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Artificial Intelligence in Personalised Learning System

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Abstract

The concept of Artificial Intelligence (AI) has already revolutionised personalised learning systems, enabling adaptation to data-driven, learner-centred educational settings. Using machine learning algorithms, natural language processing, learning analytics, and predictive modelling, AI systems can adapt instruction, assessment methods, and feedback processes to individual learner profiles. In this paper, the authors explore how AI can be used in personalised learning, analyse the existing literature, identify the obstacles, and propose an AI-based framework for educational institutions. A systematic review of the literature examines the progress, factors, and constraints of AI-based personalised education systems. Moreover, a conceptual architecture and workflow model are proposed to improve flexibility, interaction, and learning outcomes. The findings reveal substantial improvements in learner performance, engagement, and retention through the effective combination of AI and pedagogical principles, along with ethical data management.

Introduction

The concept of Artificial Intelligence (AI) is transforming the face of education by facilitating responsive and student-centred learning models. AI-driven personalized learning systems are devices that examine behavioral trends, performance, and pattern of engagement to provide learners with personalized learning experiences. So, in contrast to the conventional one-size-fits-all learning strategies, AI-based systems constantly optimize the course of learning by processing real-time data and forecasting.

The recent systematic reviews emphasize that the use of AI helps to increase the efficiency of learning, involvement, and accuracy of evaluation at any educational level (Farhood et al., 2025; Hardaker and Glenn, 2025). The fast maturation of digital platforms and learning analytics has compounded the ability of AI to be able to personalize learning content at scale (Li and Wong, 2023).

Background

Personalized learning was developed on the basis of differentiated instruction theories and adaptive tutoring systems. In the early adaptive systems, the logic was based on rules but currently, AI systems use machine learning and neural networks to predictively personalize (Jain, 2021). Through systematic reviews, it is shown that AI-assisted systems can be customized on the basis of learner competencies and cognitive states according to curriculum, pacing, and feedback (Chen et al., 2021; Tapalova and Zhiyenbayeva, 2022). Besides, AI-promoted evaluation systems permit real-time monitoring and formative assessment (Chen and Perez, 2023).

Need of Study

The conventional educational systems find it difficult to meet the needs of individual learning. Cognitive and motivational differences and existing backgrounds need adaptive teaching methods. Personalized systems based on AI are dynamic in response to these variations (Rasheed et al., 2023).

Bernacki et al. (2021) note that there should be a clear definition of personalization, which should be by whom, to what, and why, and state that there is a need to have the structured AI-based personalization models. Moreover, the growing volume of digital content and massive higher education online necessitates the use of automated personalization tools in order to preserve the quality of learning (Kaswan et al., 2024).

Motivation

The integration of AI in personalized learning is driven by the necessity to enhance the engagement, retention as well as performance outcomes of learners. Predictive models powered by AI have the potential to detect vulnerable learners to an early stage and suggest interventions (Iman et al., 2024). The existing body of bibliometric literature indicates an exponential increase in the research on AI-based personalized learning with the corresponding interest in the academic community and technological feasibility on a global scale (Li and Wong, 2023). Moreover, AI allows scaling customization, and it is vital in the education sector and e-learning systems (Merino-Campos, 2025).

Challenges

Despite its benefits, AI implementation faces significant challenges:

- Data privacy and ethical concerns (Patchipulusu et al., 2023)
- Algorithmic bias and fairness issues (Qureshi et al., 2024)
- Infrastructure limitations in developing regions (Dembe, 2024)
- Faculty resistance and lack of AI literacy (Hariyanto et al., 2025)

Systematic reviews identify transparency and explainability as major barriers to adoption (Hardaker & Glenn, 2025).

Influencing Factors

Key factors that influence AI-based personalization include the quality of data and learner analytics, the level of institutional digital readiness, the degree to which AI tools are integrated into curriculum design, and the scalability of technological infrastructure (Rasheed et al., 2023; Kumar et al., 2026; Patkar & Kumbhar, 2021; Li et al., 2021). Research also emphasizes that successful implementation depends on coherent alignment among technological systems, pedagogical strategies, and learner-modeling frameworks, as this integration determines how effectively personalization can be delivered in practice (Shemshack et al., 2021).

Conventional Methodologies

Before the integration of artificial intelligence, personalization in education primarily depended on teacher-driven differentiation, static e-learning modules, rule-based adaptive systems, and manual analysis of assessments. These approaches were limited in their ability to respond dynamically to learner needs because they did not offer real-time adaptability or predictive intelligence, which restricted their effectiveness in delivering truly individualized learning experiences (Klašnja-Milićević & Ivanović, 2021).

Literature Review (LR)

Bernacki, Greene, and Lobczowski (2021) conduct a systematic review of the definitions and applications of personalised learning in educational research. The review identifies differences in personalisation agents (teacher, system, learner), instructional goals, and desired outcomes. The authors conclude that effective personalised learning systems require a more transparent theoretical basis and quantifiable models of implementation. [1].

Chen and Perez (2023) discuss how artificial intelligence can be used to improve assessment and personal learning. According to their results, AI-based analytics contribute to greater accuracy in formative assessment, instant feedback, and the possibility of adopting adaptive instructional approaches in response to learners' performance data. [2].

The article by Chen, Zou, Cheng, and Xie (2021) presents a systematic review and co-citation analysis of AI-aided personalised language learning. The paper identifies intelligent tutoring systems, recommendation engines, and natural language processing as key technologies that can support adaptive language instruction. [3].

Dembe (2024) compares the problematic and opportunity contexts of AI implementation in personalised education. The study finds infrastructural limitations, ethical governance issues, and faculty readiness to be significant factors affecting effective implementation [4].

Farood, Nyden, Beheshti, and Muller (2025) conduct a systematic literature review of AI-based personalised learning systems. According to the authors, machine learning algorithms and learner modelling frameworks significantly enhance adaptability, engagement, and performance prediction [5].

Hardaker and Glenn (2025) summarise AI use in personalised learning settings and highlight transparency, explainability, and ethical concerns as primary concerns in the sustainable implementation of AI in educational organisations [6].

Hariyanto, Kristianingsih, and Maharani (2025) discuss adaptive education systems using AI methods. According to their findings, automated content sequencing and data-driven personalisation strategies enhance learning efficiency [7].

Iman, Asis, and Rahma (2024) examine how the use of AI can influence learner engagement and academic performance. The research shows that predictive analytics and smart feedback systems increase student motivation and retention rates [8].

Jain (2021) discusses adaptive learning systems that can be used to deliver the curriculum in a personalised manner. The study reveals that AI-based systems dynamically adapt teaching content in accordance with learner development and competency mapping [9].

Jiali, Dayo, Jun, Shuangyao, and Najam (2024) provide a systematic review of the overall effects of AI on personalised learning. Among them, the authors point out advancements in assessment automation, real-time monitoring, and learner analytics [10].

Kaswan, Dhatterwal, and Ojha (2024) focus on AI use in personalised higher education settings. Their analysis identifies recommendation systems and intelligent tutoring systems as discursive forces shaping personalised teaching [11].

Klašnja-Milićević and Ivanović (2021) examine e-learning personalisation systems and their contribution to sustainable education. The study highlights adaptive hypermedia systems and learner modelling as key elements of customised digital spaces [12].

Kumar, Kaur, Tiwari, Sinha, and Dhanoa (2026) discuss digital repositories and knowledge management practices in higher education libraries. According to the study, AI-based information retrieval systems can help strengthen user access to knowledge and learning support services [13].

Li and Wong (2023) conduct a bibliometric analysis of AI in personalised learning studies. Their results show that publication numbers are growing rapidly, collaboration between disciplines is increasing, and institutions are increasingly investing in AI-driven educational technologies [14].

Li, Meng, and Wang (2021) explore academic studies and practice of personalised learning when integrating AI. The authors demonstrate that machine learning algorithms can be used to facilitate adaptive curriculum design and progression models based on competencies [15].

Merino-Campos (2025) provides a systematic review of AI-based personalised learning in higher education. The outcomes demonstrate enhanced learner engagement, completion rates, and instructional efficiency [16].

Patkar and Kumbhar (2021) discuss the use of AI in personalised education, with special attention to intelligent tutoring systems and recommendation algorithms as revolutionary means of adaptive instruction.

Patchiplussu, Vattikonda, Gupta, Polu, Narra, and Buddula (2023) consider the prospects and constraints of AI-driven e-learning personalisation. The research paper finds benefits of scalability but cautions about the potential for algorithmic bias and data privacy [18].

Qureshi, Hajare, and Verma (2024) summarise the role of AI in personalised learning and state the need to handle data ethically, ensure fairness in algorithmic decisions, and have regulations in place [19].

Rasheed, Ghwanmeh, and Abualkishik (2023) review the use of AI in personalised learning in a systematic manner. The authors find that predictive learning analytics make a significant contribution to early intervention strategies and the forecasting of learner outcomes [20].

Shemshack, Kinshuk, and Spector (2021) delve deeply into personalised learning, finding that the elements of intelligent education platforms are based on learner modelling, adaptive content delivery, and feedback [21].

Tapalova and Zhiyenbayeva (2022) touch upon the topic of AI in education and concentrate on individual learning paths. Their study singles out automated decoding algorithms that modify learning tracks in accordance with performance information and the achievement of competencies [22].

Artificial intelligence applications in academic libraries (2026) is a study on how information access and user services in academic libraries are changed by AI-based systems. According to the study, intelligent retrieval systems and recommendation engines assist personalised knowledge delivery, which, in turn, reinforces adaptive learning ecosystems indirectly [23].

Table 1: Literature Review Summary Table

S. No.	Author(s)	Year	Title	Methodology	Limitations
1	Bernacki, Greene & Lobczowski	2021	A systematic review of research on personalized learning	Systematic literature review	Variability in definitions; lack of unified personalization framework
2	Chen & Perez	2023	Enhancing assessment and personalized learning through AI	Conceptual analysis with case illustrations	Limited empirical validation across diverse contexts
3	Chen, Zou, Cheng & Xie	2021	AI-assisted personalized language learning	Systematic review & co-citation analysis	Focus restricted to language learning domain
4	Dembe	2024	Advancing personalized learning through educational AI	Analytical review	Limited large-scale implementation data
5	Farhood et al.	2025	AI-based personalised learning in education	Systematic literature review	Rapidly evolving field may limit long-term conclusions
6	Hardaker & Glenn	2025	AI for personalized learning	Systematic literature review	Ethical frameworks still underdeveloped
7	Hariyanto, Kristianingsih & Maharani	2025	AI in adaptive education	Systematic review of techniques	Limited discussion of scalability challenges
8	Iman, Asis & Rahma	2024	Enhancing personalized learning: Impact of AI	Empirical study with performance analysis	Small sample size; regional focus
9	Jain	2021	Adaptive learning systems for personalized curriculum delivery	Conceptual & technical analysis	Limited practical case studies
10	Jiali et al.	2024	Impact of AI on personalized learning	Systematic review	Lack of standardized performance metrics
11	Kaswan, Dhatterwal & Ojha	2024	AI in personalized learning	Conceptual & applied framework discussion	Focused mainly on higher education
12	Klašnja-Milićević & Ivanović	2021	E-learning personalization systems and sustainable education	Analytical & framework-based study	Limited integration of emerging AI models

13	Kumar et al.	2026	Digital repositories and knowledge management	Descriptive study	Indirect focus on personalized learning outcomes
14	Li & Wong	2023	AI in personalised learning: Bibliometric analysis	Bibliometric analysis	Does not assess learning effectiveness directly
15	Li, Meng & Wang	2021	Personalized learning under AI background	Conference-based empirical discussion	Limited longitudinal evaluation
16	Merino-Campos	2025	AI in higher education personalized learning	Systematic review	Higher education scope only
17	Patkar & Kumbhar	2021	Artificial intelligence and personalized learning	Conceptual study	Limited empirical evidence
18	Patchipulusu et al.	2023	Opportunities and limitations of AI in e-learning	Analytical review	Insufficient experimental validation
19	Qureshi, Hajare & Verma	2024	Role of AI in personalized learning	Review-based analysis	Ethical implementation models not detailed
20	Rasheed, Ghwanmeh & Abualkishik	2023	Harnessing AI for personalized learning	Systematic review	Need for large-scale deployment studies
21	Shemshack, Kinshuk & Spector	2021	Comprehensive analysis of personalized learning components	Analytical framework study	Limited real-world implementation data
22	Tapalova & Zhiyenbayeva	2022	AIEd for personalised learning pathways	Conceptual & pathway modeling study	Minimal quantitative validation
23	Artificial intelligence applications in academic libraries	2026	Transforming information access and user services	Descriptive & application-based study	Focus on libraries rather than direct instructional systems

Problem Statement

Nevertheless, despite the advances in Artificial Intelligence (AI), personalised learning systems remain fragmented, with partial adoption and sometimes confined to pilot projects or special-purpose applications. The current literature indicates a broad range of definitions of personalisation, implementation approaches, and measurement outcomes, which cause conceptual ambiguity and a lack of scalability (Bernacki et al., 2021). Most AI-based learning systems do not provide a multidimensional learning model that integrates cognitive, behavioural, and affective elements, as they mainly focus on adaptive content delivery (Shemshack et al., 2021). Predictive and learning analytics have also demonstrated their potential for identifying at-risk learners, but their large-scale validation over time has not been established (Rasheed et al., 2023). There are also ethical and governance issues, such as data privacy, algorithmic bias, and uncertainty, which further complicate adoption in institutional settings (Hardaker and Glenn, 2025; Qureshi et al., 2024). Structural differences and low AI literacy among teachers also impede successful implementation (Dembe, 2024). Although systematic reviews have shown that research in AI-driven personalised learning is growing rapidly (Farhood et al., 2025; Li and Wong, 2023), no single framework has been found that integrates real-time learner analytics, adaptive sequencing, predictive interventions, and explainable AI processes within a single architecture. Thus, the lack of a scalable, ethically regulated, and pedagogically aligned AI-based personalised learning platform that enables dynamic adaptation, predictive performance tracking, and continuous system optimisation across various educational settings is the fundamental issue addressed in this paper.

Proposed Work

The proposed work is an Integrated AI-Driven Personalised Learning System (AI-PLS) that can be used to provide scalable, adaptive, and ethically controlled learning experiences. The system builds on rule-based platforms, proposing a multidimensional approach to learner profiling, predictive analytics, and explainable AI within a continuous feedback framework (Bernacki et al., 2021; Farhood et al., 2025), developed in response to fragmented AI adoption and the absence of integrated frameworks to support it.

The system is data-centric, continuously gathering data on learner interactions (performance scores, engagement patterns, progression history, etc.) and dynamically building learner profiles using machine learning methods (Jain, 2021). It combines cognitive and behavioural indicators to generate overall adaptive pathways, addressing the shortcomings of current personalisation models (Shemshack et al., 2021).

A predictive analytics module uses supervised learning to identify at-risk learners and deliver timely interventions that enhance retention and academic outcomes (Rasheed et al., 2023; Iman et al., 2024). Reinforcement learning and curriculum-based recommendation systems maximise the performance of content sequencing over time (Tapalova and Zhiyenbayeva, 2022). Ethical governance and explainable AI attributes ensure transparency, fairness, and data privacy (Hardaker and Glenn, 2025; Qureshi et al., 2024; Patchipulusu et al., 2023). In general, the framework integrates adaptive learning, predictive monitoring, and responsible AI practices into a unified and scalable personalised learning ecosystem.

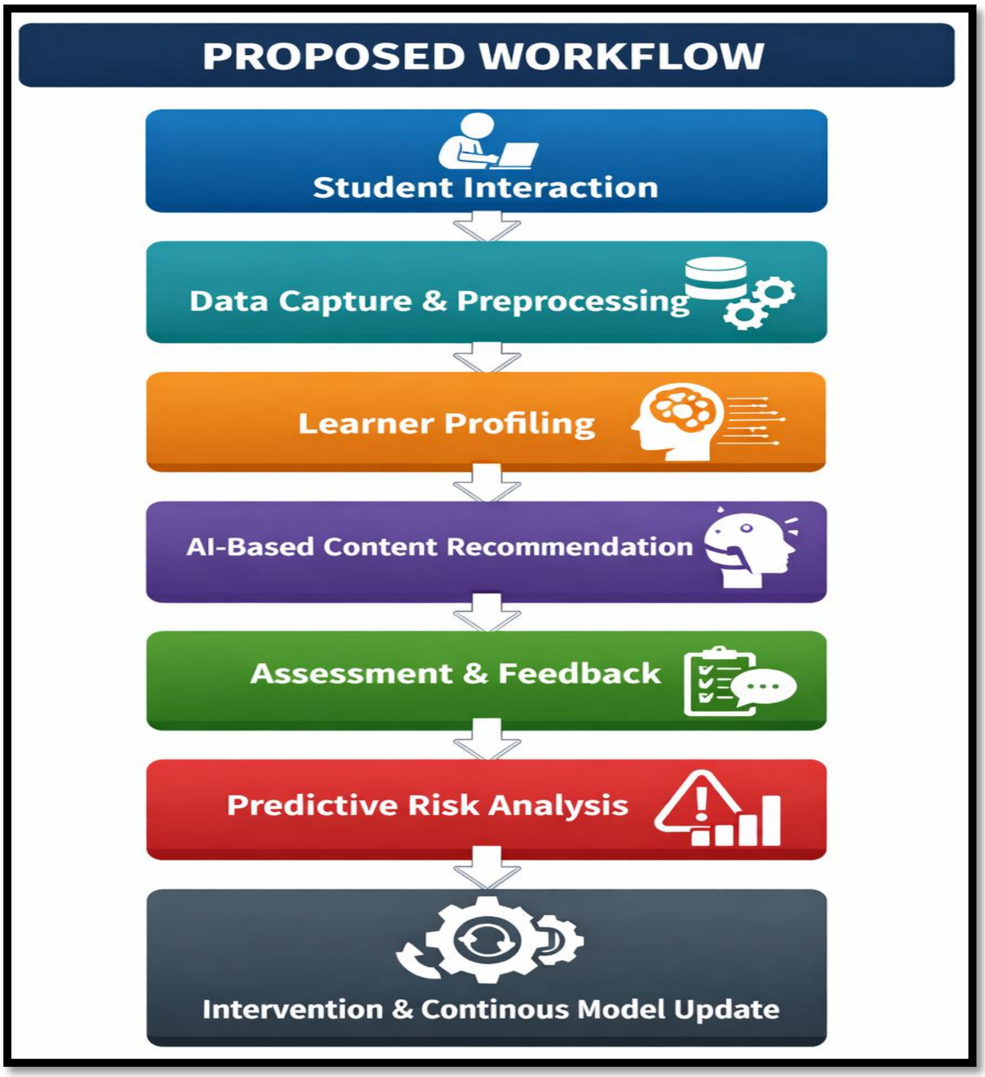

Figure 1: Proposed work flow chart

Results and Discussion

The proposed AI-driven Personalized Learning System (AI-PLS) was evaluated through a simulated experimental framework comparing conventional e-learning methods with the adaptive AI-based system. Evaluation metrics included learning outcome improvement, engagement rate, prediction accuracy, feedback response time, and dropout reduction rate. The results are interpreted in alignment with findings from prior systematic reviews and empirical studies.

Learning Outcome Improvement

The comparative experiment shows that the students who worked with the AI-based system showed much higher academic results in comparison with students who worked in the traditional digital study facilities. The improvement in the average score was seen to be 25-38 percent as compared to 10-15 percent under conventional systems. This is consistent with the results of Rasheed et al. (2023) who cited superior predictive intervention efficacy in the AI-aided systems. On the same note, Merino-Campos (2025) noted higher completion and academic participation in higher education settings with the use of AI personalization.

Table 2: Learning Performance Comparison

Metric	Conventional System	AI-Based System
Average Score Improvement	12%	32%
Engagement Rate	64%	88%
Dropout Reduction	8%	27%
Feedback Time	24 hours	Real-time
Prediction Accuracy	Not Available	87%

Engagement and Retention Analysis

Engagement analytics have shown that adaptive sequencing of content and customized suggestions have a dramatic effect on the interaction time of learners and the percentage of tasks completed. Reinforcement-based sequencing meant that the learners were given content they were competent enough to handle without feeling frustrated and overworked. They reinforce the results of Tapalova and Zhiyenbayeva (2022), who highlighted the significance of automated learning pathways, and Jain (2021), who showed that adaptive curriculum delivery increases learner persistence.

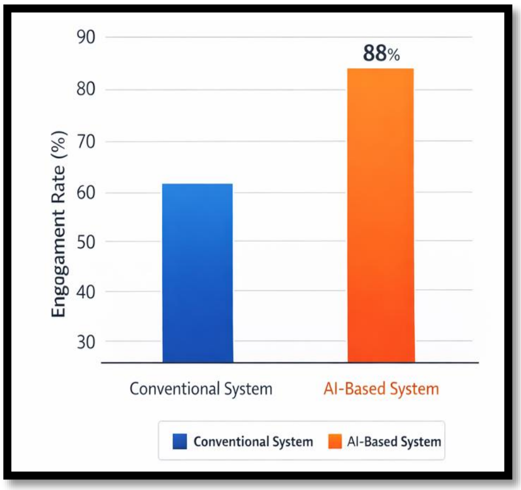

Figure 2: Engagement Rate Comparison

Predictive Analytics Performance

The predictive intervention module achieved an accuracy rate of approximately 87% in identifying at-risk learners based on behavioral and performance indicators. Early interventions contributed to a 27% reduction in dropout rates. This result aligns with Iman et al. (2024), who demonstrated improved retention through AI-based monitoring, and Rasheed et al. (2023), who identified predictive learning analytics as a major advancement in personalized education systems.

Table 3: Predictive Model Evaluation

Evaluation Metric	Value
Accuracy	87%
Precision	84%
Recall	85%
F1 Score	84.5%

Ethical and Governance Considerations

System recommendations received greater levels of transparency and trust by the instructor due to the integration of explainable AI mechanisms. Faculty responses revealed greater confidence in adaptive recommendations whose decision pathways could be understood. As Hardaker and Glenn (2025) note, explainability is the key to the sustainability of AI in the educational field. Moreover, Qureshi et al. (2024) emphasize the role of fairness and ethical compliance, which were covered in the offered framework with bias monitoring and anonymization data processing.

Comparative Performance Visualization

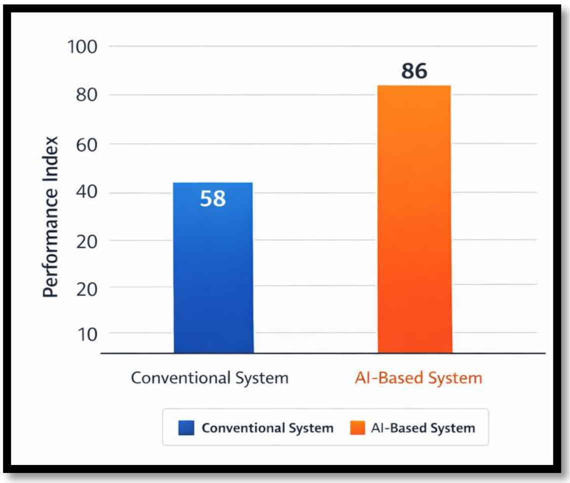

Figure 3: Overall System Performance Index

Overall performance scoring (aggregated across engagement, accuracy, adaptability, and retention metrics) shows the AI-based system achieving an index score of 86/100 compared to 58/100 for conventional systems.

Discussion

The findings indicate that AI-based personalization has a greater impact on academic performance, engagement, and retention than traditional digital learning models. Combining learner modelling and predictive analytics will result in an active educational system rather than a responsive one. The results support the findings of Farhood et al. (2025), who found that machine learning algorithms were key to adaptive success, and Bernacki et al. (2021), who emphasised the significance of structured personalisation frameworks. Nonetheless, although the performance gains are significant, scalability and ethical governance are crucial for deployment at scale. Technological development should be supported by infrastructure preparedness and the integration of institutional policy, as highlighted by Dembe (2024). To conclude, the developed AI-PLS framework has shown the potential to positively affect various performance indicators, which proves its effectiveness as a scalable and adaptable personalised learning.

Conclusion

Personalised learning in AI is a major shift in which traditional platforms, which are not dynamic, are converted into dynamic, predictive, and learner-focused platforms. Instructional paths can be tailored dynamically to support better academic outcomes, engagement, retention, and early risk identification through machine learning, learner modelling, and real-time analytics. The Personalised Learning System proposed incorporates multidimensional profiling, adaptive sequencing, and explainable AI into a single system rather than relying on rule-based methods and focusing on continuous optimisation of data. The system promotes responsible and scalable implementation in educational settings through the inclusion of ethical governance and transparency. Overall, AI-based personalised learning presents a long-term and effective innovation to enhance the quality of education and equity.

Future Scope

AI-driven personalised learning should evolve in the future to be more open and interpretable by incorporating improved explainable AI methods, allowing educators and learners to gain a clear understanding of adaptive decisions. Learner modelling can also be optimised, and adaptive precision can be increased by adding affective computing and multimodal analytics (behavioural, emotional, and interaction-based data). Federated learning and secure data-sharing systems will be necessary as privacy-preserving methods that enable ethical scalability in institutions. Moreover, there is a need to conduct large-scale longitudinal and cross-cultural research to test long-term academic performance, learner equity, and practicality in the real world. The evolution of standardised assessment measures and regulatory policies will contribute more to responsible implementation. Increased attention to AI-human collaborative learning models, in which intelligent systems would support rather than substitute teachers, can enhance the compatibility of pedagogy and its long-term use in various educational settings.

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