A Survey on Role of AI, IoT and Blockchain in Education

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Abstract : The digitization of education is driving interest in AI, IoT, and blockchain for intelligent, connected, and trustworthy learning. AI supports personalization, feedback, analytics, and administration; IoT connects classrooms and campuses to collect contextual data; blockchain enables verifiable credentials and secure records. This survey reviews research across learning and assessment, smart-campus infrastructure, academic credentials, and governance. It finds the strongest potential in combining AI insights, IoT context, and blockchain-based verification. Major barriers include privacy, cybersecurity, bias, interoperability, cost, digital inequality, resource demands, and limited evidence of long-term learning impact.
The paper presents the AI, IOT and Blockchain in Education, related work and literature survey, Role of IOT, AI And Blockchain in Education, comparative analysis of AI, IOT and Blockchain technology and Challenges and Limitations.

Keywords **- Digitization AI, IoT, Blockchain, Intelligent, Verification, Cybersecurity, Interoperability.**

1. INTRODUCTION

Education systems increasingly rely on digital platforms, connected devices, and data-driven services. Learning management systems, online assessments, virtual laboratories, and student information systems generate large volumes of data that can improve teaching practices, student support, and institutional operations. However, digital education continues to face persistent challenges, including standardized one-size-fits-all instruction, delayed feedback, fragmented academic records, limited visibility into physical learning spaces, credential fraud, and concerns over data protection [1-4]

Artificial intelligence (AI), the Internet of Things (IoT), and blockchain address different but complementary aspects of these challenges. AI can identify patterns in educational data and support personalized learning experiences. IoT sensors and connected devices can capture information on classroom occupancy, equipment use, environmental conditions, and hands-on learning activities. Blockchain can create shared, tamper-evident records for credentials and selected educational transactions. Together, these technologies may enable smart education ecosystems in which sensing, analysis, and verification operate in an integrated manner1-6].

This paper surveys the educational roles of AI, IoT, and blockchain, as well as their combined potential. It makes main contributions: (1) it summarizes major role of AI, IoT, and blockchain in education; (2) it compares their benefits and implementation challenges; and (3) it identifies research priorities for responsible and inclusive adoption.

2. RELATED WORK AND LITERATURE SURVEY.

Garzón, J et.al [1] review analyzed 155 studies (2015–2025), highlighting AI's benefits in personalized learning, academic performance, and student motivation, alongside challenges such as ethical use, teacher resistance, and digital dependency.

Andreia de Bem Machado et.al [2] scoping review examines how blockchain and AI can be applied in higher education. The findings show that smart contracts can promote student collaboration, improve data reliability, and automate academic processes, helping prepare learners for sustainable and collaborative problem-solving.

H. Crompton et.al [3] systematic review analyzed 138 articles (2016–2022) on AI in higher education using PRISMA. It identified five applications: assessment, prediction, AI assistants, intelligent tutoring, and student learning management. Research increased significantly in 2021–2022, with language learning and undergraduate students receiving the most attention. The review also highlighted research gaps and future opportunities, including ChatGPT.

T. K. F. Chiu et.al. [4] systematic review analyzed AI in education (2012–2021), identifying 13 AI roles, seven learning outcomes, and ten key challenges across learning, teaching, assessment, and administration.

P. Abichandani et al. [5] rapidly growing Internet of Things (IoT) creates opportunities for innovations that impact daily life, while requiring schools to teach relevant IoT skills. This systematic review analyzed 60 studies on IoT curricula, teaching methods, technologies, and assessments for K-12 and university students. It identifies best practices and actionable strategies—including low-cost hardware, open-source software, active learning, and direct/indirect assessment—to guide effective IoT education.

P. Ocheja et.al. [6] Blockchain has enabled decentralized applications across many fields, including education. This study uses bibliometric and qualitative analysis to examine blockchain in education, identifying key actors, adoption trends, emerging themes, and case studies. It finds that although blockchain is about 13 years old, its educational use became prominent only 5 years ago, mainly for verifying certificates and transcripts. Few studies address deeper academic data—such as learning behavior, content, and assessments—or interoperability among diverse institutions. The paper discusses implications, potential solutions, and future research directions to improve educational outcomes.

S. T. Siddiqui et.al. [7] IoT and blockchain are two rapidly growing technologies with major potential in education. IoT connects devices, software, and wearables to share data, while blockchain provides secure, decentralized, and tamper-resistant recordkeeping.

Richa Bhatia et.al [8] Blockchain, initially developed for Bitcoin, is widely applied across sectors, including education. Distributed ledger technology can improve transparency, accountability, and efficiency in education. This study examines factors influencing educational institutions and learners' intentions to adopt blockchain technology.

Faiza Loukil et.al. [9] Blockchain is increasingly used in education due to its security, decentralization, and transparency. This systematic review examines its educational applications, benefits, adoption challenges, and future research opportunities.

S. Ida Evangeline [10] AI, blockchain, and IoT enhance mobile language learning through personalized instruction, real-time feedback, secure credentials, and interactive smart learning environments.

Rajesh Kumar Kashyap et.al. [11] chapter examines blockchain in education, focusing on data security, digital identity, decentralized data sharing, adoption challenges, and its role in transforming online learning, particularly after COVID-19. Blockchain in Higher Education.

C. V. Mahamuni [12] IoT connects physical devices to the internet, enabling smart applications through sensors, data analytics, AI, and cloud computing. Emerging technologies such as blockchain, 5G, and edge computing enhance IoT in Industry 4.0, smart cities, and autonomous vehicles. This paper reviews recent IoT applications, technological advancements, and key challenges.

OECD's Digital Education Report 2021 [13] When used together in a coordinated way, AI, robotics, and blockchain can transform digital education—from schools to universities. AI can personalize learning and provide real-time feedback; robotics can support teachers with routine tasks and interactive learning; and blockchain can securely manage and verify academic records and credentials. Their success depends on teacher training and keeping humans central to the learning process.

Samala, A. D et.al.[14] This systematic review analyzes blockchain applications in education using Scopus publications (2018–2022) and bibliometric analysis in R Studio. Blockchain can improve data security, credential verification, transparency, and accountability. However, adoption barriers, technical expertise, privacy, security, and standardization remain key challenges.

Sarah Alhabeeb et.al [15] Technology is increasingly shaping education, with machine learning and blockchain playing major roles. This study reviews their applications, benefits, and challenges in educational institutions. It highlights their potential to improve educational processes and student achievement while guiding researchers and practitioners toward broader applications and solutions.

Youyang Qu et. al [16] Federated learning (FL) enables devices to train a shared model by exchanging updates rather than raw data, reducing privacy risks. However, centralized FL faces bottlenecks, data falsification, and weak incentives. Blockchain-enabled FL addresses these issues and is gaining attention in academia and industry. This survey reviews existing blockchain-enabled FL approaches, identifies key challenges, and suggests future research directions.

Afzal Badshah et. al [17] IoT, AI, and 5G are enabling the shift toward smart education, improving learner engagement, motivation, attendance, and deep learning. Traditional education faces challenges in administration, pedagogy, assessment, and supervision—issues intensified by COVID-19. This study reviews smart solutions such as smart pedagogy, assessment, classrooms, and administration, while highlighting technical and social challenges. It offers new directions for integrating ICT, IoT, and AI into education.

Tanweer Alam et.al [18] proposed a blockchain-based IoT architecture for education to improve secure communication over 5G networks. It integrates blockchain with IoT to create a secure, efficient platform connecting students, teachers, employers, developers, facilitators, and accreditors. The framework aims to enhance interaction and data security in smart education systems.

Obaidat, M.A et.al [19] provide the survey that examines the integration of blockchain with IoT, focusing on architecture, applications, security, scalability, and latency. It provides a taxonomy of IoT security concerns, analyzes integration methods, and explores consensus mechanisms for resource-constrained environments. The study also highlights emerging trends such as AI-driven blockchain, offering a foundation for secure and scalable IoT applications.

Iis Kurnia Nuryahati et.al [20] provides the bibliometric study that analyzes 134 articles from Web of Science and Scopus to examine blockchain research in education. It identifies key themes, influential publications, and collaboration networks, focusing on credential verification, academic records, and decentralized learning. The findings show growing interest in blockchain's

educational applications and provide a roadmap for future research, while noting limitations such as data bias and lack of temporal analysis.

Srinivas KOPPU et.al [21] Blockchain is increasingly used with IoT to address security challenges, though scalability remains a major issue. Integrating AI into blockchain-IoT frameworks can improve efficiency and create smarter information systems. This survey reviews AI, IoT, and blockchain integration, highlights industrial use cases, and discusses key challenges.

Elkhodr, M et.al [22] presented the reviews 25 recent papers on blockchain and AI in Australian higher education, focusing on credential verification, administrative efficiency, and academic integrity. It finds blockchain can improve credential management, integrity, and funding, but faces challenges in regulation, security, implementation, and environmental impact. Successful adoption requires strong infrastructure, staff training, regulatory alignment, and AI integration. Overall, blockchain combined with AI could enhance the integrity, efficiency, and global competitiveness of Australian higher education.

Ishteyaaq Ahmad et.al [23] presented the study explores how Industry 4.0 technologies, including AI, IoT, blockchain, robotics, and virtual reality, can create personalized, inclusive, and flexible learning environments that address diverse student needs and improve educational outcomes.

Manoj Kumar Dash et.al [24] Blockchain technology is gaining attention for its transparency, security, and data reliability. This study systematically reviews its applications, benefits, challenges, and future implementation in the government education sector.

Dziatkovskii Anton [25] Blockchain-based e-governance improves transparency, automation, document management, and online services in education, healthcare, and environmental management. In education, information serves as the foundation for knowledge, which develops through learning, critical thinking, research, and digital skills. Blockchain can support secure and transparent educational information management.

Ricardo Carre ˜no Aguilera et.al [26] Integrating IoT, AI, and blockchain through SSIoTX enables personalized, accessible, and intelligent education. These technologies support real-time learning monitoring, adaptive content, and inclusive classrooms for students with disabilities.

Jeremiah Greg [27] AI, blockchain, and IoT enable secure, transparent, and personalized smart education through adaptive learning, reliable academic records, real-time monitoring, and intelligent campus management. This study examines their benefits, challenges, and future applications.

Xianxian Wang et.al. [28] This systematic review analyzes 64 studies (2016–2023) on blockchain in education, examining its applications, projects, benefits, adoption challenges, and future research directions. Blockchain enhances academic record security, credential verification, transparency, and fraud prevention.

Rafi Muhammad et.al. [29] focused on A Systematic Literature Review and Design, in research mainly developed on the Smart Campus Architecture for a Teaching-Focused University.

Bond M. et.al.[30] Artificial Intelligence in Education (AIEd) has a long research history, but recent AI developments have made it a major public topic. This first comprehensive meta-review examines AI in higher education (AIHEd) by synthesizing 66 secondary studies published in English between 2018 and July 2023. Most were systematic reviews, often conducted by North American teams. The research mainly focused on AIHEd broadly or on profiling and prediction, with adaptive systems and personalization being the most common applications. The review highlights gaps in ethics, methodology, and context, and calls for more interdisciplinary research to strengthen future AIHEd studies.

3. ROLE OF IOT, AI AND BLOCKCHAIN IN EDUCATION

3.1 ROLE OF IOT IN EDUCATION

3.1.1 Smart Classrooms and Campuses

IoT connects devices and sensors to enable smart campus management, safety, energy efficiency, remote laboratory access, and hands-on STEM learning through real-world data. IoT devices including smartboards, environmental sensors, and automated attendance systems create a responsive, interactive, and data-enabled learning environment. These connected tools support real-time collaboration, digital content delivery, and more efficient classroom management. [1-6,27, 29].

3.1.2 IOT Supported Learning

IoT provides real-time learning and environmental data, enabling AI-based analysis, anomaly detection, predictive maintenance, and personalized learning activities [1-6,27,29]

3.1.3 Real-Time Monitoring

IoT systems capture data on attendance, participation, movement, and engagement patterns as learning takes place. This allows instructors to identify when students may be disengaged and adjust their teaching strategies immediately [27,29].

3.1.4 Environmental Optimization

Environmental sensors continuously monitor classroom conditions such as temperature, humidity, lighting, air quality, and noise levels. The resulting data can trigger automated adjustments to ventilation, lighting, or climate control, helping maintain comfortable conditions that support focus and learning [27,29].

3.2 ROLE OF ARTIFICIAL INTELLIGENCE IN EDUCATION

3.2.1 AI Applications in Education

AI in education includes machine learning, natural language processing, recommendation systems, intelligent tutoring, generative AI, and predictive analytics. It can personalize learning, provide conversational support, automate feedback, identify students needing help, and assist teachers with materials and class-level insights [1-6,30]. However, AI should support—not replace—teacher judgment. Generated content and automated scores must be validated because AI can make errors, reflect training-data bias, and perform unevenly across languages and learner groups [1-6,30].

3.2.1.1 Personalized Learning

AI algorithms analyze students' learning behaviour, performance data, and preferences to create individualized learning pathways. Tools such as adaptive quizzes, intelligent tutoring systems, and content recommendations adjust the pace, difficulty, and type of material to optimize learning outcomes [27].

3.2.1.2 Learning Analytics

Predictive models assess engagement and performance trends to identify students at risk of falling behind or dropping out, as well as gaps in understanding. These insights enable educators to intervene early with targeted academic and pastoral support [27].

3.2.1.3 Enhanced Decision-Making

By analyzing large educational datasets, AI provides educators and administrators with actionable insights into student progress, instructional effectiveness, and institutional performance. This supports evidence-based pedagogical strategies and more informed decision-making [27].

3.2.1.4 Administrative Automation

AI streamlines routine administrative tasks, including grading, attendance tracking, scheduling, and record management. This reduces manual workload and human error, freeing educators to focus more on teaching and student support [27].

3.2.2 AI Benefits and Limitations in Education

AI in education can provide timely feedback, scalable support, early identification of learning difficulties, and more efficient administration. Its effectiveness depends on data quality, model validity, pedagogical design, and context [1-6,30]

Overreliance on predictive scores can unfairly label students, and opaque systems can make decisions hard to challenge. Educational AI should be judged by learning outcomes, accessibility, teacher workload, and learner experience not technical accuracy alone [1-6,30].

3.2.3 Responsible AI Use

Institutions should disclose AI use, set clear coursework rules, protect student data, and require human review for high-impact decisions. Teachers and students need AI literacy to verify outputs, recognize uncertainty, cite AI assistance, and avoid entering confidential information into unapproved tools [1-6,30].

3.3 ROLE OF BLOCKCHAIN IN EDUCATION

3.3.1 BLOCKCHAIN APPLICATIONS IN EDUCATION

Blockchain enables secure verification of academic credentials, micro-credentials, and administrative records. Smart contracts automate workflows and improve credential portability, but data accuracy and identity verification remain essential [1-6, 24-28].

3.3.1.1 Secure Academic Credentialing

Blockchain makes degrees, diplomas, certificates, and transcripts tamper-resistant by recording verifiable credentials on a decentralized ledger. This allows students to share authenticated qualifications with institutions and employers worldwide without relying on intermediaries [27].

3.3.1.2 Smart Contracts for Certification

Smart contracts can automatically issue certifications once predefined requirements—such as course completion or assessment results are met. This automation reduces manual processing, delays, and administrative bureaucracy [27].

3.3.1.3 Decentralized Data Management

Blockchain gives students greater control over their educational data. They can selectively grant institutions or employers access to specific credentials while retaining ownership of their records [27].

3.3.1.4 Fraud Prevention

Academic records are cryptographically secured and stored across a distributed network, blockchain prevents unauthorized alterations and counterfeiting of documents. Any change to a credential would alter its cryptographic hash, making tampering immediately detectable [27].

3.3.2 BLOCKCHAIN Privacy and Governance

Blockchain education systems should protect student privacy by storing proofs rather than personal data on-chain, with secure access controls, clear governance, and appropriate permissioned networks [1-6, 24-28].

4. COMPARATIVE ANALYSIS OF AI, IOT, AND BLOCKCHAIN IN EDUCATION

Sr. No	Technology	Role	Educational Applications	Key Risks
1	AI	Analysis and personalization	Tutoring, feedback, prediction, content generation	Bias, inaccurate outputs, privacy risks
2	IoT	Sensing and connectivity	Smart classrooms, laboratories, campus management	Security breaches, surveillance, maintenance
3	Blockchain	Verification and transparency	Digital credentials, achievement records, audit trails	Privacy, cost, interoperability, key loss

Table1. Comparative analysis of AI, IOT and BLOCKCHAIN Technology in Education [1-10,12,18,19,22,27,29,30]

AI analyzes data, IoT collects real-time information, and blockchain verifies records. Their integration improves education when implemented securely, efficiently, and accessibly [1-6, 24-30].

5. Challenges and Limitations

5.1 Technical Barriers

Integrating blockchain, AI, and IoT requires reliable connectivity, interoperable systems, technical expertise, and substantial computing resources. Inadequate infrastructure and limited digital skills can therefore restrict effective implementation, especially in under-resourced institutions [1-6, 24-30].

5.2 Data Privacy and Security

AI and IoT systems depend on the large-scale collection of personal and behavioural data, creating risks of unauthorized access, misuse, and insufficient informed consent. Strong data-protection measures, encryption, and transparent data-governance practices are essential to safeguard students and educators [1-6, 24-30].

5.3 Cost and Accessibility

High upfront costs for hardware, software, maintenance, and staff training may limit adoption, particularly in low-resource schools and developing regions. Unequal access to technology can also widen existing educational inequalities rather than reduce them [1-6, 24-30].

5.4 Adoption Barriers

Blockchain adoption in education faces integration, cost, standardization, governance, and usability challenges. It is suitable when shared verification offers clear benefits over traditional databases [1-6, 24-30].

5.5 Ethical Considerations

AI-driven decisions can reflect biases present in training data or system design, potentially leading to unfair or discriminatory outcomes. Maintaining human oversight, algorithmic transparency, and regular bias testing is necessary to ensure ethical and accountable use [1-6, 24-30].

5.6 Policy and Regulation

The absence of consistent standards for educational data governance, AI use, and IoT deployment creates uncertainty for institutions and technology providers. Clear policies should address privacy, safety, accountability, bias, and equitable access before these technologies are widely adopted. IoT deployment faces security, privacy, accuracy, and maintenance challenges. Institutions should ensure secure devices, strong authentication, regular updates, minimal data collection, and responsible data use [1-6, 24-30].

6. Conclusion

Artificial Intelligence, Internet of Things, and Blockchain enable personalized learning, connected classrooms, and secure academic records. Their successful integration requires privacy, fairness, security, accessibility, and effective governance. Future research should focus on human-centred systems with measurable educational benefits.

Artificial Intelligence (AI), Blockchain, and the Internet of Things (IoT) are fundamentally transforming education by creating more trustworthy, efficient, and adaptive learning environments. AI strengthens personalization, predictive insights, and administrative efficiency, enabling educators to make informed, data-driven decisions. Blockchain safeguards the integrity, security, and verifiability of academic records, reducing credential fraud while giving students greater control over their qualifications. IoT, meanwhile, enables smart and interconnected classrooms that monitor engagement, optimize learning conditions, and deliver real-time feedback. Together, AI, Blockchain, and IoT offer a strategic pathway toward smarter, more reliable, and globally trusted educational systems capable of meeting the evolving needs of learners, educators, and institutions in the digital age.

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