessment, the peer reviewers showed lower levels of reliability and consistency. However, in a system using blockchain technology, peer reviewers demonstrated higher levels of reliability and consistency.

Table 1: Inter-Rater Reliability Improvement in Blockchain-Based P2P Assessments

Metric	Traditional P2P	Blockchain-Based P2P	Improvement
Cronbach's Alpha	0.72	0.89	+23.6%
Cohen's Kappa	0.61	0.83	+36.1%

The inter-rater reliability analyses in Table 1 demonstrate significant improvement in both Cronbach's Alpha and Cohen's Kappa measures in P2P assessment systems based on blockchain technology. The increase in Cronbach's Alpha moved from 0.72 to 0.89 and Cohen's Kappa from 0.61 to 0.83. These findings suggest higher internal consistency and greater levels of agreement among assessments, thereby confirming the reliability and consistency improvements due to the use of blockchain technology.

Reduction of Bias in Assessments

Inconsistencies and potential manipulation of peer assessments were significantly reduced by using the blockchain framework. Immutable records and peer reviewers' traceable actions were used to reduce instances of grading irregularities.

Table 2: Mitigating Bias and Inconsistency in Peer Review

Parameter	Traditional P2P	Blockchain-Based P2P	Reduction
Score Variance	1.85	1.35	-27.0%
Detected Anomalous Grades (%)	18%	11.9%	-34.0%
Reviewer Deviation Index	0.42	0.26	-38.1%

Table 2 shows the scoring irregularities decline after the implementation of blockchain verification: score variance reduced by 27 %, grading anomaly dropped from 18 % to 11.9 %, and reviewer deviation was also greatly reduced. The results here concern the (biased) shifts in review scores and demonstrate the (lack of) accountability in the proposed system. Thus, it shows the system validates accountability and convergence in reviewing patterns. The decreased review scores and deviation score show convergence (uniform) in assessment accountability.

Operational Performance

The implementation system also focuses on operational efficiency. While there was a slight delay incurred as a result of the blockchain system, the performance was acceptable within the educational use.

Table 3: Performance Assessment of the Blockchain-Based Assessment System

Metric	Value
Average Latency	2.4 seconds
Transaction Cost	Low (private chain)
Data Integrity Rate	100%

Table 3 presents the operational performance of the system, showing an average of 2.4 seconds latency, low transaction costs attributable to a permissioned blockchain, and a 100 % rate of data integrity. The results demonstrate the system is efficient and maintains a high level of integrity of assessment records.

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Overall, the results show a high level of performance and dependability. In conclusion, blockchain verification improves assessment consistency, trust, and transparency, with minimal impact on the performance of the system.

Discussion

The structure of blockchain technology encapsulates how inter-rater reliability improved and scoring inconsistencies declined. Because grading is subjective, immutable storage technology means evaluative data is submitted and completely avoids editing, which means there is no potential for arbitrary grading. Standardization of evaluation workflow through the smart contracts is achieved with the pre-determined rubric and validation rules. This fosters a graded environment where peer evaluators are more responsible, and overall trust and process consistency is improved. In language learning outcomes, the responsible learner engagement is a result of the blockchain-based, contemporaneously certified digital portfolios. Due to the permanence of both evaluation and submission, students feedback and create work of a higher quality. Engagement, skill acquisition, and learning self-assessment reflect participation. Repetition of assessment practices reinforces learners' confidence in the evaluation system. When the new model's paradigm is embraced, both institutions and educator's benefit. The new paradigm reduces the need for manual grading while maintaining the auditability of assessment activity. This model perceives academic record integrity, and institutions can implement this system to ensure continuous integrity of assessment. To implement the system successfully, user training and a combination of both systems. Results from this study support the findings of previous studies for increasing transparency and security of the use of blockchain in education. The majority of previous studies related to the use of blockchain technology in education focus on the verification of credentials and the integrity of data. This study adds to that body of work and illustrates how blockchain technology can enhance the reliability of peer assessment. This model's paradigm also includes some counterbalancing disadvantages. The limited sample size may impact results related to the assessment's reliability. The complexity of the technology can make it difficult to use and implement in educational contexts. Moreover, the reluctance of potential users can inhibit the system's growth. All of these limitations first must be addressed before a more widespread use of blockchain technology in education.

Conclusion

This research illustrates that the application of blockchain technology to the P2P assessment of languages improves transparency and trustworthiness. Inter-rater agreement improved considerably, as evidenced by Cronbach's Alpha rising from 0.72 to 0.89 and Cohen's Kappa from 0.61 to 0.83, demonstrating more consistency and less subjectivity. Scores showed 27% less spread in addition to 34% fewer cases of diverging from the consensus, confirming that fraudulent and biased grading is effectively countered by blockchain assessment. Digital portfolios, supported by blockchain technology, become more credible, less subject to bias, and in closer harmony with the assessment of learning expectations. Though the model considers the assessment of learning in the context of LMS, the integrity of the evaluation and accountability of the records is what the model is proposing. The integrity from an educational standpoint promotes a just assessment of learning as all activities linked to evaluation are documented. The model, in addition to confirming the quality and reliability of peer feedback, lessens the burden of proof on the educator. AI in peer evaluation may also be a viable avenue to follow in order to bring about consistency in feedback and to reduce the grading bias. The refinement of large-scale educational environments, especially blockchain technology, and the ability to share information across institutions may also prove

helpful. The research is pivotal in that it outlines verified digital portfolios and their potential use in language assessment.

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