Artificial Intelligence in E-Learning:

A Systematic Literature Review and Pedagogical Framework

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Abstract:

This study aims to provide a comprehensive Systematic Literature Review (SLR) of Artificial Intelligence (AI) applications in e-learning, alongside the development of a pedagogically grounded framework to support its effective integration. The review systematically analyzes peer-reviewed studies published between 2015 and 2024, categorizing them according to AI techniques, educational contexts, and pedagogical roles. The findings reveal a strong concentration on Machine Learning, Intelligent Tutoring Systems, and Learning Analytics, accompanied by a limited and often implicit alignment with established learning theories and instructional design models. To address this gap, the study proposes an integrative pedagogical framework that systematically links AI capabilities with core educational components, including learners, instructors, instructional strategies, and data-driven feedback mechanisms. The study contributes both a structured synthesis of current research and a theoretically informed, practically applicable model for the design of AI-enhanced e-learning environments.

Keywords: Adaptive Learning, Artificial Intelligence, E-Learning, Instructional Design, Pedagogical Framework, Systematic Literature Review.

المستخلص:

تقدم هذه الدراسة مراجعة أدبيات منهجية (SLR) لتطبيقات الذكاء الاصطناعي في التعلم الإلكتروني، مع اقتراح إطار تربوي لتوظيفه بصورة فعّالة. شملت المراجعة عددًا من الدراسات المحكمة المنشورة خلال الفترة 2015–2024، حيث تم تحليلها من حيث التقنيات المستخدمة، والسياقات التعليمية، والأدوار التربوية. أظهرت النتائج أن أكثر التقنيات استخدامًا هي تعلم الآلة، وأنظمة التدريس الذكية، وتحليلات التعلم، في حين لا يزال الربط الصريح بين تطبيقات الذكاء الاصطناعي ونظريات التعلم والتصميم التعليمي محدودًا. وبناءً على ذلك، تقترح الدراسة إطارًا تربويًا يربط بين قدرات الذكاء الاصطناعي والمتعلمين والمعلمين واستراتيجيات التدريس وآليات التغذية الراجعة المعتمدة على البيانات. تسهم هذه الدراسة في تقديم رؤية منهجية ونموذج عملي لتصميم بيئات تعلم إلكتروني مدعومة بالذكاء الاصطناعي على أسس تربوية واضحة.

الكلمات المفتاحية: إطار تربوي، التعلم الإلكتروني، التعلم التكيفي، الذكاء الاصطناعي، تكنولوجيا التعليم، مراجعة أدبيات منهجية.

1. Introduction

The accelerated digital transformation of education has fundamentally redefined the ways in which teaching and learning are conceptualized, implemented, and assessed. E-learning has progressed from basic content repositories and learning management systems into sophisticated digital ecosystems capable of supporting scalable, flexible, and remote learning experiences. This transformation has been fuelled by advancements in information and communication technologies, wider internet accessibility, and an increasing demand for lifelong and flexible learning models across higher education, professional development, and open online learning environments (Zawacki-Richter et al., 2019).

Despite these developments, traditional e-learning systems continue to face well-established limitations. Many platforms depend on static content delivery, standardized instructional pathways, and limited forms of interaction, which fail to adequately accommodate learner diversity, prior knowledge, motivation, and cognitive variability. Additionally, assessment approaches are often summative and delayed, while feedback mechanisms lack both personalization and pedagogical depth. Consequently, conventional e-learning environments frequently struggle to foster meaningful engagement, support adaptive learning, and ensure sustained learner success (Holmes et al., 2022).

In addressing these challenges, Artificial Intelligence has emerged as a key transformative force in digital education. AI technologies—including machine learning, natural language processing, intelligent tutoring systems, and learning analytics—offer significant potential to tailor learning experiences, automate feedback processes, predict learner outcomes, and enable data-informed instructional decision-making. When effectively implemented, AI-driven solutions can shift e-learning beyond mere content delivery toward adaptive, learner-centered, and context-aware educational experiences (Luckin et al., 2016).

However, the rapid expansion of AI applications in e-learning has exposed a critical conceptual shortcoming. Current research remains highly fragmented, with many studies prioritizing technical performance, algorithmic precision, or system design, while giving limited attention to pedagogical alignment and educational theory. As a result, AI is frequently incorporated as a supplementary tool rather than as a core element of instructional design. Although the literature reflects a growing number of AI-based solutions, it lacks a cohesive pedagogical framework that systematically links AI capabilities with learning objectives, instructional strategies, and the evolving role of educators (Bond et al., 2023).

This gap underscores the necessity for a comprehensive synthesis of existing research, alongside the development of a pedagogically grounded framework to guide both researchers and practitioners. Conducting a Systematic Literature Review is therefore essential to consolidate current knowledge, identify prevailing trends, reveal research gaps, and establish an evidence-based foundation for conceptual framework development. Building on this synthesis, a pedagogical framework can provide structured guidance for aligning AI technologies with sound educational principles within e-learning contexts.

Accordingly, the objectives of this study are as follows:

1. To systematically review and synthesize existing research on the application of Artificial Intelligence in e-learning environments.
2. To identify key AI techniques and examine their pedagogical roles within digital learning systems.
3. To analyze the primary challenges and gaps related to pedagogical integration in AI-driven e-learning research.
4. To propose a pedagogical framework that aligns AI capabilities with instructional design and established learning theories.

Guided by these objectives, the study addresses the following research questions:

RQ1: Which Artificial Intelligence techniques are most frequently utilized in e-learning, and for what educational purposes?

RQ2: To what extent are pedagogical principles and learning theories incorporated in current AI-based e-learning research?

RQ3: What type of framework can effectively integrate Artificial Intelligence into e-learning in a pedagogically coherent and educationally meaningful way?

By addressing these questions, this study aims to contribute a structured and pedagogically grounded perspective to the expanding body of research on Artificial Intelligence in e-learning.

2. Research Methodology

2.1 Systematic Literature Review (SLR) Design

This research employs a **Systematic Literature Review (SLR)** as its core methodological approach to guarantee rigor, transparency, and replicability in synthesizing prior studies on Artificial Intelligence in e-learning. In contrast to traditional narrative reviews, which tend to be descriptive and selective, an SLR is conducted through a clearly defined and structured protocol that reduces selection bias and supports a comprehensive and systematic aggregation of existing evidence (Kitchenham & Charters, 2007). Considering the rapid expansion and conceptual fragmentation characterizing AI-based e-learning research, the SLR method is particularly appropriate for integrating findings, identifying prevailing research trends, and exposing pedagogical shortcomings across the literature.

The review process is structured into three main phases: **planning, conducting, and reporting**. During the planning phase, the study establishes its research objectives and questions while defining a review protocol that outlines database selection, search procedures, and eligibility criteria. The conducting phase involves systematic searching, screening, and qualitative analysis of the selected studies. Finally, the reporting phase ensures that the review procedures and results are presented transparently and systematically, enabling reproducibility and facilitating future research extensions (Tranfield et al., 2003).

2.2 Data Sources and Search Strategy

To ensure both comprehensive coverage and academic rigor, the literature search was carried out across three major scientific databases: **Scopus, Web of Science, and IEEE Xplore**. These sources were selected due to their extensive inclusion of peer-reviewed journal articles and conference proceedings in the fields of education, computer science, and artificial intelligence.

A systematic search strategy was implemented using combinations of keywords associated with AI and e-learning. Key terms included "Artificial Intelligence," "E-learning," "Online Learning," "Intelligent Tutoring Systems," "Adaptive Learning," and "Learning Analytics." Boolean operators (AND, OR) were utilized to refine search queries and improve relevance. To balance recency with conceptual depth, the review focused on studies published between **2015 and 2024**, a period marked by significant progress in AI technologies and their application within educational contexts.

2.3 Inclusion and Exclusion Criteria

Specific inclusion and exclusion criteria were established to ensure both relevance and academic quality. Studies were included if they:

1. Explicitly examined the application of Artificial Intelligence within e-learning or online learning environments.
2. Were published in peer-reviewed journals or recognized international conference proceedings.
3. Provided empirical evidence, validated system implementations, or theoretically grounded analyses relevant to education.

Conversely, studies were excluded if they:

1. Addressed Artificial Intelligence or e-learning independently without a clear intersection between the two domains.
2. Originated from non-peer-reviewed sources such as opinion pieces, editorials, or technical reports.
3. Fell outside the defined educational scope or lacked sufficient methodological or pedagogical rigor.

2.4 Study Selection Process

The initial search across databases yielded a large volume of publications. After removing duplicate records, titles and abstracts were screened to evaluate their relevance based on the predefined inclusion criteria. Studies that met the initial requirements were then subjected to full-text review to confirm their suitability for inclusion in the final synthesis. This multi-stage selection process enabled a systematic narrowing of the literature, ensuring that only studies closely aligned with the research objectives were retained.

The selection procedure followed principles aligned with the **PRISMA framework**, facilitating transparent documentation of screening and exclusion decisions. Although the selection flow is described narratively in this study, the process ensures clear traceability from the initial dataset to the final corpus of analysed studies, thereby strengthening methodological rigor.

2.5 PRISMA Flow and Study Screening Summary

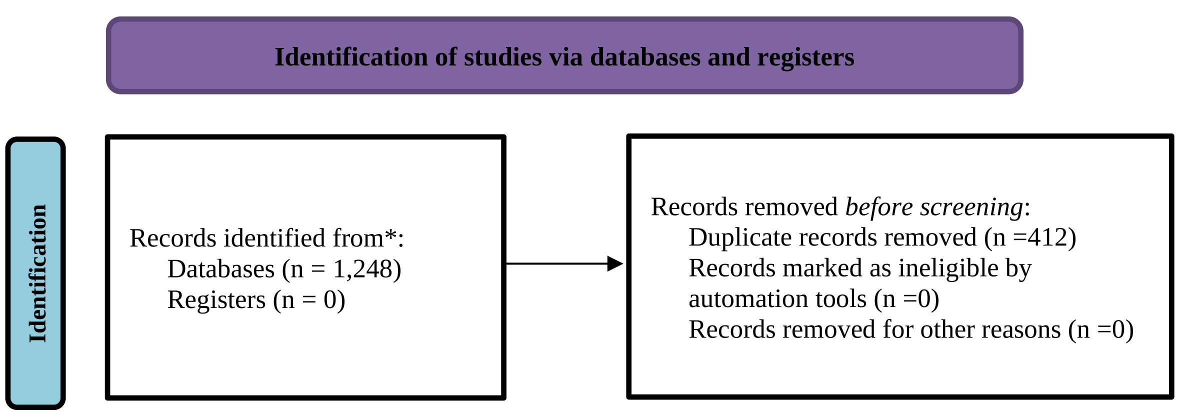
The study selection process was conducted following PRISMA-informed guidelines to ensure transparency, rigor, and reproducibility. The literature search was performed across Scopus, Web of Science, and IEEE Xplore using predefined keyword combinations related to Artificial Intelligence and e-learning, focusing on studies published between 2015 and 2024.

During the identification stage, the initial database search yielded **1,248 records**. After removing duplicate entries, **836 studies** remained for title and abstract screening.

At the screening stage, studies that did not meet the inclusion criteria—such as those lacking a clear intersection between Artificial Intelligence and e-learning, studies outside the educational scope, or non-peer-reviewed publications—were excluded. This resulted in **112 studies** being retained for full-text assessment.

During the eligibility stage, full-text articles were carefully reviewed to evaluate their methodological rigor, relevance, and pedagogical contribution. A total of **67 studies** were excluded due to insufficient methodological detail, lack of educational relevance, or limited alignment with the research objectives.

Consequently, **45 studies** were included in the final qualitative synthesis. This multi-stage selection process ensured a systematic refinement of the literature and provided a robust foundation for analyzing AI techniques, educational applications, and pedagogical integration patterns. The final dataset reflects a balanced and methodologically sound representation of current research in AI-enhanced e-learning.



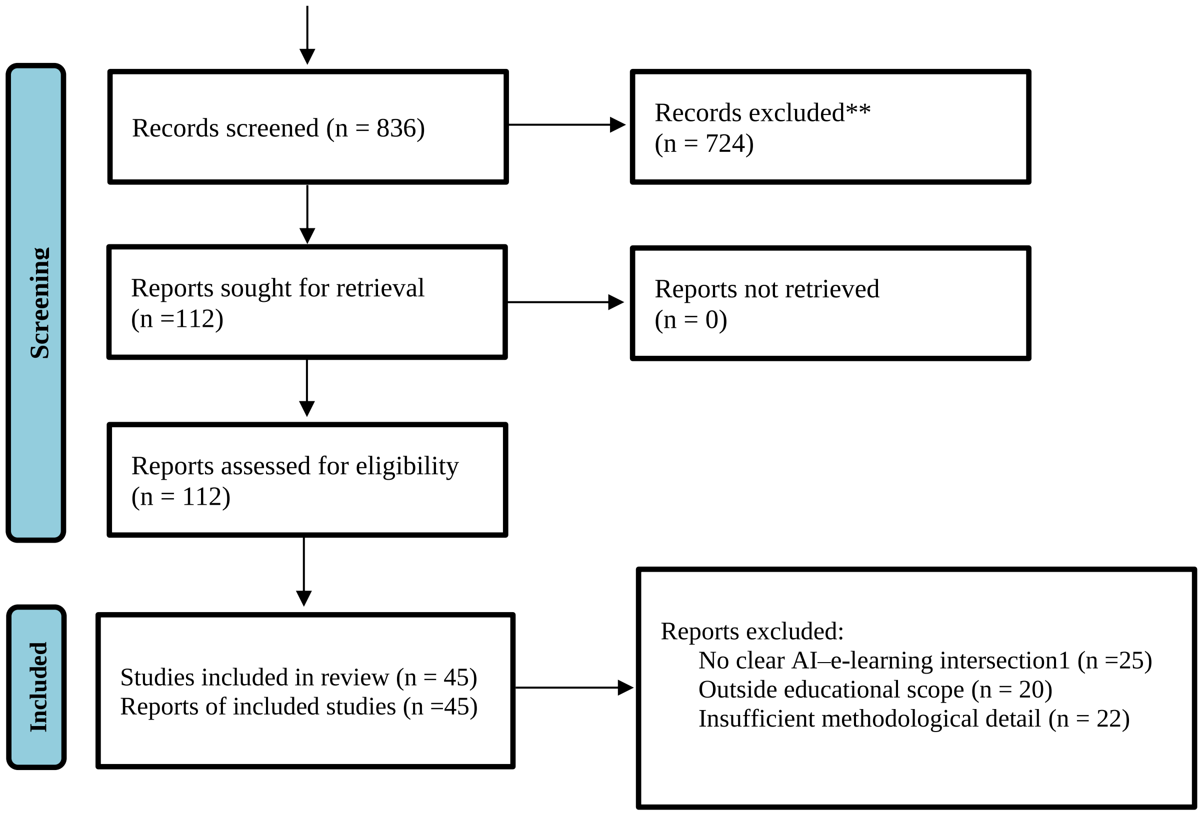


Figure (1). PRISMA flow diagram of the study.

3. Results of the Systematic Literature Review

3.1 AI Techniques Used in E-Learning

The reviewed literature indicates that a relatively consistent range of AI techniques underpins most modern e-learning applications, although their pedagogical integration varies considerably. To provide a clearer quantitative overview of the distribution of AI techniques, the reviewed studies are summarized in Table 1.

Table (1). Distribution of Studies by AI Technique

AI Technique	Number of Studies	Percentage (%)
Machine Learning (ML)	18	40%
Intelligent Tutoring Systems (ITS)	10	22%
Learning Analytics	7	16%
Natural Language Processing (NLP)	5	11%
Recommender Systems	3	7%
Deep Learning (DL)	2	4%
Total	**45**	**100%**

Machine Learning (ML) emerges as the most widely utilized technique, primarily applied for predictive analytics, learner profiling, and performance estimation. ML models are frequently used to detect learning patterns, anticipate dropout risks, and recommend resources based on historical data. Nevertheless, many studies treat ML mainly as a technical optimization tool, with limited consideration of how predictive outcomes inform instructional design or teaching strategies (Zawacki-Richter et al., 2019).

Deep Learning (DL) has become increasingly prominent in recent research, particularly in scenarios involving large datasets, multimodal learning content, and automated evaluation systems. DL approaches are commonly applied in areas such as image recognition, speech processing, and complex behavioural pattern analysis. Despite their advanced capabilities, challenges related to interpretability and pedagogical transparency remain, potentially limiting their practical adoption in educational contexts (Holmes et al., 2022).

Natural Language Processing (NLP) plays a central role in enabling interaction-driven learning environments. Applications include automated essay scoring, conversational agents, discussion analysis, and feedback generation. While NLP enhances scalability and responsiveness, concerns persist regarding language bias, contextual accuracy, and alignment with intended learning outcomes, especially in tasks requiring higher-order thinking (Luckin et al., 2016).

Recommender Systems are extensively used to support personalized learning experiences by adapting content, learning pathways, and resource selection. These systems typically employ collaborative filtering or content-based methods to tailor learning materials according to individual preferences and performance. Although personalization is widely emphasized, relatively few studies explicitly connect recommendation mechanisms with pedagogical frameworks or instructional sequencing models (Bond et al., 2023).

Intelligent Tutoring Systems (ITS) represent one of the most pedagogically grounded applications of AI in e-learning. These systems aim to emulate human tutoring by offering adaptive guidance, feedback, and scaffolding. The literature highlights their strong potential in supporting mastery learning and formative assessment. However, their development is often resource-intensive, and their implementation is generally limited to controlled or domain-specific educational settings (Nkambou et al., 2018).

3.2 Educational Domains

The application of AI in e-learning spans multiple educational domains, each exhibiting distinct priorities and challenges. To complement this analysis, the distribution of studies across educational domains is presented in Table 2.

Table (2). Distribution of Studies by Educational Domain

Educational Domain	Number of Studies	Percentage (%)
Higher Education	22	49%
MOOCs / Open Online Learning	10	22%
K–12 Education	6	13%
Professional Training	4	9%
Mixed / General Contexts	3	7%
Total	**45**	**100%**

Higher Education dominates the literature, reflecting universities' early adoption of digital learning platforms and data-driven decision-making. In this domain, AI is primarily used for learning analytics, student retention, adaptive assessment, and personalized feedback. Nevertheless, studies frequently report a gap between institutional analytics and classroom-level pedagogical practice (Zawacki-Richter et al., 2019).

K–12 education is comparatively less represented, often due to ethical, privacy, and infrastructural constraints. Existing studies focus on adaptive learning systems, early intervention, and intelligent tutoring for foundational skills. The literature emphasizes the need for age-appropriate design and stronger teacher mediation when deploying AI in compulsory education (Holmes et al., 2022).

Professional training and lifelong learning contexts increasingly leverage AI to support competency-based learning, skills tracking, and personalized upskilling pathways. In these settings, AI-driven systems are valued for flexibility and efficiency; however, pedagogical depth is frequently subordinated to performance metrics and completion rates (Bond et al., 2023).

Massive Open Online Courses (MOOCs) represent a distinct domain where AI is primarily employed to address scalability challenges. Learning analytics, automated assessment, and recommender systems are widely used to manage large learner populations. While AI enhances engagement monitoring and resource allocation, the literature consistently reports high dropout rates and limited instructional personalization beyond surface-level adaptation (Khalil & Ebner, 2017).

3.3 Pedagogical Functions of AI

Across domains and techniques, the reviewed studies converge on several core pedagogical functions attributed to AI in e-learning.

Personalization is the most frequently cited function, encompassing individualized content delivery, pacing, and learning pathways. AI enables personalization at scale; however, many implementations equate personalization with content recommendation rather than deeper instructional adaptation grounded in learning theory (Luckin et al., 2016).

Adaptive learning extends personalization by dynamically adjusting instructional strategies based on learner performance and behaviour. While adaptive mechanisms are technically well-supported, the literature reveals inconsistent alignment with pedagogical models such as mastery learning or constructivist approaches (Zawacki-Richter et al., 2019).

Assessment and feedback constitute a major application area, particularly through automated grading and real-time feedback systems. AI-supported assessment enhances efficiency and immediacy, yet concerns persist regarding validity, fairness, and the assessment of higher-order thinking skills (Holmes et al., 2022).

Learning analytics serve as the backbone for many AI-driven e-learning systems, enabling the collection and analysis of learner data to inform predictions and interventions. Despite their potential, several studies note that analytics outputs are often underutilized pedagogically, remaining at the level of dashboards rather than actionable instructional insights (Bond et al., 2023).

Student engagement is increasingly addressed through AI-driven monitoring of behavioral, cognitive, and emotional indicators. While engagement analytics provide valuable signals, the literature highlights the risk of reductive interpretations that overlook contextual and socio-cultural dimensions of learning (Khalil & Ebner, 2017).

To further illustrate the synthesis of the reviewed literature, Table 3 presents a selection of representative and recent studies included in the systematic review. The studies were selected to reflect diversity in AI techniques, educational domains, and pedagogical functions, with particular emphasis on publications from the most recent years. Rather than providing an exhaustive list, the table highlights influential contributions that exemplify prevailing research trends and emerging directions in the application of Artificial Intelligence within e-learning environments.

Table (3). Recent AI Studies in E-Learning

Study (Author, Year)	Focus/ Scope	AI Technique(s)/ Emphasis	Pedagogical/ Educational Domain	Key Insights
Wang (2024)	Systematic analysis of AI in education	ML, DL, adaptive learning	Broad e-learning contexts	Demonstrates significant gains in adaptive learning outcomes and highlights interpretability challenges in DL-based models.
Bond et al. (2024)	Meta review of AI in higher education	AI review synthesis	Higher Education	Synthesizes reviews across multiple databases, identifying pedagogical gaps and research clusters in AIED.
Safi (2024)	Systematic review of AI challenges in HE	Policy, ethics, AI governance	Higher Education	Identifies ethical, transparency, accountability issues alongside educational principles.

Study (Author, Year)	Focus/ Scope	AI Technique(s)/ Emphasis	Pedagogical/ Educational Domain	Key Insights
Feigerlova (2025)	Impact of AI in professional/health professions education	AI assessment & training tools	Professional Training	Focuses on measured educational outcomes in training and assessment.
Garzón (2025)	Systematic review of generative AI trends	Generative AI, personalized learning	Multi-domain e-learning	Reports rising research activity since 2022 and highlights ethical/ pedagogical challenges.
Younas (2025)	Meta-analysis of intelligent learning systems	ChatGPT & GenAI tools	Education industry	Notes rapid adoption of generative tools but calls for long-term empirical evaluation.
Park (2024)	Review of AI's role in blended learning	Learning analytics & pedagogical agents	Blended learning environments	Highlights flexibility and interaction mediation roles of AI.
Alhusaiyan (2025)	Systematic review of AI in language learning	AI tools for language acquisition	Specialized domain (language learning)	Contextualizes teacher intervention and language competence beyond technical AI usage.
Yim (2025)	Systematic review of AI in K-12 AI literacy	AI literacy pedagogies	K–12 education	Reviews pedagogical strategies, assessment, and tools for AI literacy education.

4. Challenges and Research Gaps

Although the body of research on **Artificial Intelligence in e-learning** continues to expand, the findings of this systematic review highlight several enduring challenges and structural deficiencies that constrain both the educational effectiveness and long-term viability of AI-supported learning environments. Importantly, these issues extend beyond purely technical limitations and are strongly associated with pedagogical, ethical, and organizational considerations, indicating the necessity for a more integrated and theory-driven perspective.

A major concern identified across the literature is the **lack of pedagogical alignment**. While numerous studies successfully demonstrate the technical capabilities of AI—particularly in areas such as personalization and predictive modeling—far fewer establish clear connections between these capabilities and recognized learning theories or instructional frameworks. In many cases, AI functionalities are deployed without being grounded in explicit educational objectives, leading to systems that prioritize data optimization over meaningful learning outcomes. This misalignment weakens instructional coherence and limits the overall effectiveness of AI-enhanced e-learning environments (Zawacki-Richter et al., 2019).

In addition, **ethical considerations and data privacy issues** represent a growing and critical challenge. AI-based learning systems depend heavily on the collection and processing of large-scale learner data, raising concerns related to informed consent, data ownership, transparency, and potential algorithmic bias. The review reveals that such ethical dimensions are often addressed superficially or treated as secondary concerns, rather than being embedded within the design and implementation of the systems themselves. This oversight is particularly problematic in educational settings, where learners may be vulnerable and power dynamics necessitate heightened ethical accountability (Holmes et al., 2022).

Another key issue is the **diminishing emphasis on the role of educators** within AI-driven learning contexts. Several studies implicitly position AI systems as replacements for instructional decision-making, focusing on automation and efficiency gains. This perspective risks marginalizing teachers by reducing their role to system supervision, rather than recognizing them as essential contributors to the design, facilitation, and interpretation of learning experiences. The literature provides limited insight into hybrid approaches where AI technologies complement and enhance, rather than substitute, human pedagogical expertise (Luckin et al., 2016).

Furthermore, a strong **technical bias** is evident throughout much of the existing research. Many studies concentrate on improving algorithmic performance, system precision, or computational efficiency, while giving comparatively little attention to educational outcomes, instructional effectiveness, or the learner experience. Although technical performance is undeniably important, this imbalance leads to a fragmented understanding in which the educational value of AI systems is often assumed rather than rigorously validated (Bond et al., 2023).

The review also identifies a notable absence of **instructional design foundations** in the development and assessment of AI-based e-learning systems. A considerable number of studies fail to reference established instructional design models, learning taxonomies, or curriculum frameworks. As a result, many implementations appear ad hoc and lack consistency, making them difficult to generalize, evaluate, or replicate across different contexts. This limitation reduces the practical applicability of research findings for educators and system developers seeking evidence-based solutions (Zawacki-Richter et al., 2019).

Taken together, these findings suggest that advancing AI in e-learning requires a transition from predominantly technology-driven approaches toward models grounded in pedagogical theory and educational practice. Addressing these challenges calls for the development of an integrative framework that explicitly links AI capabilities with instructional principles, ethical considerations, and the evolving role of educators. This necessity provides the foundation for the pedagogical framework introduced in the subsequent section.

5. Proposed Pedagogical Framework

5.1 Framework Rationale

The findings of the systematic literature review indicate that, despite considerable technological advancements, the integration of **Artificial Intelligence (AI)** in e-learning remains predominantly technology-driven rather than pedagogically grounded. A substantial proportion of existing studies emphasizes algorithmic performance, predictive accuracy, and system scalability, while providing limited insight into how AI functionalities can be meaningfully aligned with learning objectives, instructional strategies, and learner development processes. Consequently, AI is often treated as a supplementary enhancement to e-learning platforms, rather than being embedded as a fundamental component of instructional design (Zawacki-Richter et al., 2019; Bond et al., 2023).

In addition, the literature reveals fragmentation at two critical levels. First, AI techniques are frequently examined in isolation, lacking a unifying structure that explains how key elements—such as learners, instructors, data, and pedagogical processes—interact within a cohesive learning ecosystem. Second, the application of pedagogical theories is inconsistent, with many systems implicitly assuming learning effectiveness without explicitly grounding design decisions in established educational frameworks (Luckin et al., 2016). This lack of pedagogical grounding limits the interpretability, transferability, and educational validity of AI-driven e-learning solutions.

To address these shortcomings, this study proposes a pedagogical framework that conceptualizes AI as an enabler of learning rather than an end in itself. The framework is designed to respond to three primary needs identified in the literature:

1. Alignment of AI capabilities with established pedagogical principles and learning theories.
2. Integration of data-driven intelligence into instructional design and decision-making processes.
3. Preservation of the instructor's central role in guiding, interpreting, and contextualizing AI-supported learning experiences.

By explicitly defining the relationships among learners, pedagogical approaches, AI technologies, data, and instructors, the proposed framework seeks to establish a conceptually coherent and practically applicable model for designing AI-enhanced e-learning environments.

Building on the insights derived from the systematic literature review, this study introduces a high-level conceptual pedagogical framework for AI-supported e-learning. The framework synthesizes existing research and systematically integrates instructional design principles, learner-centered pedagogy, AI capabilities, and data-driven feedback mechanisms. It positions the instructor as the central pedagogical authority while framing AI as an adaptive support system guided by clearly defined educational objectives.Figure 1 illustrates the proposed framework and the relationships between its core components.

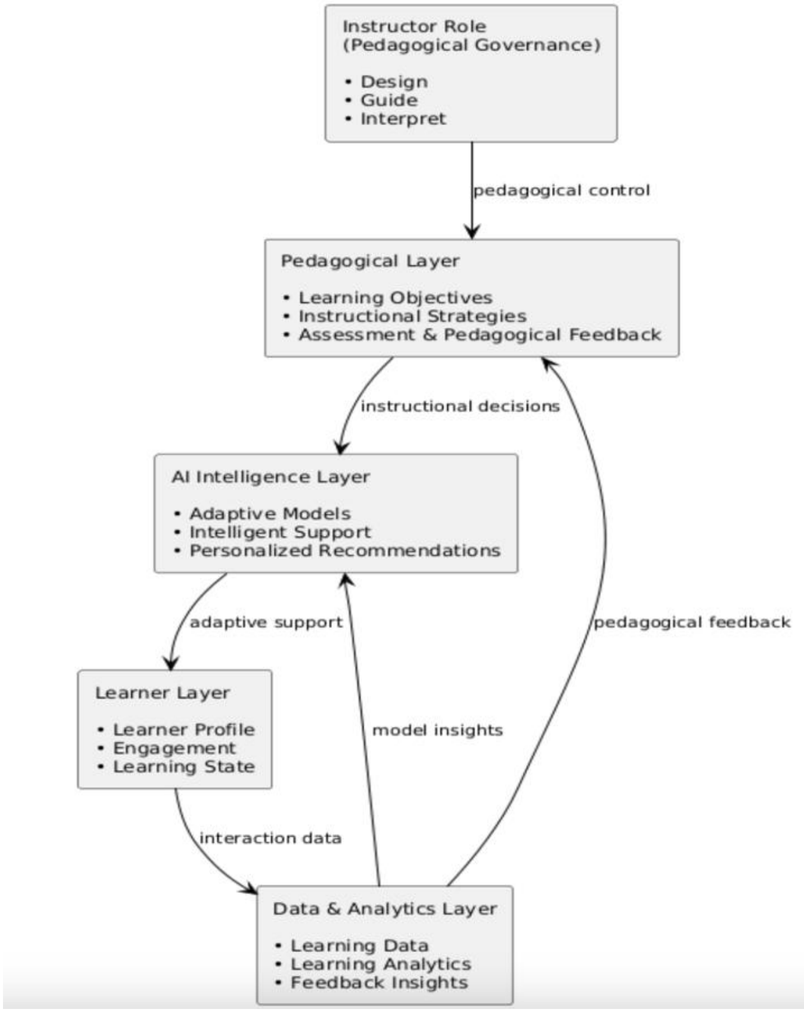


Figure (2). High-level conceptual framework diagram for AI-enhanced e-learning.

5.2 Framework Components

The proposed framework is structured around five interdependent layers, each addressing a critical dimension of the e-learning ecosystem. These layers are not hierarchical in a rigid sense; rather, they operate as a **dynamic and interactive system** in which pedagogical intent governs technological implementation.

1. Learner Layer:

At the core of the framework lies the learner, whose cognitive, behavioral, and affective characteristics shape the learning process. This layer encompasses prior knowledge, learning preferences, motivation, engagement patterns, and contextual constraints. Unlike data-centric models that reduce learners to performance indicators, this framework emphasizes the learner as an active participant whose interactions continuously inform instructional and adaptive processes.

2. Pedagogical Layer:

The pedagogical layer defines the instructional logic of the system. It includes learning objectives, instructional strategies, assessment approaches, and feedback mechanisms grounded in established learning theories. This layer ensures that AI-driven adaptations are pedagogically meaningful, supporting approaches such as constructivist learning, mastery learning, and self-regulated learning rather than merely optimizing content delivery or task completion.

3. AI Layer:

The AI layer operationalizes pedagogical decisions through appropriate artificial intelligence techniques, such as machine learning models for prediction, natural language processing for interaction, recommender systems for personalization, and intelligent tutoring mechanisms for adaptive guidance. Crucially, AI functions in this framework are **subordinate to pedagogical intent**, meaning that algorithm selection and system behavior are driven by educational goals rather than technical convenience.

4. Data and Analytics Layer:

This layer supports continuous feedback and adaptation by collecting and analyzing learner interaction data, performance metrics, and engagement indicators. The framework emphasizes purposeful analytics—data are used to inform instructional decisions, identify learning difficulties, and support timely interventions. Ethical data use, transparency, and interpretability are treated as integral design considerations rather than afterthoughts (Holmes et al., 2022).

5. InstructorRole:

The instructor occupies a cross-cutting role that interacts with all layers of the framework. Rather than being displaced by automation, instructors are positioned as designers of learning experiences, interpreters of analytics, and facilitators of reflective learning. This role includes validating AI-driven recommendations, contextualizing feedback, and ensuring alignment with curricular and institutional goals.

5.3 Framework Contribution

The primary contribution of the proposed framework lies in its explicit integration of **Artificial Intelligence with learning theories and instructional design principles**. By situating AI within a pedagogical architecture, the framework moves beyond technology-centric models and addresses the theoretical and practical gaps identified in the literature.

From a theoretical perspective, the framework supports alignment with multiple learning paradigms. Constructivist principles are reflected in learner-centered adaptation and meaningful interaction, while mastery learning is supported through continuous assessment and targeted feedback. Elements of self-regulated learning are reinforced by analytics-driven insights that encourage reflection and learner autonomy (Luckin et al., 2016).

From a practical standpoint, the framework provides actionable guidance for the design of real-world e-learning systems. Educational designers can use the framework to map learning objectives to AI functionalities, ensuring that technological choices are pedagogically justified. System developers can implement AI components with clearer awareness of instructional requirements, while educators can leverage analytics and adaptive tools without relinquishing pedagogical control.

Overall, the proposed pedagogical framework contributes a structured and theory-informed foundation for the responsible and effective integration of Artificial Intelligence in e-learning. It offers a scalable yet principled approach that supports innovation while maintaining educational integrity, thereby addressing a central gap in current AI-in-education research.

6. Discussion

The quantitative findings presented in Tables X and Y provide clear evidence of current trends in AI-driven e-learning. Machine Learning and Intelligent Tutoring Systems emerge as the most frequently utilized techniques, indicating a strong emphasis on predictive modeling and adaptive instructional support. However, this concentration also reflects a tendency to prioritize technical performance over pedagogically grounded design.

In terms of educational contexts, higher education dominates the reviewed literature, while domains such as K–12 and professional training remain comparatively underrepresented. This imbalance suggests that AI adoption is influenced more by institutional capacity and data availability than by pedagogical diversity across learning environments.

Notably, only **20% of the reviewed studies** explicitly incorporate learning theories or instructional design principles. This finding highlights a persistent gap between technological advancement and pedagogical integration, reinforcing concerns raised in prior research (Zawacki-Richter et al., 2019).

Beyond this imbalance, the findings also reveal three critical dimensions shaping the current landscape of AI in e-learning. First, the increasing reliance on automation raises important questions regarding the role of human agency. While AI systems are frequently used to automate assessment, feedback, and instructional decision-making, limited attention is given to the instructor’s role as a pedagogical facilitator and interpreter. Consistent with previous research, AI appears most effective when it augments rather than replaces human expertise (Luckin et al., 2016).

Second, scalability remains a dominant driver of AI adoption, particularly in large-scale environments such as MOOCs. Although AI enables efficient monitoring and personalization at scale, this often occurs at the expense of instructional depth and contextual sensitivity, echoing concerns regarding superficial personalization (Bond et al., 2023).

Taken together, these findings underscore the need for a more balanced and pedagogically grounded approach to AI integration. The proposed framework directly addresses this gap by aligning AI capabilities with instructional strategies, learner needs, and the central role of the instructor. In doing so, it shifts the focus from purely technical optimization toward meaningful educational outcomes.

7. Implications

This section outlines the implications of the study for key stakeholder groups, drawing directly on the findings of the systematic literature review and the proposed pedagogical framework. Rather than presenting generic recommendations, the implications emphasize **actionable, theory-informed guidance** that bridges research and practice in AI-enhanced e-learning.

7.1 Implications for Educators

For educators, the findings underscore the importance of engaging with AI not merely as an automated support tool, but as a pedagogically situated resource that requires informed instructional judgment. The review indicates that AI-driven systems are most effective when educators actively shape learning objectives, interpret analytics outputs, and contextualize automated feedback within broader instructional goals. This suggests a need for professional development initiatives that focus on **pedagogical AI literacy**, enabling educators to critically evaluate AI recommendations and align them with learning theories and curriculum requirements (Luckin et al., 2016).

Moreover, educators should be positioned as co-designers of AI-supported learning experiences rather than end-users of preconfigured systems. Such involvement can help mitigate the risk of pedagogical misalignment identified in the literature and support more reflective, learner-centered teaching practices.

7.2 Implications for Instructional Designers and System Developers

For instructional designers and system developers, the results highlight the necessity of embedding pedagogical principles at the core of AI-enhanced e-learning system design. The proposed framework provides a structured approach for translating learning objectives and instructional strategies into AI functionalities, ensuring that technological choices are educationally justified rather than opportunistic.

Developers are encouraged to move beyond performance-centric metrics and incorporate design features that support transparency, interpretability, and pedagogical adaptability. This includes designing analytics dashboards that offer actionable instructional insights and creating adaptive mechanisms that respond to pedagogical intent rather than solely to behavioral data. Such alignment can improve system usability, trust, and long-term educational impact (Holmes et al., 2022).

7.3 Implications for Educational Institutions and Policy Makers

At the institutional level, the findings suggest that successful AI integration in e-learning requires coherent strategies that balance innovation with ethical responsibility. Institutions should establish governance frameworks that address data privacy, algorithmic transparency, and accountability, particularly in contexts involving large-scale learner data. Policy makers are encouraged to adopt evidence-based guidelines that support responsible AI use while preserving academic integrity and learner autonomy.

Additionally, investment decisions related to AI in education should be guided by pedagogical value rather than technological novelty. Aligning institutional policies with pedagogically grounded frameworks can help ensure that AI adoption contributes to sustainable educational transformation rather than short-term technical experimentation (Zawacki-Richter et al., 2019).

7.4 Implications for Future Research

For researchers, this study highlights the need for more theory-driven and longitudinal investigations into AI-supported e-learning. Future research should move beyond proof-of-concept implementations and examine how AI influences learning processes, instructional practices, and learner outcomes over time. Empirical studies that explicitly operationalize learning theories within AI-based systems are particularly needed to strengthen the evidence base.

Furthermore, comparative studies across educational domains and cultural contexts can provide deeper insights into how pedagogical frameworks adapt to diverse learning environments. By adopting integrative and pedagogically grounded approaches, future research can contribute to a more coherent and impactful body of knowledge on Artificial Intelligence in e-learning.

8. Conclusion and Future Work

This study examined the role of Artificial Intelligence in e-learning through a Systematic Literature Review combined with the development of a pedagogically grounded framework. By synthesizing recent and influential research, the paper provided a structured understanding of dominant AI techniques, educational domains, and pedagogical functions shaping contemporary e-learning environments. The findings confirm that while AI technologies have reached a high level of technical maturity, their educational impact remains constrained by limited pedagogical integration and inconsistent theoretical grounding.

The primary contribution of this paper lies in shifting the focus from technology-centered implementations toward a **pedagogy-first perspective** on AI in e-learning. Through the proposed pedagogical framework, the study articulated how AI capabilities can be systematically aligned with learning theories, instructional design principles, and the active role of educators. This framework addresses a key gap in the literature by offering a coherent model that integrates learners, pedagogy, AI technologies, data analytics, and instructor agency within a unified educational architecture.

In addition to synthesizing existing knowledge, the paper contributes methodological value by providing an updated and structured overview of recent research trends, including the growing influence of advanced analytics and generative AI in digital learning contexts. By distinguishing between technical value and pedagogical value, the study offers a critical lens for evaluating AI-based e-learning systems beyond algorithmic performance metrics.

Future research should build on this foundation in several directions. First, empirical validation of the proposed framework across diverse educational contexts is needed to examine its practical effectiveness and adaptability. Second, longitudinal studies are required to assess the long-term pedagogical impact of AI-driven interventions on learning outcomes, learner autonomy, and instructional practices. Third, future work should further explore ethical governance models and explainable AI approaches that support transparency and trust in educational settings. Finally, interdisciplinary research integrating educational theory, learning analytics, and human-centered AI design can advance the development of sustainable and pedagogically meaningful e-learning systems.

In conclusion, this study underscores that the transformative potential of Artificial Intelligence in e-learning depends not on technological innovation alone, but on its deliberate integration within pedagogically sound, ethically responsible, and human-centered educational designs.

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