

Blockchain integration into the university education process: a systematic review of application, justification, and impact

Irma Aybar-Bellido¹, Maritza Arones¹, José Antonio Arévalo-Tuesta², Willy Adauto-Medina³,
Hernán Ochoa-Carbajal³

¹Faculty of Education and Humanities, Universidad Nacional San Luis Gonzaga, Ica, Peru

²Faculty of Economic Sciences, Universidad Nacional Federico Villarreal, Lima, Peru

³Faculty of Engineering and Management, Universidad Nacional Tecnológica de Lima Sur, Lima, Peru

Article Info

Article history:

Received Aug 14, 2025

Revised Dec 18, 2025

Accepted Jan 9, 2026

Keywords:

Areas of application

Blockchain

Educational process

Systematic review

University students

ABSTRACT

As universities seek to integrate disruptive technologies to optimize their academic and administrative processes, a gap persists in the adoption of Blockchain as a strategic tool. Many higher education institutions still lack its implementation, limiting its potential to improve traceability, transparency, security, and the automation of different processes. Given this scenario, this study aims to identify the areas of application, the justifications for its use, and the impact of Blockchain when integrated into the university educational process. To this end, a systematic literature review was conducted with a mixed approach and an exploratory-descriptive scope, following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guideline, in the Scopus, ERIC, and SAGE databases. Of 3,469 manuscripts identified, 42 met the inclusion and exclusion criteria. The results show a predominance of applications focused on the validation and monitoring of academic achievements, with limited integration into pedagogical approaches such as active methodologies, adaptive learning, or competency-based learning. Based on a comparative analysis of trends, application areas, and thematic gaps, it is concluded that the expansion of Blockchain into educational models requires progressive implementation strategies, curricular integration, and teacher training, thereby generating more personalized, efficient, and transparent learning environments.

This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



Corresponding Author:

Irma Aybar-Bellido

Faculty of Education and Humanities, Universidad Nacional San Luis Gonzaga

Av. Los Maestros S/N - Urb. La Palma (Panamericana Sur km 305) Ica, Peru

Email: irma.aybar@unica.edu.pe

1. INTRODUCTION

Current higher education must respond to technological transformation and evolution linked to industry and education 4.0 [1]. Education 4.0 involves providing tools that facilitate innovation in teaching-learning processes [2]. Furthermore, it seeks to redefine how integrated knowledge is evaluated through continuous review and feedback for sustainable learning improvement [3]. This technological evolution encourages digital transformation in the educational field, highlighting the need for universities to adapt to new global demands [4]. Digital transformation introduces new products, processes, services, and resource distribution channels into learning environments, which is reflected in the modification of platforms, instructional content, evaluation, and credential management [5].

Universities must therefore evolve in their structures, processes and professional profiles, to align with digital transformation [6]. However, digital transformation is a complex process, and ongoing process.

It involves more than simply incorporating technologies into management or classrooms and requires strategic planning to ensure meaningful educational [7]. It requires designing sustainable educational models supported by innovation [8]. Therefore, it is not enough to invest in technology; its integration must align with pedagogical objectives and teaching practices [9]. Emerging technologies must support new learning models and help overcome barriers that prevent educational renewal [10]. In this context, Blockchain stands out for its potential to address these challenges and support new educational scenarios [11]–[13].

Recent advances in artificial intelligence have boosted the personalization of learning processes [14]. However, educational quality cannot improve if classrooms remain overcrowded, where students are expected to learn at the same pace [15]. To address this, flexible methodologies such as gamification and interactive peer feedback, combined with Blockchain, are required to ensure secure and transparent validation of knowledge [16]. Therefore, implementing Blockchain in universities can boost active methodologies and curricular flexibility, while maintaining traceability in academic pathways [17], [18]. Blockchain enables the replicated recording of events, ensuring security, privacy, and transparency [19], [20]. It is defined as a chain of blocks containing information shared between decentralized nodes [21], [22]; collectively validated by network participants [23], [24]. Therefore, it is called a decentralized network [25]; unlike other data networks, which are centralized and more vulnerable [26], with Blockchain, stored information can never be lost, modified, or deleted [27]. Therefore, the development of Blockchain-based applications for course management and grade recording are tools that contribute to improving information handling and data transparency [28]–[30].

While Blockchain has proven to be very effective in validating business transactions, it is also important to validate it in the educational field [31], more specifically in the university setting, where degrees are issued that qualify for the practice of professions and serve as the basis for granting professional registration [32]. Several academic institutions have begun issuing their degrees, diplomas, and certificates using this technology [33]. In this sense, the application of Blockchain is necessary because many universities have vulnerabilities in current systems, such as the enrollment system, so this technology guarantees the storage of information in the cloud [34]. Another key application of Blockchain in education is the digitalization and decentralization of educational certifications [35], [36]. However, as with most innovations and technologies that become trends, its use in education is just in its infancy; we will likely see new and continuous implementations very frequently [37].

The adoption of disruptive technologies, such as Blockchain, in higher education is better understood through theoretical frameworks such as the technology acceptance model (TAM), the unified theory of acceptance and use of technology (UTAUT), and Rogers' diffusion of innovation theory, which show how users perceive, incorporate, and integrate innovations into educational ecosystems [38]. The TAM establishes a solid foundation for analyzing how perceived usefulness and ease of use shape educators' and students' intentions to adopt Blockchain in teaching, learning, and credential management processes [39]. Recent studies highlight that institutional readiness, trust, and organizational alignment decisively influence the relationship between technological acceptance factors and effective adoption in Blockchain-based systems [40]. The combination of the diffusion of innovations theory with the TAM offers a comprehensive approach to explain how trial likelihood, relative advantage, and compatibility impact the perceived usefulness and ease of use of Blockchain technologies in smart learning environments [41]. According to Rogers' diffusion of innovation theory, Blockchain adoption depends on key attributes such as compatibility and observability that determine how institutions perceive and implement technological innovations [42].

Furthermore, the spread of Blockchain technologies in various sectors shows that their adoption goes through different stages of the innovation-decision process (knowledge, persuasion, decision, implementation and confirmation), which highlights how social and organizational factors influence the speed and depth of its integration [43]. As a general-purpose technology, Blockchain diffusion involves a dynamic process of invention and recombination, in which its fusion with other digital tools and institutional structures drives transformative changes in economic, financial, and educational ecosystems [44]. Ultimately, the diffusion of Blockchain technologies is not limited to technical maturity, but also depends on the institutional capacity to adapt processes, policies, and governance models that sustain innovation over time, ensuring the creation of lasting value in educational ecosystems [45]. These theoretical perspectives collectively establish the conceptual foundation of this systematic review, guiding the identification and analysis of Blockchain applications, challenges, and impacts in higher education.

In line with the challenges and opportunities posed by the digital transformation in higher education, this study aims to identify the main areas of application of Blockchain technology, the problems or challenges that justify its implementation, and the reported impacts on the university education process. Accordingly, the present study employs a systematic literature review following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) methodology, adopting a mixed approach and an exploratory-descriptive scope. The research focuses exclusively on studies on higher education published between 2020 and 2025 and is based on the analysis of 42 scientific articles selected after a rigorous

screening and quality assessment process. The findings will provide relevant evidence to guide future practices and research in the field of university education. Table 1 presents the research questions, the focus of the study, and the objectives that guide the development of this work.

Table 1. Research questions

Research questions (RQ)	Focus of scientific study	Objective
RQ1: what are the main areas of university education where Blockchain applications are implemented?	Areas of application of Blockchain technology	Map and classify Blockchain applications across different university functions.
RQ2: what are the systematic and technological challenges in higher education that Blockchain implementation addresses?	Problems addressed through Blockchain technology	Identify the institutional and technological challenges that justify the Blockchain adoption.
RQ3: what are the measurable outcomes and benefits of integrating Blockchain into higher education?	Results of the impact of Blockchain technology	Evaluate the measurable outcomes and educational benefits of Blockchain integration.

2. METHOD

2.1. Focus and scope of the research

This study conducts a systematic review aimed at analyzing the contribution of Blockchain in higher education, focusing on the areas of application, reasons for its use, and its reported impact on the educational system. A mixed methods approach was adopted, combining qualitative content analysis to categorize areas of application, purposes, and outcomes, with quantitative analysis to determine the prevalence of each category across studies. This process allows for the identification of potential uses of Blockchain in higher education. Notably, the mixed approach integrates qualitative and quantitative analysis with critical theory [46], offering a more comprehensive understanding of the research topics rather than relying solely on one approach [47]. Additionally, the mixed method responds to researchers' need to address the complexity of educational phenomena from a holistic and integrative perspective [48]. The scope of this study is exploratory-descriptive. It is exploratory because it initially seeks to define the state of the art regarding the different uses and explanations of Blockchain in the university education process, thus contributing to closing the existing gaps in this field of knowledge. It is descriptive because it aims to characterize the applications of Blockchain in higher education, emphasizing the different uses in the educational field, the justifications supporting its adoption, and the results demonstrating its impact on the teaching-learning process. This aligns with descriptive research, which examines a defined variable—in this case, the “contribution of Blockchain in the university education system”—within a specific context [49]. Furthermore, descriptive studies seek to expose the characteristics of said variable in a specific context or field of application [50], represented by peer-reviewed research published between 2020 and 2025.

2.2. Search strategy and selection criteria

A fundamental aspect in the manuscript extraction process was to first define the databases from which publications relevant to the application of Blockchain in the university education process would be identified. Therefore, Scopus, ERIC, and SAGE, were selected because they are recognized repositories of high-impact academic literatures and apply rigorous indexing criteria, ensuring the quality and relevance of studies included indexed manuscripts. Once the databases were defined, the search equations were constructed based on keywords aligned with the study's title and research objectives. It was essential to know the specific search syntax of each database, since from this the equations could be structured through the use of Boolean operators. The resulting search equations are summarized in Table 2.

Table 2. Search equation

Database	Search equation
Scopus	((TITLE-ABS-KEY (Blockchain) OR TITLE-ABS-KEY (technologies AND Blockchain))) AND ((TITLE-ABS-KEY (higher AND education) OR TITLE-ABS-KEY (university)))
ERIC	((Blockchain technologies) OR (Blockchain)) AND (University OR Higher education))
SAGE	

Additionally, in order to delimit the selection of scientific manuscripts in a more precise and rigorous manner, a set of “inclusion and exclusion criteria” was defined as a very relevant aspect in this type of study [51]. These criteria are aligned with the objectives of the systematic review and the focus on the contribution of Blockchain in the university academic environment. The inclusion criteria focused on ensuring that the selected studies were directly relevant to the educational context and to the areas of application, justification of their use, and the impact of Blockchain in higher education. Meanwhile,

the exclusion criteria allowed us to discard research focused on educational levels other than higher education, or that do not represent original contributions in the field. Table 3 shows the inclusion and exclusion criteria, guaranteeing the relevance and thematic coherence in the search and selection of relevant information for the purpose of the study.

Table 3. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Publications that demonstrate results on the application of Blockchain in the higher education. Publications must only be scientific articles.	Publications on the application of Blockchain developed in areas other than the higher education process. Publications such as theses, books, or conference papers are not considered for the study.
Scientific articles published between 2020 and 2025. Scientific publications whose review has been carried out through peer evaluation. Open access scientific articles.	Scientific articles, published before 2020. Scientific publications whose review has not been through peer review. Scientific articles with restricted access to their full content.

2.3. Data selection and extraction process

Following the PRISMA methodology [52], the data selection and extraction process was developed to guarantee the rigor of this systematic review that seeks to identify gaps regarding the contribution of Blockchain in the university educational process. Therefore, it was considered to follow four phases, each one with its respective purposes of including only those manuscripts that allow answering the three research questions. In the identification phase, 3,469 manuscripts were initially collected from the Scopus (n=1,626), ERIC (n=105), and SAGE (n=1,738) databases. The preliminary filtering consisted of eliminating duplicates and discarding publications prior to 2020, in accordance with the inclusion criterion that establishes to consider only scientific articles published between 2020 and 2025. After this process, the total number of manuscripts was reduced to 2,693. In the screening phase, titles and abstracts were reviewed, excluding 1,699 manuscripts that were not directly related to the object of study, that is, those that did not address the application of Blockchain in the university education process. This exclusion was based on the criterion that excludes research in areas outside the university setting. As a result, 944 studies were retained for detailed evaluation. Figure 1 shows the data selection and extraction process.

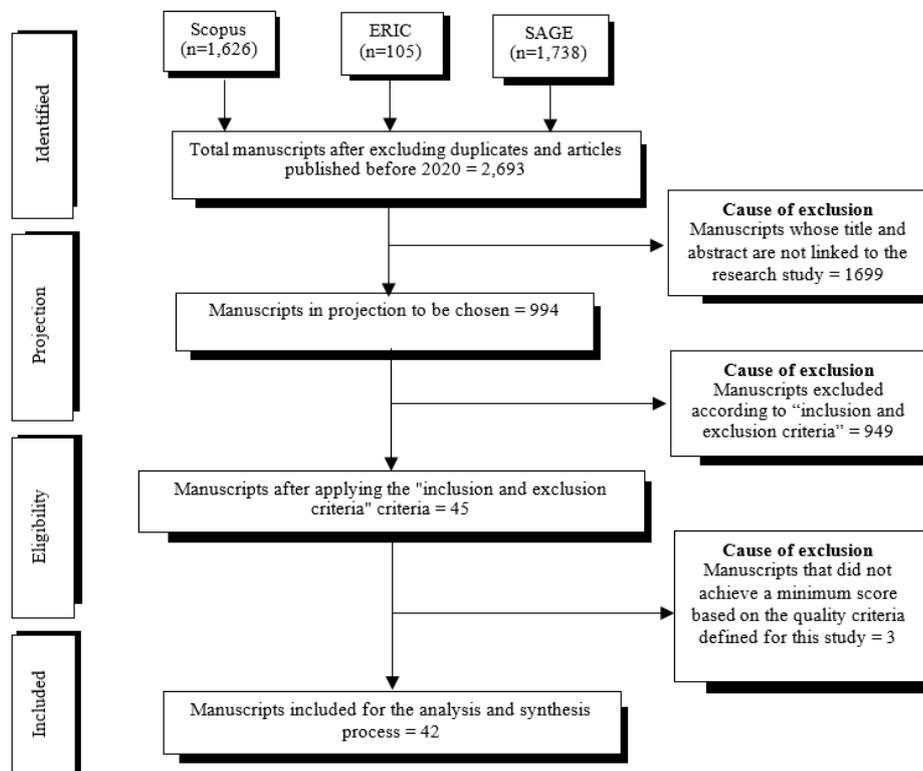


Figure 1. Data selection and extraction process

In the eligibility phase, the other previously defined inclusion and exclusion criteria were rigorously applied, such as including only open access scientific articles that had undergone peer review. A total of 949 manuscripts were eliminated, leaving a total of 45 potentially eligible manuscripts. Finally, in the inclusion phase, the 45 manuscripts underwent a methodological quality assessment using the Critical Appraisal Skills Programme (CASP) scale, widely recognized for the critical appraisal of scientific studies. This analysis allowed us to assess the validity, relevance, and rigor of each study. As a result, three articles that did not meet the established minimum score were excluded, leaving 42 manuscripts that met the methodological and thematic criteria. These constitute the definitive corpus for the analysis and final synthesis, serving as the basis for answering the three research questions about the areas of application, the justification for its use, and the impact of Blockchain on the university education process. With this corpus established and methodological rigor assured, the following section presents the main results derived from the systematic analysis, highlighting publication trends, mapping Blockchain applications, identifying implementation challenges, evaluating contributions, and addressing ethical considerations.

3. RESULTS

Regarding the scientific production identified in the 42 studies included in the systematic review process, an increasing trend was observed from the beginning of the analyzed period in 2020, with just 2 publications, until reaching its peak in 2023 with 15 publications; which shows a progressive interest of the academic community in exploring the application of Blockchain technology in higher education system. However, in more recent years (2024 and so far in 2025) a decrease is observed, with 5 and 4 publications respectively, which raises the need to promote new research that addresses the integration of Blockchain in different areas of university mission functions, such as teaching, research and social projection. On the other hand, from a contextual perspective, during the pandemic years (2020-2021), characterized by the accelerated adoption of digital technologies, 8 studies were identified, marking an initial surge in interest in this topic. In contrast, in the post-pandemic period (2022-2025), 35 publications were identified, reflecting a more consolidated trend among universities to migrate toward technologies that contribute to integrating and optimizing educational processes through innovative and secure solutions, among which Blockchain is positioned as a key tool. Figure 2 shows the annual distribution of reviewed publications.

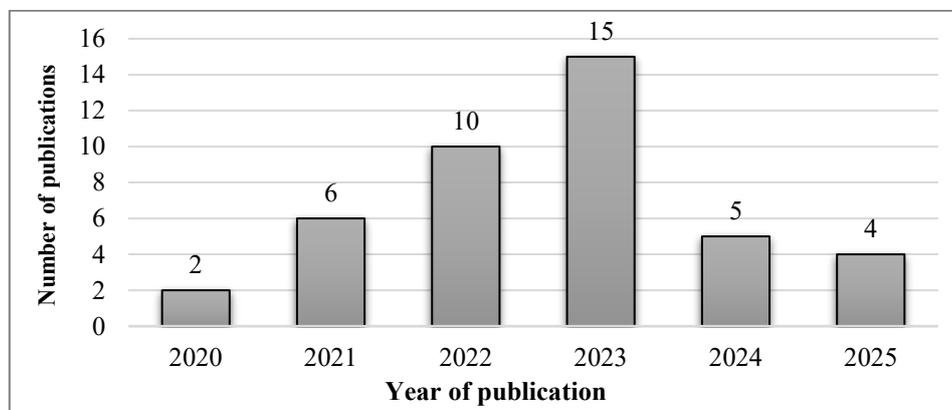


Figure 2. Annual distribution of peer-reviewed publications on Blockchain's contribution to higher education

3.1. What are the main areas of university education where Blockchain applications are implemented?

The literature review identified three main categories: “management and verification of academic credentials”, “administration of academic records and data”, and “certification of competencies and learning achievements”. Regarding the “management and verification of academic credentials” category, it is observed that most research has focused its efforts on ensuring the authenticity, traceability, and fraud resistance of degrees, diplomas, microcredentials, and certificates issued by university institutions. This use of Blockchain strengthens institutional trust and promotes national and international academic mobility, ensuring that a student's academic record is verifiable in any context and at any stage of the teaching-learning process. Another identified category is “management of academic records and data”, which represents a key pillar for the secure and decentralized management of university information. This area stands out for its contribution to interoperability between institutions, the protection of sensitive data, and the

improved accessibility of academic records for students and faculty. The availability of accurate, real-time information supports academic planning, personalized tutoring, and educational continuity, adding value to the entire educational process. Finally, there is the “certification of competencies and learning achievements” category, which directly links Blockchain to university assessment and accreditation processes. This application allows for the certification of skills acquired in formal and informal contexts, as well as the implementation of digital portfolios that support students in their transition to the professional field. This approach enhances individualized learning monitoring and encourages continuous pedagogical feedback. While all three categories demonstrate a positive impact, a gap is identified in the integration of Blockchain into active pedagogical strategies, adaptive learning, and certified collaborative ecosystems. This represents a potential area for expansion for its use beyond administrative management, bringing it more directly into the core of the university teaching-learning process. Table 4 shows the categorization of the studies reviewed in the existing literature during the years 2020 to 2025.

Table 4. Categorization of the areas of application of Blockchain technology in the higher education

Categories	Description	References
Management and verification of academic credentials	It includes the issuance, storage, and secure verification of degrees, diplomas, certificates, and micro-credentials, ensuring authenticity, traceability, and reducing academic fraud in the university context.	[53]–[68]
Administration of academic records and data	It includes secure management, storage, traceability, and decentralized access to academic records and student data, facilitating institutional interoperability and trust between universities, students, and employers.	[69]–[82]
Certification of competencies and learning achievements	It refers to the validation and authenticity of competencies, skills, and learning outcomes acquired by students, including their use in institutional accreditation and educational incentive systems.	[83]–[94]

From a quantitative perspective, the results show that “management and verification of academic credentials” accounts for the largest percentage of reviewed studies (38.10%), confirming a sustained interest from the scientific community in strengthening university document validation mechanisms. This predominance indicates the existence of a more consolidated conceptual and technical framework, which facilitates the continuity and deepening of online research, including the development of global standards and their integration with existing educational platforms. The “management of academic records and data” category represents 33.33% of the reviewed research, reflecting an equally relevant field that, however, is less mature in terms of large-scale interoperability and the application of educational analytics based on data managed through Blockchain. On the other hand, the “certification of competencies and learning achievements” category, with 28.57% presence, although it is the least addressed category, shows significant potential to expand its impact on university education, particularly in areas such as project-based learning, validation of non-formal learning, and automatic recognition of micro-credentials in work environments. These figures identify a clear orientation toward administrative and institutional management applications, while implementations directly linked to learning and teaching remain a research gap. Figure 3 shows the percentage distribution of scientific articles reviewed based on the categories addressed in the studies, by area of application in the educational process of higher education.

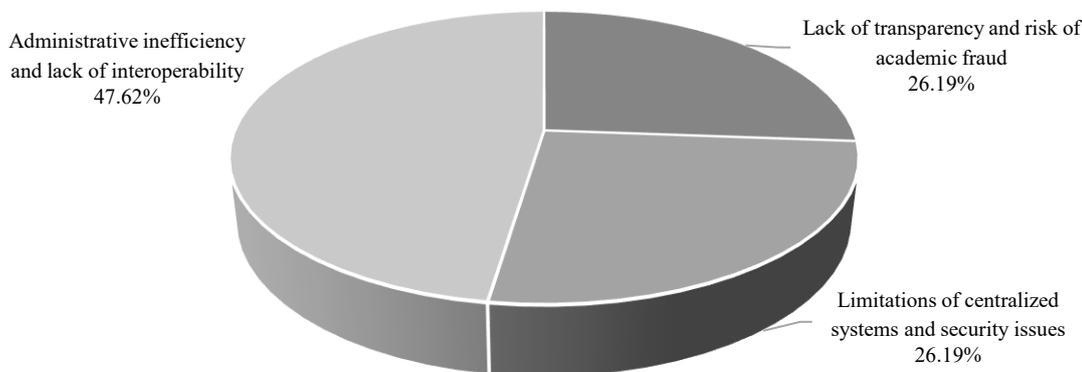


Figure 3. Percentage distribution of scientific articles by area of application in the educational process of higher education

3.2. What are the systematic and technological challenges in higher education that Blockchain implementation addresses?

Regarding the problems that justify the use or application of Blockchain in the university education process, three main categories were identified from the reviewed studies. The first corresponds to “lack of transparency and risk of academic fraud”, which indicates that traditional systems present vulnerabilities that facilitate the falsification or alteration of degrees, certificates, and academic records. The lack of traceability and reliable verification mechanisms results in a loss of trust between institutions and students. The second category encompasses the limitations of centralized systems and security issues, demonstrating that conventional university platforms are susceptible to cyberattacks, data loss, and unauthorized access, in addition to lacking resilience to failures. Finally, the third category refers to administrative inefficiency and lack of interoperability, a problem that translates into slow, costly, and intermediary-dependent procedures, as well as poor integration between universities, platforms, and employers. This demonstrates that the adoption of Blockchain technology in universities responds to the need to strengthen trust, security, and efficiency in academic management, as well as to promote greater institutional interoperability to optimize processes related to training, accreditation, and academic recognition. Table 5 categorizes the problems that justify the use of Blockchain in the university education process.

Table 5. Categorization of the problems that justify the use of Blockchain in the higher education

Categories	Description	References
Lack of transparency and risk of academic fraud	Traditional systems have vulnerabilities that facilitate the falsification or alteration of degrees, certificates, and academic records. The lack of traceability and reliable verification mechanisms leads to a loss of trust among institutions, students, and employers.	[53]–[58], [62]–[66]
Limitations of centralized systems and security issues	Centralized platforms at universities are susceptible to cyberattacks, data loss, and unauthorized access, and lack resilience to failures.	[59]–[61], [67]–[74]
Administrative inefficiency and lack of interoperability	Academic records management often involves slow, costly, and intermediary-dependent procedures, with little interoperability between universities, platforms, and employers.	[75]–[94]

From a quantitative perspective, the results show that, among the reviewed studies, the most common problem justifying the application of Blockchain technology in the university education process is administrative inefficiency and lack of interoperability, present in 48% of the studies analyzed. This finding demonstrates that almost half of the studies identify the optimization of institutional processes, the reduction of intermediaries, and improved information exchange between platforms and university actors as priority needs. Secondly, two problems with the same incidence are identified: “lack of transparency and risk of academic fraud” and “limitations of centralized systems and security issues”, each with 26% representation in the reviewed literature. This indicates that more than a quarter of the studies prioritize the need to guarantee the authenticity and traceability of credentials, as well as resilience and security against unauthorized access or data loss. Taken together, these quantitative results reflect a focus on three critical areas whose resolution could significantly impact the integrity, efficiency, and reliability of university education processes through the adoption of Blockchain. Figure 4 shows the percentage distribution by identified problem justifying the use of Blockchain in the university education process.

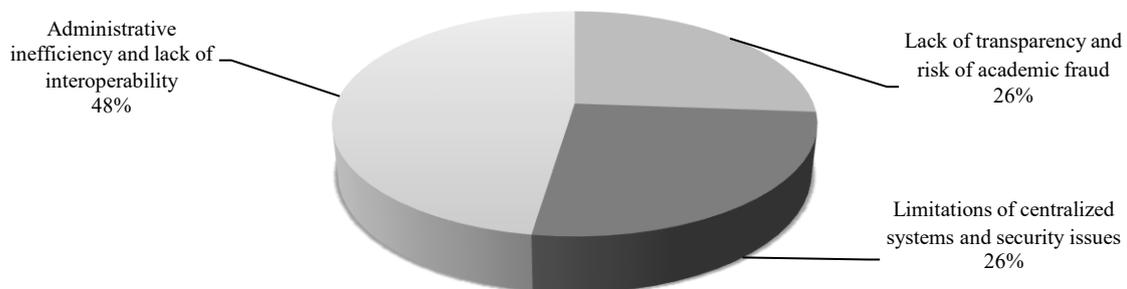


Figure 4. Percentage distribution by identified problem that justifies the use of Blockchain in the higher education

3.3. What are the measurable outcomes and benefits of integrating Blockchain into higher education?

Regarding the results of applying Blockchain technology to the university education process, four categories were identified from the reviewed studies that summarize the observed benefits: “transfer and trust in academic management”, “administrative efficiency and process optimization”, “academic mobility and international recognition”, and “pedagogical innovation and learning personalization”. This demonstrates that the implementation of Blockchain not only reinforces institutional integrity and reliability but also opens up new possibilities for optimizing the teaching-learning process. The “transparency and trust in academic management” category is associated with the creation of safer and more reliable educational environments, which strengthens the legitimacy of academic achievements and generates a climate of credibility that positively impacts student motivation. “Administrative efficiency and process optimization” contributes to reducing time and costs in academic management, allowing teachers and students more resources and time for training and research activities. “Academic mobility and international recognition” facilitates the traceability and portability of competencies, eliminating bureaucratic barriers and expanding opportunities for academic exchange and collaboration globally. Finally, “pedagogical innovation and learning personalization” favors the development of more flexible learning experiences tailored to student needs, incorporating incentives and personalized pathways that strengthen active participation and independent learning. Table 6 shows the categorization of the results obtained from the application of Blockchain technology in the higher education.

Table 6. Categorization of the results obtained by applying Blockchain technology in the higher education

Categories	Description	References
Transparency and trust in academic management	The use of Blockchain strengthens institutional credibility, improves academic integrity, and ensures the authenticity of credentials and records, increasing the confidence of students, employers, and authorities in the university education process.	[53], [54], [57], [68], [72], [73], [75], [78], [80], [82], [84], [87]–[89], [92]
Administrative efficiency and process optimization	Blockchain streamlines and automates tasks such as degree verification, credit transfers, and document management, reducing costs, wait times, and human error, contributing to more efficient university administration.	[55], [56], [58]–[60], [65], [66], [74], [77], [79], [83], [90], [93]
Academic mobility and international recognition	Blockchain enables the portability and traceability of certifications and competencies, facilitating international academic and professional recognition, as well as access to global study and employment opportunities.	[61], [67], [69]–[71], [76], [81], [85], [86], [91], [94]
Pedagogical innovation and personalization of learning	Blockchain fosters more flexible educational models, with micro-credentials, digital reward systems, and voice tailored to student needs, integrating technology into the teaching-learning process.	[62]–[64]

Based on the results obtained, the percentage distribution reflects that the most prevalent category is “transparency and trust in academic management” (35.71%), which shows that the adoption of Blockchain is being used primarily to strengthen institutional integrity and the authenticity of academic records. This trend directly impacts the teaching-learning process by generating an environment of greater credibility and security, facilitating the traceability of student achievements, and reducing the risk of academic fraud. The second category, “administrative efficiency and process optimization” (30.95%), indicates that the technology is helping to streamline degree verifications, improve credit transparency, and improve document management. From a pedagogical perspective, this improvement in administrative infrastructure frees up resources and time that can be used to strengthen teacher-student interaction and the design of dynamic educational experiences. Third, “academic mobility and international recognition” (26.19%) reflects a significant contribution to the portability and global validation of certifications, which expands opportunities for training and collaboration between universities in different countries. This not only increases students’ exposure to intercultural learning contexts but also helps close the gap in access to international academic programs. Finally, the “pedagogical innovation and learning personalization” category (7.14%), although less present in the reviewed studies, constitutes an area with high potential to address. Its low proportion suggests a gap in the exploration of Blockchain as a tool to develop adaptive educational models, with micro-credentials, reward systems, and personalized learning paths. This shows that, while the potential of this technology to transform pedagogical design is recognized, its effective integration into the curriculum and teaching practice still needs to be further explored. Figure 5 shows the percentage distribution of the results of the use of Blockchain in the university academic environment. Taken together, these results reveal a consistent pattern: although Blockchain adoption has advanced in administrative and management areas, its pedagogical dimensions remain underdeveloped. This analytical imbalance forms the basis of the following discussion, which interprets the findings in light of the theoretical and practical frameworks for Blockchain integration in higher education.

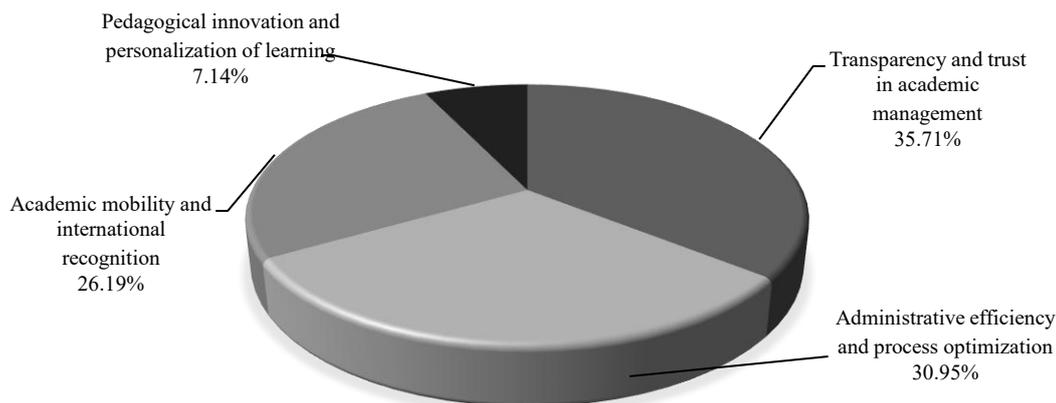


Figure 5. Percentage distribution of the results of the use of Blockchain in the university academic environment

4. DISCUSSION

4.1. Mapping Blockchain applications in higher education

The results show that Blockchain technology in universities is mainly focused on the management and verification of academic credentials, the administration of student records, and the certification of competencies and learning achievements. Ocheja *et al.* [95] point out that these applications improve institutional trust and ensure the integrity of records; however, their direct pedagogical impact remains limited, particularly in practical classroom applications. Plasencia *et al.* [96] argue that, although Blockchain has been interested in educational management, new lines of research are needed to incorporate it into teaching activities, fostering pedagogical innovation, and active learning environments, such as Blockchain-based student portfolios. For example, smart contracts within Blockchain platforms can automate the validation of competencies in real-time during active learning sessions, enabling adaptive feedback loops that support competency-based education. Desplebin *et al.* [97] reveal that integrating Blockchain into higher education fosters a paradigm shift in teaching practices, promoting active, competency-based, and innovation-oriented learning models that challenge traditional instructional routines. Li and Zhang [98] highlight that individualized learning paths enabled by Blockchain accreditation can promote fair assessments and adaptive instruction, empowering students in their journey. However, technical applications often overshadow pedagogical ones. Similarly, Zeng *et al.* [99] suggest that Blockchain fosters a trustworthy and collaborative ecosystem for knowledge sharing, reconfiguring the dynamics of educational communication and collective learning within academic institutions. Practical applications such as Blockchain-integrated curricula further illustrate how decentralized applications (dApps) can facilitate collaborative projects in active learning, debating the balance between administrative efficiency and innovative teaching tools. Overall, the evidence shows that Blockchain is consolidating its role within university structures, although its potential to transform teaching practices remains only partially explored. This gap leads to the next dimension of analysis: how to understand the systematic challenges driving its adoption.

4.2. Identifying the challenges driving Blockchain adoption in higher education

Across contexts, the literature reveals contrasting realizations. In technologically advanced regions, Blockchain is integrated with artificial intelligence and learning analytics, while in developing countries, barriers such as cost and institutional readiness limit progress. Technical applications dominate over pedagogical innovations, underscoring the need to align Blockchain with teaching and learning objectives rather than just administrative management. Regarding the challenges justifying Blockchain adoption, the literature identifies transparency gaps, where academic documents undermine institutional credibility. Rustemi *et al.* [100] indicate that the limitations of traditional systems in verifying academic documents weaken organizational credibility, particularly in developing contexts prone to fraud. Previous study [101] emphasizes the pedagogical implications of eliminating fraudulent degrees, preserving the legitimacy of learning achievements. Raimundo and Rosario [102] point out that Blockchain's secure information transparency facilitates equitable access to validated educational resources, which can be integrated into instructional design to foster inclusive learning environments. Zheng *et al.* [103] observe that dApps designs that rely solely on smart contract interfaces create usability barriers for non-programmers, while web-and-

contract architectures with intuitive graphical user interfaces (GUIs) significantly improve accessibility for end-users. Aufiero *et al.* [104] emphasize that strengthening the security and resilience of dApps—particularly around critical “bridging” functions—helps sustain end-user trust and, in turn, supports the wider adoption of Blockchain applications. Arndt and Guercio [105] indicate that Blockchain-based transcript systems empower students by giving them control over their records, facilitating inter-institutional mobility, and reducing administrative friction in higher education. Savelyeva and Park [106] argue that a human-centered approach to educational Blockchain should empower educators and learners—including vulnerable communities—through trusted peer-to-peer collaboration, shared resources, and strong protections for privacy and individual rights. Qualitative perspectives from higher education institutions further highlight how these challenges vary by stakeholder group, with administrators often citing integration barriers while faculty emphasize pedagogical alignment. These challenges reveal that blockchain adoption depends not only on technological maturity but also on institutional readiness and ethical alignment, which shape its eventual educational contributions.

4.3. Evaluating the contributions and outcomes of Blockchain integration in higher education

Regarding contributions, Blockchain has improved transparency, efficiency, mobility, and, to a lesser extent, pedagogical innovation. Delgado-Von-Eitzen *et al.* [107] acknowledges that Blockchain improves the reliability of academic data, supporting secure learning ecosystems. However, unresolved technological and academic challenges limit its pedagogical reach. Al-Imamy and Zygiaris [108] argues that Blockchain can transform education through personalized and competency-based learning paths, promoting active participation and continuous feedback. Ali *et al.* [109] emphasize that students perceive Blockchain as a way to gain autonomy over their learning records, while educators and administrative staff value its transparency and ability to strengthen institutional trust and effectiveness. In this sense, Dudek [110] points out that almost 80% of university students surveyed believe that Blockchain technology can contribute to making open educational resources more accessible, highlighting its potential to improve credential verification and reduce barriers to inclusive learning. Alsobhi *et al.* [111] demonstrate that Blockchain in smart educational environments enables adaptive assessments and progress monitoring, optimizing feedback and personalization of learning. Smart contract-driven e-portfolios exemplify this, allowing real-time tracking of competencies in adaptive learning scenarios, thus bridging administrative tools with active pedagogy. To bridge the gap between Blockchain’s potential and its pedagogical impact, universities and policymakers should promote pilot projects, such as Blockchain-based micro-credential issuance, for competency-based learning, alongside teacher training and digital credential ecosystems. Although measurable benefits are evident in transparency and efficiency, ethical and legal considerations emerge as crucial dimensions to ensure the responsible and sustainable adoption of Blockchain in higher education.

4.4. Ethical considerations

Beyond the technical and pedagogical aspects, ethical and legal dimensions are essential in Blockchain-based academic systems. Kirchsclaeger [112] emphasizes that a human rights-based approach to Blockchain must safeguard informational autonomy and privacy, ensuring compliance with data protection principles compatible with the general data protection regulation (GDPR). Similarly, the European Expert Group on Blockchain Ethics [113] states that Blockchain systems should not only cover GDPR, but also enhance data protection and privacy regulations, emphasizing fairness and social responsibility. These principles underpin responsible data governance, transparency, and user consent in decentralized educational environments. In that sense, Dierksmeier and Seele [114] argue that ethical Blockchain governance requires regulatory frameworks equal to or very close to corporate social responsibility standards, ensuring transparent and participatory data use grounded in accountability. Recent research [115] has empirically demonstrated that Blockchain technology strengthens ethical governance and social accountability practices, which mediate its positive effect on social sustainability, highlighting the ethical imperative of transparency and accountability in decentralized environments. In educational contexts, these ethical frameworks are particularly relevant to protect student data, ensure informed consent, and encourage institutional accountability in the use of Blockchain-based learning systems. Overall, the discussion highlights that the educational, technological, and ethical dimensions of Blockchain technology are significantly interconnected, revealing both its transformative potential and the practical challenges that must be addressed. This summary serves as the basis for the concluding reflections.

5. CONCLUSION

The literature review reveals that Blockchain technology in higher education focuses on credential management, academic records administration, and competency certification, strengthening institutional trust, traceability, and record integrity. These advances address transparency deficits, academic fraud, and

limitations of centralized interoperability systems, fostering safer and more inclusive educational environments. However, while improvements in transparency, administrative efficiency, and academic mobility are evident, the pedagogical impact remains limited, with incipient development in didactic innovations and learning personalization. Therefore, Blockchain provides tangible benefits in academic management and the validation of learning outcomes, but a gap persists in strengthening pedagogy and teaching innovation. Future research should prioritize hybrid models that integrate Blockchain with adaptive learning platforms, competency-based education, and real-time feedback ecosystems. Policymakers and academic leaders should encourage interdisciplinary collaborations and pilot projects to demonstrate the pedagogical value of Blockchain beyond administrative efficiency. Furthermore, integrating ethical frameworks, such as the GDPR, is essential to ensure responsible adoption that protects student data and promotes equity. Finally, while this study provides valuable insights into the educational and ethical dimensions of Blockchain, its methodological scope presents specific limitations that should be acknowledged and addressed in future research.

This study's methodological design presents some limitations. The literature search was restricted to three databases (Scopus, ERIC, and SAGE), ensuring high academic quality, but potentially excluding emerging Blockchain innovations from conference papers or industry-driven initiatives. The inclusion criteria, limited to peer-reviewed, open-access articles published between 2020 and 2025, excluded prior or non-open-access research that could offer historical or methodological insights. Similarly, excluding thesis, books, and conference proceedings limited the integration of exploratory or applied evidence, such as innovative applications like Blockchain-based micro-credentialing in non-academic settings. The focus on the university context also excluded studies from other educational levels. These methodological choices ensure coherence but limit the scope, opening opportunities for broader future reviews.

ACKNOWLEDGMENTS

We would like to thank the National University of San Luis Gonzaga for their support in the development of this research.

FUNDING INFORMATION

Authors state no funding involved.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Irma Aybar-Bellido	✓		✓	✓	✓	✓		✓	✓		✓			✓
Maritza Arones	✓	✓	✓		✓	✓	✓			✓		✓		✓
José Antonio Arévalo-Tuesta	✓	✓		✓		✓		✓	✓		✓			✓
Willy Adatao-Medina	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓		
Hernán Ochoa-Carbajal		✓		✓	✓	✓	✓	✓		✓	✓	✓		✓

C : **C**onceptualization

M : **M**ethodology

So : **S**oftware

Va : **V**alidation

Fo : **F**ormal analysis

I : **I**nvestigation

R : **R**esources

D : **D**ata Curation

O : Writing - **O**riginal Draft

E : Writing - Review & **E**ditng

Vi : **V**isualization

Su : **S**upervision

P : **P**roject administration

Fu : **F**unding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

Derived data supporting the findings of this study are available from the corresponding author [IA-B] on request.

REFERENCES

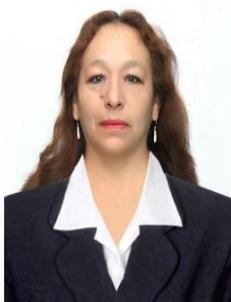
- [1] A. Jain, K. R. Naik, K. Kakade, S. Bhanot, and S. C. Kulkarni, "Reimagining management education: Navigating the shift to education 4.0 in the digital era," *The International Journal of Management Education*, vol. 23, no. 2, pp. 1–16, 2025, doi: 10.1016/j.ijme.2025.101182.
- [2] A. Bohari, W. Wider, L. Jiang, J. C. M. Tanucan, S. P. Lim, and S. F. A. Hossain, "Exploring the key factors influencing the adoption of Education 4.0 in the Malaysian institute of teacher education (IPGM)," *Asian Education and Development Studies*, vol. 14, no. 3, pp. 436–456, 2025, doi: 10.1108/AEDS-10-2024-0223.
- [3] A. Dehbi, A. Bakhoui, R. Dehbi, and M. Talea, "Towards technology-enhanced learning: A novel machine learning approach in education 4.0," *Telematics and Informatics Reports*, vol. 18, pp. 1–11, 2025, doi: 10.1016/j.teler.2025.100194.
- [4] C. Yin, A. Wang, and J. Ma, "Substance over symbol: The disciplinary influence of Industry–University–Research Cooperation in digital transformation," *Finance Research Letters*, vol. 85, pp. 1–8, 2025, doi: 10.1016/j.frl.2025.108040.
- [5] I. Nnaji *et al.*, "Enhancing governance and performance in Nigerian higher education through AI-driven digital transformation: Insights from stakeholder perspectives," *Social Sciences & Humanities Open*, vol. 13, pp. 1–13, 2026, doi: 10.1016/j.ssaho.2025.102348.
- [6] W. Y. W. Lai, P. Kim, and J. S. Lee, "Designing and validating an AI-supported tool for enhancing critical inquiry in EFL education," *Research Methods in Applied Linguistics*, vol. 4, no. 3, pp. 1–18, 2025, doi: 10.1016/j.rmal.2025.100266.
- [7] M. Madanchian, G. Drazenovic, S. R. Ramzani, and H. Taherdoost, "Integrating AI Tools to Enhance Learning Outcomes in Modern Education Systems," *Procedia Computer Science*, vol. 263, pp. 514–521, 2025, doi: 10.1016/j.procs.2025.07.062.
- [8] S. M. Azmir and M. Atikuzzaman, "Students' use of AI tools and attitudes towards using ChatGPT in higher education: a developing country perspective," *The Electronic Library*, vol. 43, no. 6, pp. 937–954, 2025, doi: 10.1108/EL-01-2025-0038.
- [9] F. J. Agbo, C. Olivia, G. Oguibe, I. T. Sanusi, and G. Sani, "Computing education using generative artificial intelligence tools: A systematic literature review," *Computers and Education Open*, vol. 9, pp. 1–13, 2025, doi: 10.1016/j.caeo.2025.100266.
- [10] P. Saha, M. S. Hossain, N. C. Roy, A. A. Masud, and R. Amin, "Unlocking the power of AI in education: students' intentions and AI tool use driving learning success in an emerging economy," *On the Horizon*, vol. 33, no. 1, pp. 126–144, 2025, doi: 10.1108/OTH-10-2024-0066.
- [11] R. Straight, "Beyond the Blockchain: A Comparative Analysis of Educator and Non-Educator Perspectives on Web3 Technologies in Educational Contexts," *Turkish Online Journal of Educational Technology - TOJET*, vol. 24, no. 1, pp. 32–50, 2025.
- [12] B. Duarte, M. R. F. Da Costa, M. Y. Zarouk, A. P. Da Silva, M. Martins, and F. Paraguaçu, "ALEX (Active Learning EXperience): A Decentralized, Offline-First, Student-Centered LMS," *International Journal of Information and Communication Technology Education (IJICTE)*, vol. 21, no. 1, pp. 1–27, 2025, doi: 10.4018/IJICTE.386526.
- [13] B. Pathak, F. Alakkad, and V. Kumar, "Institutional Environment and the Use of Blockchain Technology: Exploring the Context and Conditions of Using Blockchain in the Higher Education Institutions," *Higher Education Quarterly*, vol. 79, no. 3, pp. 1–18, 2025, doi: 10.1111/hequ.70034.
- [14] M. Á. Conde and F. J. Rodríguez-Sedano, "Is learning analytics applicable and applied to education of students with intellectual/developmental disabilities? A systematic literature review," *Computers in Human Behavior*, vol. 155, pp. 1–13, 2024, doi: 10.1016/j.chb.2024.108184.
- [15] M. Madanchian and H. Taherdoost, "Examining Critical Factors in Selecting AI Tools for Educational Success," *Procedia Computer Science*, vol. 263, pp. 923–933, 2025, doi: 10.1016/j.procs.2025.07.111.
- [16] M. Jabeen, R. M. S. Jafar, and Z. Li, "Leveraging metaverse technologies for a sustainable future: The role of knowledge management practices and technology readiness," *Technology in Society*, vol. 84, pp. 1–13, 2026, doi: 10.1016/j.techsoc.2025.103122.
- [17] R. A. Mishra, P. Bhaskar, M. Khan, "An integrated blockchain architecture for sustainable higher education administration," *On the Horizon*, vol. 33, no. 4, pp. 460–474, 2025, doi: 10.1108/OTH-07-2025-0084.
- [18] D. Dave, S. Parikh, R. Patel, and N. Doshi, "A Survey on Blockchain Technology and its Proposed Solutions," *Procedia Computer Science*, vol. 160, pp. 740–745, 2019, doi: 10.1016/j.procs.2019.11.017.
- [19] A. Gurtu and J. Johny, "Potential of blockchain technology in supply chain management: a literature review," *International Journal of Physical Distribution & Logistics Management*, vol. 49, no. 9, pp. 881–900, 2019, doi: 10.1108/IJPDLM-11-2018-0371.
- [20] G. T. Suyambu, M. Anand, and M. Janakirani, "Blockchain – A Most Disruptive Technology on the Spotlight of World Engineering Education Paradigm," *Procedia Computer Science*, vol. 172, pp. 152–158, 2020, doi: 10.1016/j.procs.2020.05.023.
- [21] P. Bhaskar, C. K. Tiwari, and A. Joshi, "Blockchain in education management: present and future applications," *Interactive Technology and Smart Education*, vol. 18, no. 1, pp. 1–17, 2020, doi: 10.1108/ITSE-07-2020-0102.
- [22] A. Kosmarski, "Blockchain Adoption in Academia: Promises and Challenges," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 6, no. 4, pp. 1–15, 2020, doi: 10.3390/joitmc6040117.
- [23] J. Li, M. Lan, Y. Tang, S. Chen, F.-Y. Wang, and W. Wei, "A Blockchain-based Educational Digital Assets Management System," *IFAC-PapersOnLine*, vol. 53, no. 5, pp. 47–52, 2020, doi: 10.1016/j.ifacol.2021.04.082.
- [24] P. Dutta, T.-M. Choi, S. Somani, and R. Butala, "Blockchain technology in supply chain operations: Applications, challenges and research opportunities," *Transportation Research Part E: Logistics and Transportation Review*, vol. 142, pp. 1–33, 2020, doi: 10.1016/j.tre.2020.102067.
- [25] B. Bhushan, A. Khamparia, K. M. Sagayam, S. K. Sharma, M. A. Ahad, and N. C. Debnath, "Blockchain for smart cities: A review of architectures, integration trends and future research directions," *Sustainable Cities and Society*, vol. 61, pp. 1–27, 2020, doi: 10.1016/j.scs.2020.102360.
- [26] R. A. Mishra, A. Kalla, A. Braeken, and M. Liyanage, "Privacy Protected Blockchain Based Architecture and Implementation for Sharing of Students' Credentials," *Information Processing & Management*, vol. 58, no. 3, pp. 1–25, 2021, doi: 10.1016/j.ipm.2021.102512.

- [27] I. Alnafrah and S. Mouselli, "Revitalizing blockchain technology potentials for smooth academic records management and verification in low-income countries," *International Journal of Educational Development*, vol. 85, pp. 1–12, 2021, doi: 10.1016/j.ijedudev.2021.102460.
- [28] A. Aoun, A. Ilinca, M. Ghandour, and H. Ibrahim, "A review of Industry 4.0 characteristics and challenges, with potential improvements using blockchain technology," *Computers & Industrial Engineering*, vol. 162, pp. 1–11, 2021, doi: 10.1016/j.cie.2021.107746.
- [29] L. Lu, C. Liang, D. Gu, Y. Ma, Y. Xie, and S. Zhao, "What advantages of blockchain affect its adoption in the elderly care industry? A study based on the technology–organisation–environment framework," *Technology in Society*, vol. 67, pp. 1–10, 2021, doi: 10.1016/j.techsoc.2021.101786.
- [30] C. Wang, J. P. Alvarez-Gaitan, S. Moore, and R. Stuetz, "Social and institutional factors affecting sustainability innovation in universities: A computer re-use perspective," *Journal of Cleaner Production*, vol. 223, pp. 176–188, 2019, doi: 10.1016/j.jclepro.2019.03.093.
- [31] D. Li *et al.*, "MOOCsChain: A blockchain-based secure storage and sharing scheme for MOOCs learning," *Computer Standards & Interfaces*, vol. 81, pp. 1–10, 2022, doi: 10.1016/j.csi.2021.103597.
- [32] M. Sreenu, N. Gupta, C. Jatoth, A. Saad, A. Alharbi, and L. Nkenyerere, "Blockchain based secure and reliable Cyber Physical ecosystem for vaccine supply chain," *Computer Communications*, vol. 191, pp. 173–183, 2022, doi: 10.1016/j.comcom.2022.04.031.
- [33] M. D. C. G. Sánchez, C. De-Pablos-Heredero, J.-A. Medina-Merodio, R. Robina-Ramírez, and L. Fernandez-Sanz, "Relationships among relational coordination dimensions: Impact on the quality of education online with a structural equations model," *Technological Forecasting and Social Change*, vol. 166, pp. 1–12, 2021, doi: 10.1016/j.techfore.2021.120608.
- [34] I. J. Orji, F. Ojadi, and U. K. Okwara, "Assessing the pre-conditions for the pedagogical use of digital tools in the Nigerian higher education sector," *The International Journal of Management Education*, vol. 20, no. 2, pp. 1–26, 2022, doi: 10.1016/j.ijme.2022.100626.
- [35] V. Chukowry, G. Nanuck, and R. K. Sungkur, "The future of continuous learning–Digital badge and microcredential system using blockchain," *Global Transitions Proceedings*, vol. 2, no. 2, pp. 355–361, 2021, doi: 10.1016/j.gltp.2021.08.026.
- [36] W. Chen, S. M. Bohloul, Y. Ma, and L. Li, "A blockchain-based information management system for academic institutions: a case study of international students' workflow," *Information Discovery and Delivery*, vol. 50, no. 4, pp. 342–352, 2021, doi: 10.1108/IDD-01-2021-0010.
- [37] A. Devine, A. Jabbar, J. Kimmitt, and C. Apostolidis, "Conceptualising a social business blockchain: The coexistence of social and economic logics," *Technological Forecasting and Social Change*, vol. 172, pp. 1–13, 2021, doi: 10.1016/j.techfore.2021.120997.
- [38] S. Dwivedi and S. Vig, "Blockchain adoption in higher-education institutions in India: identifying the main challenges," *Cogent Education*, vol. 11, no. 1, p. 2292887, Dec. 2024, doi: 10.1080/2331186X.2023.2292887.
- [39] N. Liu and Z. Ye, "Empirical research on the Blockchain adoption – based on TAM," *Applied Economics*, vol. 53, no. 37, pp. 4263–4275, Aug. 2021, doi: 10.1080/00036846.2021.1898535.
- [40] A. H. Hamadeh, R. M. Nouraldeen, R. M. Mahboub, and M. S. Hashem, "Auditors' intention to use Blockchain technology and TAM3: the moderating role of age," *Administrative Sciences*, vol. 15, no. 2, p. 61, Feb. 2025, doi: 10.3390/admsci15020061.
- [41] N. Ullah, W. M. Al-Rahmi, A. I. Alzahrani, O. Alfarraj, and F. M. Alblehai, "Blockchain technology adoption in smart learning environments," *Sustainability*, vol. 13, no. 4, p. 1801, Feb. 2021, doi: 10.3390/su13041801.
- [42] M. S. Alalyan, N. A. Jaafari, and F. K. Hussain, "Technology Factors Influencing Saudi Higher Education Institutions' Adoption of Blockchain Technology: A Qualitative Study," in L. Barolli, (Eds), *Advanced Information Networking and Applications. AINA Lecture Notes in Networks and Systems*, Springer, Cham, 2023, vol. 661, pp. 267–278, 2023, doi: 10.1007/978-3-031-29056-5_19.
- [43] P. Grover, A. K. Kar, and M. Janssen, "Diffusion of Blockchain technology: insights from academic literature and social media analytics," *Journal of Enterprise Information Management*, vol. 32, no. 5, pp. 735–757, Sep. 2019, doi: 10.1108/JEIM-06-2018-0132.
- [44] A. J. Windawi, "The diffusion of Blockchain as a general purpose technology driving digital transformation," *Technology Innovation Management Review*, vol. 12, no. 1/2, pp. 1–9, May 2022, doi: 10.22215/timreview/1478.
- [45] C. R. dos S. Ramos and M. M. Queiroz, "Blockchain in education: the influence of trust on adoption and implementation," *RAUSP Management Journal*, vol. 57, no. 3, pp. 316–331, Jul. 2022, doi: 10.1108/RAUSP-06-2021-0097.
- [46] G. Chen, B. Xu, M. Lu, and N.-S. Chen, "Exploring blockchain technology and its potential applications for education," *Smart Learning Environments*, vol. 5, no. 1, pp. 1–10, 2018, doi: 10.1186/s40561-017-0050-x.
- [47] S. Dawadi, S. Shrestha, and R. A. Giri, "Mixed-Methods Research: A Discussion on its Types, Challenges, and Criticisms," *Journal of Practical Studies in Education*, vol. 2, no. 2, pp. 25–36, 2021, doi: 10.46809/jpse.v2i2.20.
- [48] M. A. Adeoye, "From Variables to Research Design: A Deep Dive into Educational Research Methodology," *Journal of Education Research and Evaluation*, vol. 7, no. 4, pp. 622–628, 2023, doi: 10.23887/jere.v7i4.68173.
- [49] C. K. Giri, "Variables in Educational Research," *The International Journal of Indian Psychology*, vol. 12, no. 3, pp. 1–10, 2024. [Online]. Available: <https://ijip.in/pdf-viewer/?id=44647>
- [50] H. Nassaji, "Good qualitative research," *Language Teaching Research*, vol. 24, no. 4, pp. 427–431, 2020, doi: 10.1177/1362168820941288.
- [51] Y. Xiao and W. Watson, "Guidance on Conducting a Systematic Literature Review," *Journal of Planning Education and Research*, vol. 39, no. 1, pp. 93–112, 2017, doi: 10.1177/0739456X17723971.
- [52] M. J. Page *et al.*, "The PRISMA 2020 statement: an updated guideline for reporting systematic reviews," *BMJ*, vol. 372, p. n71, Mar. 2021, doi: 10.1136/bmj.n71.
- [53] Y. Luo *et al.*, "A secure storage and verification framework based on consortium Blockchain for engineering education accreditation data," *Computers, Materials & Continua*, vol. 83, no. 3, pp. 5323–5343, 2025, doi: 10.32604/cmc.2025.063860.
- [54] A. A. M. A. Ali, R. Kadhem, and M. Mabrouk, "Application models and practical challenges of Blockchain technology in the field of higher education in Iraq," *Procedia Computer Science*, vol. 246, pp. 3723–3732, 2024, doi: 10.1016/j.procs.2024.09.184.
- [55] M. Gottlieb, C. Deutsch, F. Hoops, H. Pongratz, and H. Krčmar, "Expedition to the Blockchain application potential for higher education institutions," *Blockchain: Research and Applications*, vol. 5, no. 3, p. 100203, Sep. 2024, doi: 10.1016/j.bcra.2024.100203.
- [56] A. S. Sangeetha and S. Shunmugan, "Privacy-enabled academic certificate authentication and deep learning-based student performance prediction system using Hyperledger Blockchain technology," *Journal of Parallel and Distributed Computing*, vol. 204, p. 105119, Oct. 2025, doi: 10.1016/j.jpdc.2025.105119.

- [57] A. S. Balobaid, Y. H. Alagrash, A. H. Fadel, and J. N. Hasoon, "Modeling of Blockchain with encryption based secure education record management system," *Egyptian Informatics Journal*, vol. 24, no. 4, p. 100411, Dec. 2023, doi: 10.1016/j.eij.2023.100411.
- [58] R. Hu *et al.*, "EduASAC: a Blockchain-based education archive sharing and access control system," *Computers, Materials & Continua*, vol. 77, no. 3, pp. 3387–3422, 2023, doi: 10.32604/cmc.2023.042000.
- [59] Y. Wang, Q. Sun, and R. Bie, "Blockchain-based secure sharing mechanism of online education data," *Procedia Computer Science*, vol. 202, pp. 283–288, 2022, doi: 10.1016/j.procs.2022.04.037.
- [60] B. Lund, "Blockchain applications in higher education based on the NIST cybersecurity framework," *Journal of Cybersecurity Education, Research and Practice*, vol. 2024, no. 1, pp. 1–6, Feb. 2024, doi: 10.62915/2472-2707.1178.
- [61] E. P. Fedorova and E. I. Skobleva, "Application of Blockchain technology in higher education," *European Journal of Contemporary Education*, vol. 9, no. 3, pp. 552–571, Sep. 2020, doi: 10.13187/ejced.2020.3.552.
- [62] P. Panagiotidis, "Blockchain in education - the case of language learning," *European Journal of Education*, vol. 5, no. 1, pp. 66–82, Apr. 2022, doi: 10.26417/443gjm83.
- [63] S. Ugur, G. D. Dincer, and D. P. Bas, "An evaluation of the managerial context for digital transformation in the context of open education in higher education," *Turkish Online Journal of Distance Education*, vol. 25, no. 3, pp. 225–242, Jul. 2024, doi: 10.17718/tojde.1417658.
- [64] A. Ghoni and I. Corpuz, "Moving toward a digital competency-based approach in applied education: developing a system supported by Blockchain to enhance competency-based credentials," *International Journal of Higher Education*, vol. 10, no. 5, pp. 33–45, Apr. 2021, doi: 10.5430/ijhe.v10n5p33.
- [65] R. McGreal, "Blockchain and micro-credentials in education," *International Journal of E-Learning & Distance Education (IJEDE)*, vol. 38, no. 1, pp. 1–17, Sep. 2023, doi: 10.55667/ijede.2023.v38.i1.1250.
- [66] Z. Hao, M. Y. bin Yahya, and J. Lu, "Influence of Blockchain technology application in education on online teaching resources sharing," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 18, no. 11, pp. 25–37, Jun. 2023, doi: 10.3991/ijet.v18i11.39361.
- [67] Y. Ma and Y. Fang, "Current status, issues, and challenges of Blockchain applications in education," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 15, no. 12, pp. 20–31, Jun. 2020, doi: 10.3991/ijet.v15i12.13797.
- [68] A. Y. Al-Zoubi and M. Aldmour, "Refining the process of credit transfer of MOOCs with the utilization of ChatGPT and Blockchain," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 18, no. 18, pp. 23–34, Sep. 2023, doi: 10.3991/ijet.v18i18.43089.
- [69] Y. Zheng, "Design of a Blockchain-based e-portfolio evaluation system to assess the education and teaching process," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 16, no. 5, pp. 261–280, Mar. 2021, doi: 10.3991/ijet.v16i05.21081.
- [70] J. Liu and T. Zhu, "Application of Blockchain technology in cultural and creative design and education," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 16, no. 4, pp. 228–239, Feb. 2021, doi: 10.3991/ijet.v16i04.15233.
- [71] A. Widiyanto *et al.*, "Influence of Blockchain implementation for virtual meetings at home learning Indonesia," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 18, no. 6, pp. 220–227, Mar. 2023, doi: 10.3991/ijet.v18i06.37255.
- [72] M. Fartitchou, I. Lamaakal, K. El Makkaoui, Z. El Allali, and Y. Maleh, "BlockMEDC: Blockchain smart contracts system for securing Moroccan higher education digital certificates," *IEEE Access*, vol. 13, pp. 39152–39175, 2025, doi: 10.1109/ACCESS.2025.3546177.
- [73] A. S. Alammary, "Building a sustainable digital infrastructure for higher education: a Blockchain-based solution for cross-institutional enrollment," *Sustainability*, vol. 17, no. 1, p. 194, Dec. 2024, doi: 10.3390/su17010194.
- [74] C. Kontzinos, E. Karakolis, P. Kokkinakos, S. Skalidakis, D. Askounis, and J. Psarras, "Application and evaluation of a Blockchain-centric platform for smart badge accreditation in higher education institutions," *Applied Sciences*, vol. 14, no. 12, p. 5191, Jun. 2024, doi: 10.3390/app14125191.
- [75] A. Tariq, H. B. Haq, and S. T. Ali, "Cerberus: a Blockchain-based accreditation and degree verification system," *IEEE Transactions on Computational Social Systems*, vol. 10, no. 4, pp. 1503–1514, Aug. 2023, doi: 10.1109/TCSS.2023.3188453.
- [76] E. Tan, E. Lerouge, J. du Caju, and D. du Seuil, "Verification of education credentials on European blockchain services infrastructure (EBSI): action research in a cross-border use case between Belgium and Italy," *Big Data and Cognitive Computing*, vol. 7, no. 2, p. 79, Apr. 2023, doi: 10.3390/bdcc7020079.
- [77] J. Wu, "Research on the development of watercolor painting education in universities based on smart contract model," *Applied Mathematics and Nonlinear Sciences*, vol. 9, no. 1, pp. 1–12, Jan. 2024, doi: 10.2478/amns.2023.2.00141.
- [78] J. Swati and P. Nitin, "CryptoScholarChain: revolutionizing scholarship management framework with Blockchain technology," *International Journal of Advanced Computer Science and Applications*, vol. 14, no. 8, pp. 652–659, 2023, doi: 10.14569/IJACSA.2023.0140872.
- [79] L. Chen, "Research on the path of integrating Blockchain technology into the teaching of film and television courses in higher education institutions," *Applied Mathematics and Nonlinear Sciences*, vol. 8, no. 1, pp. 2821–2834, Jan. 2023, doi: 10.2478/amns.2023.1.00003.
- [80] O. A. Khashan, S. Alamri, W. Alomoush, M. K. Alsmadi, S. Atawneh, and U. Mir, "Blockchain-based decentralized authentication model for IoT-based e-learning and educational environments," *Computers, Materials & Continua*, vol. 75, no. 2, pp. 3133–3158, 2023, doi: 10.32604/cmc.2023.036217.
- [81] B. Dai and X. An, "Higher educational information resource sharing model based on Blockchain," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 18, no. 7, pp. 72–88, Apr. 2023, doi: 10.3991/ijet.v18i07.39241.
- [82] O. S. Saleh, O. Ghazali, and N. B. Idris, "A new privacy-preserving protocol for academic certificates on Hyperledger fabric," *International Journal of Advanced Computer Science and Applications*, vol. 14, no. 2, pp. 595–609, 2023, doi: 10.14569/IJACSA.2023.0140271.
- [83] K. O. Asamoah *et al.*, "A Blockchain-based crowdsourcing loan platform for funding higher education in developing countries," *IEEE Access*, vol. 11, pp. 24162–24174, 2023, doi: 10.1109/ACCESS.2023.3252917.
- [84] Y. Kistaubayev, G. Mutanov, M. Mansurova, Z. Saxenbayeva, and Y. Shakan, "Ethereum-based information system for digital higher education registry and verification of student achievement documents," *Future Internet*, vol. 15, no. 1, p. 3, Dec. 2022, doi: 10.3390/fi15010003.
- [85] G. Bjelobaba, M. Paunovic, A. Savic, H. Stefanovic, J. Doganovic, and Z. M. Bogavac, "Blockchain technologies and digitalization in function of student work evaluation," *Sustainability*, vol. 14, no. 9, p. 5333, Apr. 2022, doi: 10.3390/su14095333.
- [86] A. Garg, A. Sharmila, P. Kumar, M. Madhukar, O. Loyola-González, and M. Kumar, "Blockchain-based online education content ranking," *Education and Information Technologies*, vol. 27, no. 4, pp. 4793–4815, May 2022, doi: 10.1007/s10639-021-10797-5.

- [87] Q. Aini, N. Azizah, R. Salam, N. P. L. Santoso, and S. Millah, "iLearning education based on gamification Blockchain," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 26, no. 1, pp. 531–538, Apr. 2022, doi: 10.11591/ijeecs.v26.i1.pp531-538.
- [88] B. Li, "Online music teaching resource sharing algorithm based on Blockchain technology," *International Journal of Emerging Technologies in Learning (IJET)*, vol. 17, no. 24, pp. 69–86, Dec. 2022, doi: 10.3991/ijet.v17i24.35373.
- [89] A. Z. Junejo, A. Dziatkovskii, M. A. Hashmani, U. Hryneuski, and E. Ovechkina, "Blockchain based framework for efficient student performance tracking (BloSPer)," *International Journal of Advanced Computer Science and Applications*, vol. 13, no. 11, pp. 46–55, 2022, doi: 10.14569/IJACSA.2022.0131105.
- [90] S. Alangari, S. M. Alshahrani, N. A. Khan, A. A. Alghamdi, J. Almalki, and W. Al Shehri, "Developing a Blockchain-based digitally secured model for the educational sector in Saudi Arabia toward digital transformation," *PeerJ Computer Science*, vol. 8, p. e1120, Sep. 2022, doi: 10.7717/peerj-cs.1120.
- [91] K. B. Dubey and M. Goyal, "Smart certificate using Blockchain," *Journal of Computer Science*, vol. 18, no. 9, pp. 877–884, Sep. 2022, doi: 10.3844/jcssp.2022.877.884.
- [92] J. Zhong, H. Chen, Q. Zhang, and W. He, "Discussion and application of Blockchain technology in information management of internet of things in smart lab," *Mobile Information Systems*, vol. 2022, no. 9, pp. 1–11, Aug. 2022, doi: 10.1155/2022/1038526.
- [93] D. Shah, D. Patel, J. Adesara, P. Hingu, and M. Shah, "Integrating machine learning and Blockchain to develop a system to veto the forgeries and provide efficient results in education sector," *Visual Computing for Industry, Biomedicine, and Art*, vol. 4, no. 1, p. 18, Dec. 2021, doi: 10.1186/s42492-021-00084-y.
- [94] C.-L. Chen, T. Wang, W.-J. Tsaur, W. Weng, Y.-Y. Deng, and J. Cui, "Based on consortium Blockchain to design a credit verifiable cross university course learning system," *Security and Communication Networks*, vol. 2021, no. 1, pp. 1–18, Dec. 2021, doi: 10.1155/2021/8241801.
- [95] P. Ocheja, F. J. Agbo, S. S. Oyelere, B. Flanagan, and H. Ogata, "Blockchain in education: a systematic review and practical case studies," *IEEE Access*, vol. 10, pp. 99525–99540, 2022, doi: 10.1109/ACCESS.2022.3206791.
- [96] C. J. T. Plasencia, A. S. J. Trinidad, F. A. G. Rosas, and J. W. T. Franco, "Blockchain technology in education: a systematic review," *Revista Conrado*, vol. 19, no. 92, pp. 326–334, 2023. [Online]. Available: <https://conrado.ucf.edu/cu/index.php/conrado/article/view/3038>
- [97] O. Desplebin, G. Lux, and N. Petit, "Inclusion of Blockchain in university accounting curricula: an overview of practices and strategies," *Accounting Education*, vol. 34, no. 2, pp. 265–286, Mar. 2025, doi: 10.1080/09639284.2024.2321125.
- [98] Z. Li and W. Zhang, "Technology in education: Addressing legal and governance challenges in the digital era," *Education and Information Technologies*, vol. 30, pp. 8413–8443, 2025, doi: 10.1007/s10639-024-13036-9.
- [99] J. Zeng, F. Li, and H. Qin, "The exploration of Blockchain technology in academic research field," *International Journal of Frontiers in Engineering Technology*, vol. 3, no. 1, pp. 45–50, Feb. 2021, doi: 10.25236/IJFET.2021.030108.
- [100] A. Rustemi, F. Dalipi, V. Atanasovski, and A. Risteski, "A systematic literature review on Blockchain-based systems for academic certificate verification," *IEEE Access*, vol. 11, pp. 64679–64696, 2023, doi: 10.1109/ACCESS.2023.3289598.
- [101] S. Downes, "Recognising Achievement with Badges and Blockchain in a Connectivist MOOC," *Journal of Learning for Development*, vol. 6, no. 3, pp. 273–286, 2019, doi: 10.56059/jl4d.v6i3.348.
- [102] R. Raimundo and A. Rosário, "Blockchain system in the higher education," *European Journal of Investigation in Health, Psychology and Education*, vol. 11, no. 1, pp. 276–293, Mar. 2021, doi: 10.3390/ejihpe11010021.
- [103] P. Zheng, Z. Jiang, J. Wu, and Z. Zheng, "Blockchain-based decentralized application: a survey," *IEEE Open Journal of the Computer Society*, vol. 4, pp. 121–133, 2023, doi: 10.1109/OJCS.2023.3251854.
- [104] S. Auffero, G. Ibba, S. Bartolucci, G. Destefanis, R. Neykova, and M. Ortu, "DApps ecosystems: mapping the network structure of smart contract interactions," *EPJ Data Science*, vol. 13, no. 1, p. 60, Sep. 2024, doi: 10.1140/epjds/s13688-024-00497-8.
- [105] T. Arndt and A. Guercio, "Blockchain-based transcripts for mobile higher-education," *International Journal of Information and Education Technology*, vol. 10, no. 2, pp. 84–89, 2020, doi: 10.18178/ijiet.2020.10.2.1344.
- [106] T. Savelyeva and J. Park, "Blockchain technology for sustainable education," *British Journal of Educational Technology*, vol. 53, no. 6, pp. 1591–1604, Nov. 2022, doi: 10.1111/bjet.13273.
- [107] C. Delgado-von-Eitzen, L. Anido-Rifón, and M. J. Fernández-Iglesias, "Blockchain applications in education: a systematic literature review," *Applied Sciences*, vol. 11, no. 24, p. 11811, Dec. 2021, doi: 10.3390/app112411811.
- [108] S. Y. Al-Imamy and S. Zygiaris, "Innovative students' academic advising for optimum courses' selection and scheduling assistant: A Blockchain based use case," *Education and Information Technologies*, vol. 27, pp. 5437–5455, 2022, doi: 10.1007/s10639-021-10844-1.
- [109] A. A. M. A. Ali, M. Mabrouk, and M. Zrigui, "A review: Blockchain technology applications in the field of higher education," *Journal of Hunan University Natural Sciences*, vol. 49, no. 10, pp. 88–99, Oct. 2022, doi: 10.55463/issn.1674-2974.49.10.10.
- [110] D. Dudek, "Blockchain in OER: students' perspectives on the use of Blockchain technology for credential authentication," *Procedia Computer Science*, vol. 225, pp. 4648–4656, 2023, doi: 10.1016/j.procs.2023.10.463.
- [111] H. A. Alsobhi, R. A. Alakhtar, A. Ubaid, O. K. Hussain, and F. K. Hussain, "Blockchain-based micro-credentialing system in higher education institutions: systematic literature review," *Knowledge-Based Systems*, vol. 265, p. 110238, Apr. 2023, doi: 10.1016/j.knsys.2022.110238.
- [112] P. G. Kirchsclaeger, "Blockchain ethics," *Philosophies*, vol. 9, no. 1, p. 2, Dec. 2023, doi: 10.3390/philosophies9010002.
- [113] R. Beck and S. Agerskov, *Ethical guidelines for Blockchain systems*. Copenhagen: European Blockchain Center, 2024. [Online]. Available: https://blockchain-observatory.ec.europa.eu/news/ethical-guidelines-blockchain-systems-2024-05-15_en
- [114] C. Dierksmeier and P. Seele, "Blockchain and business ethics," *Business Ethics: A European Review*, vol. 29, no. 2, pp. 348–359, Apr. 2020, doi: 10.1111/beer.12259.
- [115] A. I. Aljumah, "Investigating the impact of Blockchain technology on social sustainability and the mediating role of ethics and CSR," *Sustainability*, vol. 15, no. 21, p. 15510, Nov. 2023, doi: 10.3390/su152115510.

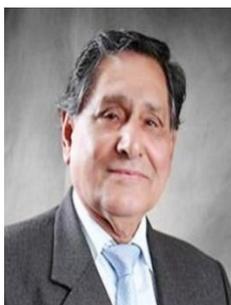
BIOGRAPHIES OF AUTHORS



Irma Aybar-Bellido     is a specialist in biological sciences and chemistry. She holds a master's degree in higher education administration and planning and a Ph.D. in education from the National University of San Luis Gonzaga. She has 30 years of experience in primary education, serving as a secondary school teacher, and is also the Director of Educational Institutions. She can be contacted at email: irma.aybar@unica.edu.pe.



Maritza Arones     has a Ph.D. in Education, postdoctoral in research methodology and scientific production, master's in education with a specialization in higher education administration and planning. Secondary specialization in teaching methodology, bachelor's degree in educational sciences, specializing in mathematical sciences and physics, bachelor's degree in educational sciences, and internship at the University of Santiago de Compostela, Spain. She is a principal lecturer at the Faculty of Educational Sciences and Humanities of the National University "San Luis Gonzaga", attached to the Academic Department of Social Sciences. She can be contacted at email: marones@unica.edu.pe.



José Antonio Arévalo-Tuesta     is an economist with a master's degree in educational administration and management. He holds a doctorate in economics and education. He has experience in business management, strategic planning for public and private institutions, and the design, planning, execution, and evaluation of private and social strategic projects. He is a professor in masters and doctorate in strategic planning, investment projects and programs, public economics - research methodology, epistemology, thesis seminar, thesis, and territorial development in different institutions. Currently is a member of the board of directors of the national center for strategic planning - CEPLAN and head of the postgraduate unit of the faculty of economic sciences of the UNFV. He can be contacted at email: jareavalo@unfv.edu.pe.



Willy Adauto-Medina     is professor at the Universidad Nacional Tecnológica de Lima Sur, Faculty of Engineering and Management. Graduate in language and writing, with a master's degree in communication didactics and another master's degree in environmental education and sustainable development, both obtained at the Universidad Nacional de Educación Enrique Guzmán y Valle, Lima-Peru. His research interest covers the impact of information and communication technologies (ICT) on digital writing, as well as texts in digital environments: multimodal, transmedia narrative and hypertextual texts on reading comprehension. He can be contacted at email: wadauto@untels.edu.pe.



Hernán Ochoa-Carbajal     is a systems engineer, with a master's degree in business administration and a master's degree in educational administration. He holds a doctorate in systems engineering. He holds a diploma in research in higher education, a diploma in curriculum management, and university accreditation. He has over 15 years of experience in university teaching. He can be contacted at email: hochoa@untels.edu.pe.