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Education, artificial intelligence and blockchain: a systematic review on the convergence of emerging technologies and learning processes

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Abstract: This article presents the first phase of a broader project examining the integration of Artificial Intelligence (AI) and Blockchain in education. A systematic review was conducted following the PRISMA protocol, analysing literature indexed in Google Scholar between 2018 and 2025. From 798 records, 103 studies met the inclusion criteria. The review shows a rapidly expanding field that is beginning to consolidate its methods and conceptual boundaries. Findings highlight three main trends: the use of AI and Blockchain to support adaptive and immersive learning environments; the development of distributed credentialing systems, including micro-credentials and self-sovereign identity; and growing attention to ethical, governance and transparency issues. Across the corpus, AI provides analytical and adaptive capabilities, while Blockchain ensures authenticity, traceability and trust in learning data and processes. This exploratory mapping offers a baseline for the next phase of the project, which will extend the review to Scopus and Web of Science and conduct a qualitative analysis of full texts. Overall, the evidence suggests that AI–Blockchain convergence is reshaping how educational processes are organised and how knowledge is validated within digital learning ecosystems.

Keywords: Education; Artificial Intelligence; Blockchain

1. Introduction

The growing convergence among Artificial Intelligence (AI), Blockchain technology and educational systems is generating a new research area, marked by rapid expansion and by a conceptual evolution that brings together computer science, pedagogy and the philosophy of technology. This intersection encourages a reconsideration of knowledge models, assessment practices and forms of governance in education.

As Floridi (2014, 2019) notes, the ongoing digital transformation reshapes the infosphere in which subjects, artefacts and processes operate, blurring the boundaries between the human, the artificial and the digital. AI becomes part of the cognitive environment, while Blockchain introduces new modes of distributed trust that affect the very notion of evidence and authenticity. Within this framework, educational

research is called to examine the relationship between autonomy, responsibility and learning mediated by intelligent and decentralised technologies.

Reflections on distributed learning draw on the connectivist perspective (Siemens, 2005) and on the later developments of networked learning (Garrison & Anderson, 2011), where knowledge takes shape within networks of relationships and information flows. The decentralised logic of Blockchain fits into this scenario as an infrastructure able to trace interactions and redistribute control over learning processes.

Recent literature has highlighted several directions of development. Grech and Camilleri (2017) initiated the European debate on the use of Blockchain for skills certification, while Chen et al. (2018) showed how the traceability of educational data can strengthen transparency and verifiability. Studies such as those by Williamson (2021) and Popenici and Kerr (2017) have also drawn attention to the social, political and ethical implications of adopting intelligent systems in educational governance.

Within this framework, the present contribution represents the first phase of a systematic review conducted following the PRISMA model. Its aim is to map the literature indexed in Google Scholar between 2018 and 2025 concerning the simultaneous integration of AI and Blockchain in education. The review combines the methodological structure of the PRISMA protocol with the guidelines proposed by Zawacki-Richter et al. (2020), with the goal of outlining research trends, emerging models and still unexplored areas. The decision to begin with Google Scholar responds to the need to include a wide range of contributions not always present in more selective databases, building a preliminary picture that will support the later extension to Scopus and Web of Science.

Many studies included in the review (e.g., Elkhodr et al., 2024; Uddin et al., 2024) describe the convergence between AI and Blockchain as a synergy capable of reshaping models of personalisation, assessment and data management in education. AI offers analytical and adaptive capacities, while Blockchain provides traceability, integrity and distributed information management. Their interaction gives rise to emerging forms of distributed educational intelligence, in which personalisation and digital trust are closely connected.

Three research questions guide this review:

(1) What are the main research lines concerning AI–Blockchain integration in education?

(2) What models are emerging for personalisation, certification and data governance?

(3) What contribution does Italian scholarship offer within the international landscape?

The phase presented here is a first step toward a more in-depth qualitative synthesis, planned for the second stage of the project, which will analyse full texts retrieved from Scopus and Web of Science to consolidate the evidence identified in this exploratory mapping.

2. Methodology (PRISMA model)

The review was conducted following the PRISMA protocol, Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Moher et al., 2009), recognised as an international standard for transparency and replicability in systematic reviews. Applying this model supports the need to establish a solid methodological foundation

for the future extension of the study to the Scopus and Web of Science databases, ensuring procedural consistency and traceability at every stage.

The PRISMA model includes four phases – identification, screening, eligibility and inclusion – which allow a precise reconstruction of the selection process. In this first phase, the search focused on Google Scholar, chosen for its open nature, its multidisciplinary coverage and its ability to provide a broad overview of recent publications, including pedagogical and educational studies that are not always indexed in Scopus or Web of Science (Beel et al., 2010; Martín-Martín et al., 2021). This choice supported the creation of an exploratory mapping of literature, consistent with the goal of identifying emerging trends and knowledge gaps.

The search strategy adopted in this first phase is summarised in Table 1.

Table 1. Search Strategy – Google Scholar (Phase 1)[1]

Element	**Details**
Database	Google Scholar
Time span	2018–2025
Languages	English, Italian
Main query	"Education" AND "Blockchain" AND "Artificial Intelligence"
Semantic extensions	"Higher Education", "E-learning", "Digital Learning"; "Machine Learning", "Intelligent Systems", "Learning Analytics"; "Distributed Ledger", "Credential Verification", "Smart Contracts".
Type of material analysed	Titles, abstracts, keywords (preliminary phase)
Limitations of Phase 1	No full-text assessment; no risk-of-bias evaluation; variable coverage of Google Scholar.

[1] This table summarises the search strategy applied in Phase 1, which focused on titles, abstracts, and keywords only. Full-text assessment and risk-of-bias analysis will be conducted in Phase 2.

The search was conducted between July and September 2025, using the query: "Education AND Blockchain AND Artificial Intelligence", with a time filter of 2018–2025 and a language restriction to English and Italian.

The year 2018 was selected as the starting point because it marks, in literature, the beginning of systematic studies addressing the three domains together. Earlier works, such as Grech and Camilleri (2017), though relevant for the conceptual framework,

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were not included in the analysed corpus and were considered only as contextual references.

To ensure completeness, the query was expanded to include semantic variants and related terms. In the educational domain, terms such as Higher Education, E-learning, Digital Learning and Instructional Design were included; for artificial intelligence, Machine Learning, Intelligent Systems and Learning Analytics; and for Blockchain, Distributed Ledger, Smart Contracts, Credential Verification and Decentralized Identity. This extension made it possible to capture contributions that, while not explicitly mentioning the triad in the title, addressed the topic substantially.

The inclusion criteria prioritised articles that presented a joint discussion of the three areas – education, AI and Blockchain – whether theoretical, methodological or applied. Studies mentioning only one of the two technologies, purely technical works without educational context and sources lacking verifiable bibliographic information were excluded.

In total, the search identified 798 potentially relevant contributions. After removing duplicates and conducting title and abstract screening, 103 articles were selected for analysis, while 695 were excluded due to limited relevance or insufficient information. All decisions concerning screening, eligibility and inclusion were documented in the PRISMA tracker sheet, an internal tool developed according to the PRISMA model. This supported transparency, ensured the traceability of decisions and functioned as an operational tool to maintain methodological consistency and rigour in corpus selection.

The screening process applied in this preliminary phase is summarised in Table 2.

Table 2. PRISMA Flow – Phase 1 (Google Scholar Search 2018–2025)[2]

Phase	Number of studies	Description
Records identified	798	Google Scholar search
Duplicates removed	0	No duplicates found
Records screened (title/abstract)	798	Preliminary screening
Records excluded	695	Not relevant / insufficient information
Records included	103	Included in the exploratory mapping

[2] This preliminary PRISMA flow reflects title/abstract screening only. Full-text eligibility assessment will be conducted in Phase 2.

The inclusion and exclusion criteria adopted during screening are reported in Table 3.

Table 3. Inclusion and Exclusion Criteria (Phase 1)

Category	Criteria
Inclusion	Studies addressing education, artificial intelligence, and blockchain together. Publications from 2018 to 2025. English or Italian language. Indexed in Google Scholar. Presence of at least one of the following terms: "Higher Education", "E-learning", "Digital Learning"; "Machine Learning", "Intelligent Systems", "Learning Analytics"; "Distributed Ledger", "Credential Verification", "Smart Contracts".
Exclusion	Studies focusing exclusively on AI or exclusively on blockchain without an educational context. Purely technical papers with no pedagogical or educational relevance. Documents lacking verifiable bibliographic metadata. Duplicated versions (e.g., preprints or conference papers already available in extended form).

After defining the screening criteria, the analysis proceeded with the classification of the included studies based on the information available in titles, abstracts, keywords and reading-sheet summaries. After screening, the 103 included studies were analysed inductively, following the methodological guidelines proposed by Zawacki-Richter et al. (2020), to identify recurring conceptual patterns and group the contributions into eight thematic clusters describing the structure of the field.

The analysis led to the identification of eight thematic clusters: Metaverse and immersive environments; Higher Education and E-learning; Credentials and Micro-credentials; Adaptive Learning and Intelligent Tutoring; Traceability and the Educational Supply Chain; Governance, Privacy and Ethics; Smart Contracts and Automation; and Theoretical and Conceptual Studies.

This categorisation provided the basis for an initial taxonomy of contributions, useful for interpreting the distribution of research by domain, methodology and educational context. It also helped mitigate distortions linked to the dynamic nature of Google Scholar and strengthened the reliability of the resulting mapping. Some limitations needed to be considered, such as the presence of non–peer-reviewed publi-

cations, possible duplication of preprints and the partial absence of bibliometric indicators.

Phase 2 of the project will extend the PRISMA protocol to Scopus and Web of Science, using the same criteria and search string to integrate and validate the results of this exploratory stage.

3. Results

3.1. General overview of the corpus

The search conducted on Google Scholar returned 798 potentially relevant publications, from which 103 articles were included after screening according to the PRISMA criteria (see Table 2). The chronological distribution shows a steady increase in scientific production starting from 2018, with a significant rise between 2022 and 2024, a period in which themes such as the educational metaverse, micro-credentials and applications of generative artificial intelligence in learning contexts appear more frequently.

The corpus reflects a rapidly developing research field, where theoretical and conceptual contributions coexist with a growing number of applied studies, experiments and architectural proposals. Around forty per cent of the works fall within the theoretical–conceptual category, while the remaining sixty per cent show a design-oriented or empirical approach.

Among the most cited contributions are those combining a solid methodological structure with broad pedagogical reflections: Chen et al. (2018), who propose a Blockchain-based model for tracking competences; Elkhodr et al. (2024), who analyse the Australian context of integrated AI–Blockchain adoption in higher education; and Uddin et al. (2024), who provide a systematisation of technological paradigms related to immersive ecosystems.

Alongside these, other key contributions include Mozumder et al. (2023), who outline a technological roadmap for the educational metaverse, and Alsobhi et al. (2023), who examine the role of Blockchain in skills certification and micro-credentials. These works represent central nodes in the citation network of the corpus and contribute to shaping an initial genealogy of research on AI–Blockchain integration in education.

Temporal progression also shows a thematic and geographical evolution: contributions published between 2018 and 2020 come mainly from computer science and educational engineering, while from 2021 onward the number of studies situated within the educational sciences increases. This shift suggests a move from the exploration of technical potential toward the development of instructional and organisational models grounded in transparency, adaptivity and sustainability.

3.2. Research trends and thematic clusters

The analysis of the titles, keywords and abstracts made it possible to identify eight main thematic trends that describe how the field developed between 2018 and 2025.

- The first and most substantial cluster concerns Higher Education and e-learning, which includes many contributions from the corpus. These studies explore the combined potential of AI and Blockchain in managing university platforms, analysing learning data and supporting automated assessment processes. Several works interpret the integration of these technologies as an enabling factor for

more transparent and interoperable educational systems, oriented toward continuous monitoring of learning experiences. Elkhodr et al. (2024) examine the impact of AI–Blockchain integration on the Australian higher education ecosystem, highlighting implications for governance, data authenticity and decision-making support. Studies such as Naidoo (2023) and Rakhimberdiev et al. (2022) focus on e-learning, showing how the convergence of machine learning, predictive models and distributed infrastructures can improve engagement, personalisation and the quality of feedback. Additional contributions, including Madupuri et al. (2025) and Poikaryil et al. (2025), analyse learning analytics through hybrid architectures, while works like Ouf et al. (2025) propose intelligent frameworks for smart learning environments. Overall, this cluster points to a growing convergence toward data-driven educational models that combine reliability, traceability and adaptivity, with significant implications for innovation in higher education systems and online learning platforms.

- A second group of studies, which is rapidly expanding, focuses on digital credentials and micro-credentials. These are usually defined as digital attestations of specific skills acquired through short, modular and verifiable learning pathways, consistent with the conceptual framework proposed by the European Commission (2020, 2022) and with Oliver's (2019) definition of the features and role of micro-credentials in contemporary learning systems. Within the analysed corpus, several contributions examine the joint role of AI and Blockchain in skills certification and in safeguarding the integrity of educational documents. Alsobhi et al. (2023) propose a Blockchain-based micro-credential system for universities, while McGreal (2024) highlights how the integration of AI and Blockchain can strengthen the issuing, sharing and verification of digital certifications. Other studies discuss the operational implications of distributed certification, such as automated recognition of qualifications (Kanavheti et al., 2025) and Blockchain-based document management systems (Chinnasamy et al., 2025). The use of open badges as forms of micro-credential also appears in the corpus (Mainetti et al., 2022). Overall, these contributions identify micro-credentials as a key component for the development of interoperable learning ecosystems oriented toward lifelong learning.
- A third cluster concerns adaptive learning and intelligent tutoring systems, represented by a significant set of contributions. These works explore educational solutions in which artificial intelligence analyses student interactions in real time and generates personalised learning paths, while Blockchain ensures transparency, verifiability and traceability of algorithmic decisions. Kumar et al. (2025) propose an adaptive learning model that integrates machine learning and distributed infrastructures to personalise content and ensure the coherence of learning data. A similar perspective emerges in Cha (2025), who develops an intelligent framework for nursing education based on AI monitoring and Blockchain-based certification. Jamsheed and Suhailam (2025) also discuss how the convergence of AI and Blockchain can support advanced forms of personalisation by improving the transparency of evaluation criteria and the quality of automated feedback. Overall, these contributions show that personalisation is no longer only an adaptive process but also an auditable one: the decisions made by intelligent systems can be reconstructed, verified and validated within distributed

infrastructures, strengthening the reliability and integrity of the learning experience.

- Another group of studies addresses traceability, authenticity and the management of educational resources, with a focus on the creation, sharing and validation of digital content. In this domain, Blockchain is used to guarantee the integrity and immutability of materials, while artificial intelligence supports classification, organisation and quality control. Ako-Nai et al. (2021) present a platform for producing educational content supported by AI and Blockchain, designed to improve transparency and traceability in authoring and distribution processes. Liao (2023) examines secure data-sharing mechanisms through Blockchain within hybrid teaching models. Dziatkovskii (2023) explores the combined use of AI and Blockchain for reviewing and checking the integrity of textbooks, showing how technology can support the monitoring of material reliability. Overall, these contributions suggest that the management of educational resources is evolving toward more transparent and verifiable digital ecosystems, where educational provenance becomes essential to ensure quality, trust and reusability of content.
- A fifth cluster, which cuts across the others, concerns governance, privacy and trust in digital education systems. Several studies address issues related to data security, certification integrity and transparency in AI-based decision-making processes. Haney and Egeghy (2024) show how the integration of cryptographic techniques, AI and Blockchain can support the protection of sensitive data. Wiputra et al. (2024) analyse the role of Blockchain in ensuring certificate integrity and preventing document fraud. Algorithmic transparency emerges in the work of Krishnan and Surendran (2024), who use an XAI model to make Blockchain-based assessment processes interpretable. Overall, these studies emphasise that the development of intelligent educational systems requires responsibility, traceability and trust, in line with the European regulatory framework (GDPR, AI Act).
- Another cluster focuses on smart contracts and the automation of educational processes. The contributions included show how AI–Blockchain integration can support automated management of educational procedures, from certificate verification to the organisation of learning pathways. Kim (2022) analyses the use of smart contracts to prevent certificate falsification through AI-based consensus mechanisms. Marshoud et al. (2025) explore a decentralised solution for university admissions, where validation and control functions are automated through distributed protocols. A similar approach appears in Garg et al. (2024), who employ AI and Blockchain to optimise student application management. Overall, these works suggest that distributed automation can improve efficiency, transparency and traceability in educational processes.
- Another cluster focuses on digital identity models and Decentralized Identity (DID) solutions, a rapidly expanding area in educational systems. Jahankhani et al. (2023) analyse the use of self-sovereign identity in higher education, showing how Blockchain can support secure and user-controlled identification practices. Nguyen-Hoang et al. (2024) propose an advanced platform integrating privacy-preserving identity models and AI-based recommendation systems, showing how these technologies can reinforce trust, security and interoperability. These

contributions converge in suggesting that identity management will become central to the circulation of competences and the digital mobility of students.

- Finally, a last cluster concerns the Metaverse and immersive environments, a still limited but growing area. Several studies explore the integration of AI and Blockchain in the development of traceable and customisable virtual learning spaces. Uddin et al. (2024) provide a systematic analysis of the convergence between the Metaverse, artificial intelligence and distributed technologies, highlighting their potential for immersive educational scenarios. Mozumder et al. (2023) propose a technological roadmap combining IoT, AI and Blockchain to design secure and interoperable virtual learning environments. Overall, these studies indicate that the Metaverse is emerging as a domain in which AI and Blockchain support the development of more adaptive, verifiable and modular educational experiences.

3.3. Educational contexts and associated technologies

Almost all the examined contributions are situated in higher education and professional training, while studies focusing on the K–12 school system remain limited. This confirms a trend already observed in other review studies (Zawacki-Richter et al., 2020), which indicate that universities and lifelong learning organisations serve as the main testing ground for emerging technologies.

From a technological standpoint, the corpus highlights a predominant use of machine learning models, recommendation systems and predictive analytics, while references to Blockchain mostly concern smart contracts, verifiable credentials and, to a lesser extent, architectures based on Decentralized Identity.

Semantic analysis shows considerable terminological heterogeneity: the terms "AI", "machine learning" and "deep learning" are often used interchangeably, and the types of Blockchain are rarely specified. This suggests that the field is still in a phase of linguistic and conceptual definition.

3.4. Focus on the Italian context

Within the analysed corpus, references to the Italian context are limited but present. The only contribution explicitly linked to Italian institutions is Mainetti et al. (2022), who propose a Blockchain- and open badge–based model to improve the student experience in higher education. This work reflects a pedagogical perspective oriented toward transparency, traceability and student centrality—topics that also recur in Italian educational debates.

The absence of additional Italian studies in the indexed literature suggests that the field is still at an early stage nationally. However, this gap represents an opportunity for future research that can integrate ethical and pedagogical perspectives with emerging technical dimensions, in line with European guidelines on digital education (European Commission, 2021).

3.5. Summary of findings

Overall, the review depicts a research field that is dynamic but still developing, marked by quantitative growth and increasing methodological alignment.

Three main directions summarise the findings:

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• the transformation of educational processes through adaptive and immersive environments;
• the digitalisation of institutional processes through verifiable credentials and Identity systems;
• the redefinition of ethical and governance dimensions in intelligent educational systems.

The corpus points to AI–Blockchain integration as a convergence that supports rethinking trust, transparency and assessment within learning processes.

This exploratory mapping, based on Google Scholar data, represents the first step toward a more detailed qualitative synthesis, which will be developed in the next phase of the project through full-text analysis and integration with the Scopus and Web of Science databases.

4. Discussion

4.1. Evolution of the field and maturation of paradigms

The analysis of the 103 included contributions shows a gradual maturation of research on the integration of Artificial Intelligence and Blockchain in education. Publications from 2018 to 2020 open the field by outlining the potential of distributed technologies for competence tracking and secure data management, as illustrated by the early models proposed by Chen et al. (2018) and by the pioneering analyses of Jekov et al. (2018) and Ocheja et al. (2022).

From 2021 onwards, the literature takes on a more design-oriented direction. Experimental architectures and operational applications appear in studies such as Elkhodr et al. (2024), which examine the integrated adoption of AI and Blockchain in higher education, and Uddin et al. (2024), who systematise the technological paradigms linked to immersive environments. Contributions focusing on micro-credentials and open badges also gain prominence, as in Alsobhi et al. (2023) and Mainetti et al. (2022), offering insights into interoperability and distributed certification.

This evolution aligns with the broader transformation of the infosphere described by Floridi (2014, 2019), where cognitive processes unfold within increasingly integrated informational environments. The integration of AI and Blockchain reflects this dynamic: AI interprets and adapts data, while Blockchain provides distributed memory and verifiability. This creates a cognitive ecology in which learning develops through socio-technical networks, consistent with the perspectives of connectivism and networked learning (Siemens, 2005; Garrison & Anderson, 2011).

The theme of trust appears as a recurring element. Studies such as those by Wiputra et al. (2024) and Haney and Egeghy (2024) show how the combination of AI and distributed ledgers supports transparent, traceable and coherent processes in terms of educational data integrity.

Overall, the synergy between AI and Blockchain points to an educational infrastructure model grounded in adaptive processes, verifiability and responsibility, shaping emerging forms of reliable and distributed educational intelligence.

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4.2. The three interpretative directions

a. Educational Processes and Personalisation

The first direction concerns the reorganisation of teaching and learning processes.

The studies analysed show that AI is used to model student profiles, adapt content and generate dynamic feedback through predictive models, as seen in the foundational work of Woolf (2010) and in more recent developments oriented toward advanced personalisation, such as Jamsheed and Suhailam (2025). Blockchain contributes by offering tools for ensuring the integrity and traceability of learning evidence, making it possible to document interactions among students, teachers and systems.

The combination of these technologies turns personalisation into an auditable process, based on verifiable and accessible traces. This perspective aligns with Siemens' (2005) idea of connected learning, where knowledge emerges from networks linking people, content and technologies. In this view, the network becomes self-documenting: each interaction is recorded and certified, making assessment more transparent and replicable. This interpretation echoes the notion of a "digital community of inquiry" described by Garrison and Anderson (2011), where trust is distributed throughout the learning environment.

b. Institutional processes and competence recognition

The second direction concerns institutional processes and the formal management of competences.

The literature shows a consolidated use of Blockchain for creating distributed registers of micro-credentials, open badges and verifiable attestations, as highlighted in the contributions of Chen et al. (2018), Grech and Camilleri (2017), Alsobhi et al. (2023) and Elkhodr et al. (2024). AI supports these processes through the analysis of individual performance and the creation of learning pathways aligned with professional profiles.

These solutions fit within the paradigm of self-sovereign identity (SSI), examined in depth by Jahankhani et al. (2023), where credential management shifts to the individual through personal educational wallets. European institutions recognise the strategic relevance of these technologies: the European Commission (2021) and the OECD (2023) emphasise the role of digital credentials in building integrated and interoperable learning systems. The contributions included converge on the idea that such infrastructures strengthen trust among educational institutions, learners and employers.

c. Ethics, Governance and Sustainability of Intelligent Systems

The third direction concerns ethical and regulatory dimensions. The sources analysed show growing attention to algorithmic transparency, data protection and accountability.

Williamson (2021) and Popenici and Kerr (2017) highlight how the introduction of AI in educational processes reshapes power structures and calls for pedagogical and political reflection on the governance of intelligent systems.

The corpus includes contributions that directly address trust, security and data integrity. Wiputra et al. (2024) show how Blockchain can support reliable and tamper-proof verification procedures; Haney and Egeghy (2024) explore the protection

of educational data through architectures that integrate AI, distributed ledgers and cryptographic techniques; Krishnan and Surendran (2024) examine models of algorithmic transparency applied to assessment systems. These studies resonate with UNESCO's (2021) principles promoting the design of educational AI grounded in equity, inclusion and sustainability.

The convergence between AI and Blockchain suggests the possibility of developing educational infrastructures that are more transparent and participatory, in which every decision generated by intelligent systems can be traced, verified and interpreted.

4.3. A field under construction and evolving toward the qualitative phase

The review shows a rapidly expanding research field, marked by heterogeneity in language and conceptual framing. Many contributions use non-uniform terminology to describe artificial intelligence and its different forms, and the distinction between machine learning, deep learning and generative models is not always made explicit. Blockchain is also sometimes discussed as a general idea, associated with decentralisation or security, without clarifying the specific architectures or protocols involved.

This variety confirms what Zawacki-Richter et al. (2020) observed in the early stages of a new research area: the vocabulary becomes more stable over time through a gradual convergence between theoretical descriptions, experimentation and operational models. The mapping proposed in this review is part of this process of epistemic construction, situated at the intersection of educational technology, educational sciences and ethical reflection.

The Italian contribution, although limited in number, shows a distinct orientation. Studies such as Mainetti et al. (2022) highlight an interest in transparency, traceability and the pedagogical role of distributed technologies. These concerns resonate with the European educational tradition, which values responsibility, participatory governance and the sustainability of learning systems.

This review represents the exploratory phase of the project and provides the conceptual basis for the next step. Extending the search to Scopus and Web of Science will allow for a qualitative analysis of the selected full texts, helping verify the robustness of the identified trends and deepen the theoretical, methodological and applied models emerging from the initial mapping. The aim is to build an interpretative synthesis that connects the most recurring approaches and outlines possible directions for the development of the field.

From this perspective, the corpus analysed on Google Scholar serves as a methodological baseline for a possible configuration of *AI & Blockchain Education Studies*, understood as an interdisciplinary area dedicated to analysing the educational, cognitive and organisational implications of intelligent and distributed technologies.

The growth of the field will require ongoing dialogue among epistemological questions, pedagogical needs and ethical principles, ensuring that innovation remains aligned with an idea of education centred on individuals and learning communities.

5. Practical implications

The implications identified in the review concern educational institutions, research and public governance. These are interconnected dimensions that reflect different aspects of a shared transformation process. The integration of AI and Blockchain reshapes how knowledge is produced, validated and circulated, introducing new

forms of traceability and transparency that influence educational systems, scientific practices and institutional policies.

This convergence positions education as a space of negotiation between human and artificial agents, where responsibility, fairness and verifiability become central. Institutions, researchers and policymakers are therefore called to design innovation models that support learning while ensuring justice and participation.

5.1. Implications for educational institutions

The literature indicates that AI–Blockchain integration affects the organisational culture of educational institutions. A first implication concerns the management of digital credentials. Studies by Grech and Camilleri (2017) and Chen et al. (2018) show that distributed ledgers can guarantee authenticity, verifiability and interoperability, supporting the emergence of transnational educational ecosystems aligned with European initiatives on digital credentials.

These infrastructures support forms of data sovereignty, allowing students to manage their learning portfolios through decentralised systems. A second implication relates to personalised learning. The interaction between AI and Blockchain enables adaptive environments where progress is recorded in a verifiable way, increasing transparency in the behaviour of intelligent systems. Studies inspired by Woolf (2010) show that traceability can support more justified assessment decisions and higher accountability.

A third area concerns immersive learning environments. Uddin et al. (2024) describe how the metaverse, AI and Blockchain can combine to create collaborative learning spaces integrated with digital badges and smart contracts. Institutions adopting such models need to consider the equity principles highlighted by UNESCO (2021) to avoid new forms of digital exclusion.

Digital transformation also requires investment in staff competences and internal organisation. Studies such as Mainetti et al. (2022) show that innovation becomes effective when it is translated into shared teaching practices and transparent governance structures capable of integrating experimentation and reflection.

5.2. Implications for research and the scientific community

From a research perspective, the review highlights the need for stronger epistemological integration between educational sciences, computer science and digital governance studies. The terminological fragmentation observed in the corpus confirms what Zawacki-Richter et al. (2020) argue: the maturation of a field depends on building a shared vocabulary and structuring interdisciplinary perspectives.

This work represents a first step toward defining a coherent framework for AI & Blockchain Education Studies, in which learning, trust, transparency and automation are studied as interrelated dimensions. Three directions appear central:

- developing taxonomies that clearly distinguish the different forms of AI and Blockchain;
- strengthening empirical evidence through longitudinal studies;
- creating theoretical models able to integrate technical complexity with pedagogical perspectives.

Italian research can contribute through its reflective tradition and attention to the ethical dimension of educational innovation, promoting approaches centred on the learner and the educational context.

5.3. Implications for educational policy and governance

Intelligent and distributed technologies introduce new governance needs for education systems. Documents such as UNESCO's Recommendation on the Ethics of Artificial Intelligence (2021) and the European Commission's Digital Education Action Plan 2021–2027 stress the importance of regulation based on transparency, fairness and participation.

Blockchain can support this vision by offering verifiable infrastructures for credential management, process traceability and data protection. In the Italian context, opportunities linked to the PNRR make it possible to experiment with governance models that combine digital innovation and democratic values. Mainetti et al. (2022) show how transparency and distributed certification can strengthen trust in educational processes.

As Williamson (2021) notes, the digitalisation of education is increasingly a matter of public policy. The integration of AI and Blockchain can support more transparent forms of algorithmic governance, provided it is accompanied by clear regulatory frameworks and adequate ethical competence among education professionals.

6. Conclusions

The systematic review conducted on Google Scholar for the period 2018–2025 provides a structured overview of how research on the integration of Artificial Intelligence and Blockchain in educational contexts has evolved. Applying the PRISMA model made it possible to select 103 relevant contributions, showing a growing body of work and increasing methodological consistency.

Three main indications emerge from the review.

The first concerns the evolution of the field. The interaction between AI and Blockchain is examined as part of a digital ecosystem that reshapes learning processes through adaptive capacities, traceability of evidence and new forms of data management. The applications described in the included studies—such as immersive systems presented by Uddin et al. (2024), distributed certification platforms analysed by Alsobhi et al. (2023) and design models proposed by Mainetti et al. (2022)—illustrate a transformation that affects both technical infrastructures and educational practices.

The second indication concerns the theoretical maturation of the sector. Recent studies show increased attention to the ethical and social implications of intelligent technologies. Reflections such as Williamson's (2021) work on algorithmic governance and Floridi's (2014, 2019) analyses of the infosphere help interpret AI–Blockchain integration as a process that reshapes trust, knowledge management and the relationship between automated decision-making and educational responsibility. The corpus also shows an increasingly explicit connection with the principles of equity and inclusion promoted by UNESCO (2021).

The third indication concerns operational implications. The selected contributions show how AI and Blockchain can support more transparent assessment practices, strengthen credential interoperability and expand opportunities for personalised learning. The adoption of these technologies requires specific skills, ethical awareness and appropriate governance models. The documented experiences highlight the need to accompany technical innovation with training processes for teachers, students and institutional decision-makers.

This first phase of the project, exploratory and descriptive in nature, provides the methodological basis for the future qualitative synthesis. Phase 2 will extend the PRISMA protocol to the Scopus and Web of Science databases, with the aim of verifying the robustness of the trends identified and analysing the full texts in depth through their methodologies and empirical results. In parallel, bibliometric networks and co-citation patterns will be examined to identify the authors and institutions shaping the field at the international level.

In the medium term, the goal is to build an integrated framework that links educational dimensions, technological architectures and ethical–political reflection. This framework will support the development of AI & Blockchain Education Studies and contribute to designing educational systems that are transparent, reliable and supportive of learning communities.

Overall, the evidence collected indicates that the integration of AI and Blockchain concerns not only process efficiency but the transformation of how knowledge is produced, validated and shared. Education becomes a space where human and artificial agents cooperate in knowledge construction, and where trust is based on verifiable and shared practices. Artificial intelligence provides analytical and adaptive capabilities, while Blockchain ensures authenticity and traceability. Their convergence opens the possibility for a more transparent, inclusive and responsible form of education supported by an informed ethical and pedagogical vision.

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