Harnessing Blockchain and Generative AI to Prevent Certificate Forgery and Enhance Educational Integrity

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Abstract—**The growing prevalence of certificate forgery in today's digital age poses a significant threat that undermines the integrity of educational qualifications. This study explores the potential of blockchain and generative AI to optimize the certificate validation process and combat certificate falsification. The research adopts the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for literature review. The findings reveal that integrating blockchain and generative AI can effectively reduce certificate forgery, enhance the accuracy and reliability of certificate data, and streamline the employee recruitment process by providing faster and more precise validation. This approach curbs certificate fraud and improves the quality of education and the workforce.**

Keywords—Blockchain, Generative AI, Academic Record, PRISMA

I. INTRODUCTION

Education is a critical investment for boosting economic development in Indonesia. However, the quality of education in Indonesia is still considered low compared to other ASEAN countries. The government has implemented various policies and programs to address this issue, including digitizing education. The technology that can advance education includes e-learning, the Internet of Things (IoT), blockchain, and artificial intelligence (AI).

These advancements reflect the education system's adaptation to better prepare younger generations for future demands. Among these technologies, blockchain has recently gained traction in education [1]. Blockchain holds significant potential for improving the education industry through smart contracts, a decentralized application program for data management, security, and integrity [2].

The adoption of Blockchain within educational institutions has increased in recent years, as blockchain offers several advantages [3]. The data managed by smart contracts is more secure and transparent, reducing the risk of errors and fraudulent activities [4]. Furthermore, blockchain can play an essential role in the educational sector by combating the falsification of degrees and the validity of academic credentials [5][6]. Blockchain implementation in academic credential management improves the efficiency of universities in storing and verifying degree-related data [7].

Beyond the issue of diploma forgery, educational data is often stored in centralized systems, making it vulnerable to hacking or manipulation by unauthorized parties. The lack of data transparency within these systems can seriously affect universities and other educational institutions [8]. This context makes the implementation of blockchain technology particularly compelling for verifying degrees, sharing academic certificates, and recording learning outcomes. Blockchain technology in educational institutions can significantly enhance data security, transparency, and integrity [9].

However, blockchain alone may not fully address all challenges. Issues such as slow administrative processes, human error, and the proliferation of fake degrees continue to undermine the quality of human resources in Indonesia, where individuals need more qualifications [10]. Integrating blockchain technology with generative AI can address these problems more effectively.

Generative AI can analyze patterns, detect anomalies in large datasets, and provide an additional layer of security and efficiency. It can also automate administrative processes, reducing human error and accelerating the validation of academic credentials. The collaboration between blockchain and generative AI is crucial for optimizing security, transparency, efficiency, and accuracy in managing educational data.

In light of these considerations, this study aims to analyze the potential of blockchain technology, enhanced by generative AI, in combating diploma forgery and improving educational data management. By leveraging these technologies, academic institutions can optimize their data validation processes' speed, accuracy, and efficiency, ultimately enhancing the quality and reliability of educational credentials in Indonesia.

II. METHODOLOGY

This research employed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, a widely recognized framework for conducting

and reporting systematic reviews. PRISMA provides a structured approach to identifying, selecting, and evaluating relevant literature, ensuring transparency and rigor in the review process. It is an established standard for synthesizing evidence in systematic reviews and meta-analyses, as Samala et al. (2023) noted.

A. Stage 1 (Planning Stage)

The planning stage involves defining the research objectives, keywords, and inclusion and exclusion criteria. This research aims to explore how blockchain technology and generative AI can combat diploma forgery. Key search terms, including "Blockchain in Education," "Smart Contract," "Academic Certificate," "Academic Validity," and "Generative AI in Education," were identified to shape the initial search criteria. These keywords set the research parameters and offer a comprehensive overview of the current applications of blockchain and generative AI in the education sector.

TABLE I.   PRIMARY AND SECONDARY CRITERIA

Primary		Secondary	
Inclusion	*Exclusion*	*Inclusion*	*Exclusion*
1. Journal articles 2. Conference articles 3. Peer-reviewed 4. Accessible online 5. Written in English	1. Duplicate records 2. Textbooks 3. Patent	Blockchain in Education OR Smart Contract OR Academic Certificate OR Academic Validity OR Generative AI in Education	Not in Academic related issue Not in Smart Contract Blockchain technology scope (e.g., cryptocurrency trading)

The initial search covered several bibliographic repositories, including IEEE Xplore, Science Direct, ProQuest, and Google Scholar. The search was conducted in November 2023 and included articles published between November 2018 and January 2024. A total of 1,139 results met the search criteria.

B. Stage 2 (Filter and Review Stage)

The remaining 90 articles were screened at this stage using the main inclusion/exclusion criteria. This filtering stage has a 2 step filtering process. First, we read the title, abstract, and keywords, and then we discarded articles that were excluded from inclusion. The second step is the reading process. We read the contents of the articles thoroughly to find papers to review. The final number of articles in the review process was 36. This review will be based on the initial research objectives, which include research questions :

- How can implementing blockchain smart contracts guarantee the security and privacy of students' educational history data?

- How can blockchain smart contracts optimize student educational history data sharing between departments, companies, and academic institutions?

- What is the impact of using blockchain technology in overcoming diploma forgery in education?

- What challenges arise in applying blockchain technology to improve the validity and management of diploma data?

- How can the integration of Blockchain and Generative AI enhance academic data integrity?

C. Stage 3 (Reporting Stage)

In this stage, 36 articles will be processed using explanatory descriptive techniques. This report will be separated into five sections, including an overview and research objectives. This information must provide vital insight for readers because the articles selected in this research have passed a strict screening process.
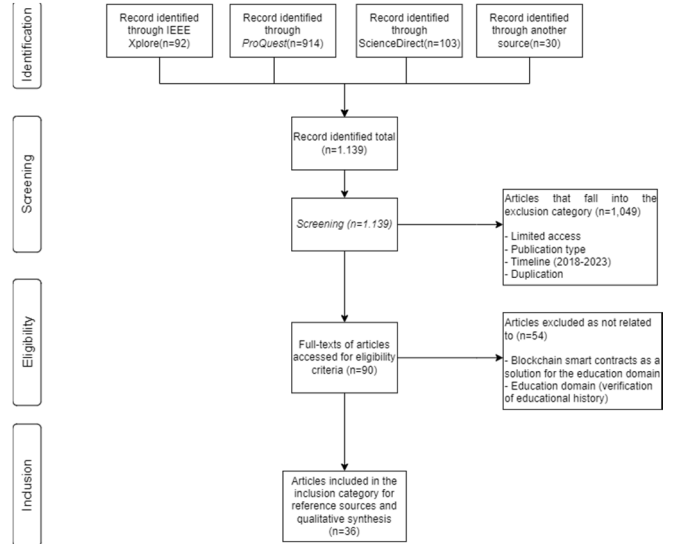

Fig. 1.   Search, filter, and review process.

After processing the 36 selected articles using descriptive techniques, the analysis will focus on extracting key insights and patterns related to integrating blockchain and generative AI in educational data management.

III. RESULT

The following sections will present the findings, which offer a comprehensive view of how blockchain and generative AI can enhance academic data integrity and combat diploma forgery. The results section will detail the outcomes of this analysis, highlighting the potential impact and practical implications for educational institutions.

A. General Description

The general description section of the results highlights trends in the number and types of publications on blockchain and generative AI in education. This analysis reveals the trend in publications over recent years, with a diverse range of publication types, including journal articles and conference papers.
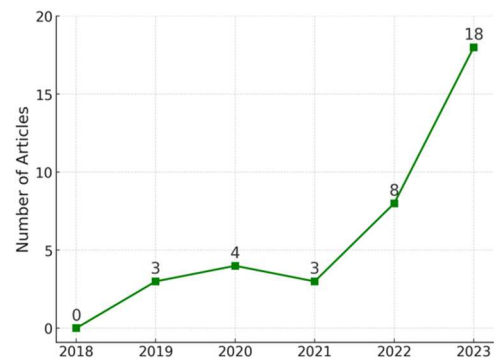

Fig. 2.   Publication trend of blockchain in education

Academic studies published over the last decade show that research on blockchain in improving transparency and sharing of educational history data has grown significantly over the past five years. (2018-2023). Although blockchain has been studied by researchers in other sectors, such as finance, food, and construction, it has been seen that the growth of blockchain research to improve transparency and the sharing of educational history data is slower than in any other sector. Figure 2 shows the exponential growth of research since 2018, which shows an increasing interest in implementing smart contract blockchain in the education industry. However, research is still in its early stages and requires some aspects, such as decision-makers and researchers, to explore the viability of this technology further.
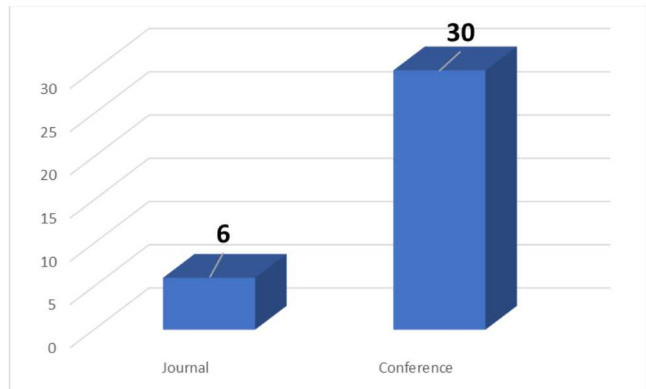

Fig. 3. Publication types

By conducting further analysis, 36 papers are relevant to the blockchain smart contract system in improving transparency and sharing student educational history data, as shown in Figure 3. The above data shows that more than half (83.3%) are as many as 30 papers whose type of publication is a conference, and about (16.7%) are papers with the type of journal publication.
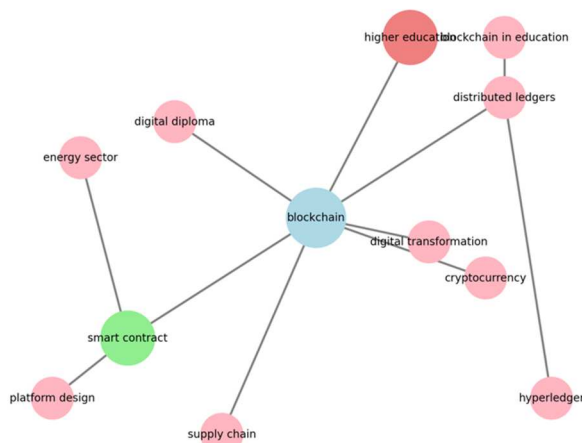

Fig. 4. Cluster identification

Figure 4 provides a brief overview of the studied subject's coverage. The image is a bibliometric network based on keywords from a total of 36 papers obtained from IEEE Xplore (2 papers), ProQuest (19 papers, Science Direct (5 papers), and other searches (10 papers). The first cluster discusses the use of blockchain in the education sector using IPFS and meta-mask technology. The second cluster addresses the utilization of blockchain with distributed ledger technology. The fourth cluster deals with the issues of

fraudulent academic certifications. The seventh cluster uses blockchain as an AI and helps learning and teaching in the education system. The eighth cluster deals with digital transformation. The ninth covers the evaluation and performance of blockchain in the educational sector. The tenth is about blockchain as a central sector scheme for academic scholarships.

B. How can implementing blockchain smart contracts guarantee the security and privacy of student's educational history data?

Students' educational history data listed in the degree is vulnerable to falsification and manipulation [16][17]. Smart contracts in blockchain can maintain data security and prevent data manipulation because of its decentralization feature[18] [19][20]. This decentralization feature enhances the security and resilience features of the system by avoiding a single point of failure and eliminating confidence in one side [21]. At the same time, smart contracts are commonly used to validate educational credentials [22]. Colleges, schools, or other educational institutions can issue certificates or academic records as smart contracts on the blockchain. This facilitates verification of credentials by third parties without disclosing all the educational history details, and smart contracts can also facilitate proper access authorization.

There are also cryptographic techniques on blockchain systems, such as AES (Advanced Encryption Standard) and RSA (Rivest-Shamir-Adleman) [23]. AES is commonly used to encrypt sensitive data that needs to be sent or stored securely [24]. In contrast, RSA is used for secure communication over the internet, such as email and digital signatures. It allows students to maintain their privacy while giving them the necessary access. With its decentralized and blockchain-based smart contracts, it can provide the transparency and security needed to build a fast and cost-effective verification system.

C. How can blockchain technology optimize student educational history data sharing between departments, companies, and academic institutions?

Every year, colleges in Indonesia issue thousands of degrees due to the higher education process. According to data recorded in the Government Central Database for Higher Education (PDDikti), the number of university graduates in Indonesia reached approximately 1,001,833 graduates per year from 4,424 colleges. This phenomenon reflects the significant contribution of the higher education system in drawing skilled and educated human resources to support development and progress in various sectors of life.

Many companies spend quite a lot of money on the recruitment process, one of which is the cost of validating the authenticity of a new job candidate's degree. In field studies, many fake degrees are used for job application activities.
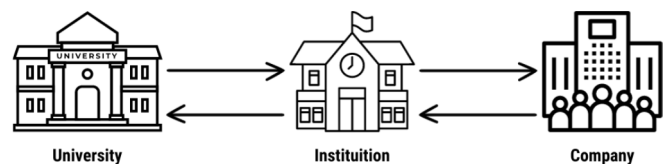

Fig. 5. Manual degree validation process

Figure 5 illustrates the manual process of validating and distributing degree data between universities, institutions, and

companies before using smart contracts. The process begins with the university issuing the degree, which the graduate submits to the company or institution where they seek employment. The company or institution verifies the degree's authenticity and records the graduate's information. If the degree status changes later, such as being revoked, the university must inform the relevant institution or company. This manual process involves multiple parties and requires extensive verification and communication between the university, the graduate, and the company or institution.

Blockchain technology supports companies in recruiting new graduates in job search [25]. Figure 4.7 shows the process of using blockchain technology. The process starts with the university publishing its degree on the blockchain, and then the degree can be seen and distributed to many institutions, including companies [26]. Once the student has completed his education and wants to find a job, the student can come to a company to apply for a job. Then, the company can easily and quickly prove the authenticity of the degree through the blockchain system. Various agencies and government officials can also do it, and they can easily and quickly prove the authenticity of such a degree.[27]
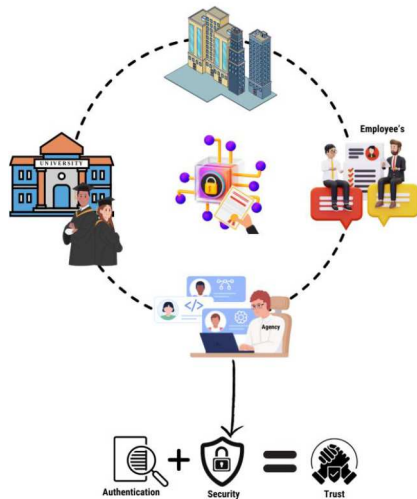

Fig. 6.   Process automation of blockchain-based university degree

Storing and preserving university degrees using blockchain technology is more time-efficient and cost-effective than without blockchain technology [28][29][30][31]. It will produce competent workers in their respective fields because of the difficulty of counterfeiting diplomas [32] [33].

D. What is the impact of using blockchain smart contract technology in overcoming diploma forgery in education?

The most common forms of academic fraud include grade changes, adding false degrees, and forging signatures and institutional stamps. These acts are often committed by individuals seeking better jobs or higher positions. Such falsifications harm the reputation of educational institutions and erode public trust.

Blockchain smart contract technology offers several advantages in addressing these issues. The transparency and automation provided by smart contracts reduce the likelihood of fraud, as all participants in the blockchain network share duplicate records, and any changes require consensus [34].

Blockchain technology makes it much harder to counterfeit degrees and significantly speeds up the process of verifying their authenticity, reducing it from days to minutes [16]. By preventing degree falsification, blockchain technology can help improve the quality of education in Indonesia, ensuring that graduates receive recognition based on their actual achievements [4].

E. What challenges arise in applying blockchain technology to improve the validity and management of diploma data?

Applying blockchain technology to improve the validity and management of academic data presents several challenges. One major challenge is educational institutions' low adoption rate of blockchain technology. Widespread adoption is crucial for successful integration in education [35], requiring a large-scale network capable of handling numerous transactions and involving participation from students, educators, institutions, and businesses [36][27][8].

The transition from traditional systems to blockchain demands adaptation from all stakeholders [37]. Since blockchain is still relatively new, educating and training users is vital. This includes creating training programs and materials to help everyone understand the system [38].

Implementing blockchain technology also involves significant costs, including transaction expenses, that must be addressed in education [29][39]. For example, the Ethereum public blockchain has high storage and power consumption costs due to the resources needed for cryptography. The storage cost on the Ethereum blockchain is substantially higher than traditional storage, with a terabyte of data costing around EUR 60,00 on a hard disk but approximately EUR 6000.0083 on Ethereum [35].

Regulatory challenges also arise, as blockchain technology requires legal validation, which varies by country. Few regulations currently govern the use of blockchain in education, making clear privacy and data protection policies crucial for successful implementation. Additionally, ensuring blockchain interoperability with existing information systems in colleges and companies is essential for smooth integration [15]. Data security remains a significant concern, with risks such as hacking or data manipulation within the blockchain. Errors in data input are also a potential issue, as they become permanent. Lastly, the high costs of building and operating a blockchain system for managing academic credentials are a unique challenge that must be addressed for effective and sustainable implementation [40].

F. How can the integration of Blockchain and Generative AI enhance academic data integrity?

The rapid advancements in Generative AI technologies, such as Generative Adversarial Networks and Diffusion Models, have introduced unprecedented opportunities to transform the educational landscape [41]. These AI-powered systems have shown remarkable capabilities in generating human-like text, images, and multimedia content, raising significant implications for academic data integrity.

In this context, integrating Blockchain technology can offer a viable solution to enhance the trustworthiness and reliability of academic data. Generative AI can further improve this process by automating the generation of high-quality, unique educational content, reducing the risk of plagiarism, and ensuring the originality of student work [42].

The use of Generative AI in academic assessments has raised concerns about academic integrity, as these systems can potentially generate content indistinguishable from human-authored work [43]. To address this challenge, educational institutions can leverage Blockchain technology to create a tamper-evident, auditable record of academic activities, including Generative AI in assessments [44] [45].

Integrating generative AI with blockchain technology can automate the validation of academic credentials, reducing the time and cost associated with traditional verification processes. For instance, generative AI can automatically cross-check academic records stored on a blockchain against various data points, ensuring that all entries are consistent and accurate. However, integrating generative AI with blockchain technology also comes with several disadvantages. One major concern is the potential for data privacy issues, as sensitive academic records might be exposed to vulnerabilities if the blockchain is not properly secured. Additionally, the reliance on AI-driven systems increases the risk of algorithmic biases, which could inadvertently affect the accuracy of the verification process.

IV. Conclusion

Integrating blockchain technology and generative AI presents a powerful combination for enhancing the validity and management of academic degree data. Blockchain's inherent security features make it highly effective in combating degree falsification, as the immutable nature of blockchain records makes data manipulation exceedingly tricky. This technology streamlines the recruitment process by enabling rapid, cost-effective verification of credentials, thus enhancing security and efficiency.

The rapid advancements in generative AI technologies, such as Generative Adversarial Networks and Diffusion Models, have opened new avenues for transforming education. These AI-powered systems can generate high-quality, unique academic content, reducing plagiarism risk and ensuring student work's originality. However, using generative AI in academic assessments raises concerns about academic integrity. To address this challenge, integrating blockchain technology with generative AI can provide a robust solution. Blockchain can create a tamper-evident, auditable record of academic activities, including those involving generative AI, thereby enhancing the trustworthiness and reliability of academic data.

By leveraging blockchain and generative AI, the education system can become more sophisticated, transparent, and efficient. This not only strengthens the validity of academic credentials but also enhances the credibility and competence of the workforce. Integrating these technologies can lead to a more trustworthy and high-quality educational environment, benefiting all stakeholders and contributing to the nation's economic development.

Acknowledgment

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