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AI-Powered Personalised Learning: Promise and Pitfalls

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Abstract

The integration of artificial intelligence (AI) into personalised learning is reshaping educational practices by enabling adaptive, learner-centred experiences. This narrative review, structured to synthesise recent empirical and conceptual research (2022–2025), assesses both the transformative potential and the challenges of AI-powered personalised learning. The findings demonstrate that AI can enhance student performance, motivation, and engagement through the provision of real-time feedback, tailored content delivery, and intelligent tutoring systems. Additionally, AI supports teacher efficiency by automating routine tasks and providing data-driven insights. However, the study also highlights pressing concerns, including data privacy, algorithmic bias, lack of explainability, and the erosion of essential human elements in teaching. The review identifies a significant gap in longitudinal and inclusive research, particularly involving underrepresented learner populations. Recommendations are offered for designing ethical, transparent, and inclusive AI systems, while advocating for balanced integration with human pedagogy. This work contributes to a comprehensive understanding of how AI can support learning equitably and effectively in diverse educational contexts.

Keywords: AI-Powered Personalised Learning; Adaptive Learning Systems; Intelligent Tutoring Systems; Machine Learning In Education; Educational Technology; Data Privacy

1. Introduction

The integration of artificial intelligence (AI) into education is transforming the way learning is designed, delivered, and experienced worldwide, unlike past waves of educational technology that often reinforced traditional teaching models. AI-driven, personalised learning offers the potential to alter pedagogical practices fundamentally. By enabling tailored learning pathways, real-time feedback, and adaptive content delivery, AI can address persistent challenges such as diverse learner needs, engagement gaps, and unequal access to quality education (Harry, 2023). As educational institutions increasingly adopt AI tools—from intelligent tutoring systems to large language models (LLMs)—it is crucial to evaluate both their transformative potential and potential pitfalls.

The topic warrants urgent and systematic study for several reasons. First, global demand for scalable and equitable education solutions has accelerated in the wake of disruptions, such as the COVID-19 pandemic (Kamruzzaman et al., 2023). Second, AI technologies are evolving rapidly, outpacing the development of ethical guidelines, regulatory frameworks, and pedagogical best practices (Yang & Weng, 2023). Finally, while AI-powered personalised learning is often celebrated for its potential, concerns related to bias, privacy, transparency, and the erosion of human elements in education remain underexplored (Al-Omari et al., 2025).

The concept of personalised learning predates AI but was historically constrained by technological and logistical limitations. Early adaptive systems relied on simple, rule-based frameworks and lacked the sophistication to

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differentiate instruction meaningfully (Rekha et al., 2024). Recent advancements in machine learning, natural language processing, and data mining have transformed this landscape, enabling dynamic personalisation based on continuous analysis of student data (Wen et al., 2024).

Studies demonstrate that AI-powered personalised learning can improve student performance, motivation, and satisfaction by aligning content delivery with individual learning profiles (Xu, 2025; Ye et al., 2024). Intelligent tutoring systems, chatbots, and adaptive assessment tools have been shown to enhance both learning outcomes and teacher efficiency (Yarlagadda, 2025; Silva et al., 2024). Moreover, AI-driven insights can support data-informed decision-making for educators and institutions (Saragih, 2024).

However, the literature also highlights significant challenges. Ethical concerns around data privacy, algorithmic bias, and the transparency of AI systems remain pressing (Yang & Weng, 2023; Al-Omari et al., 2025). Technical limitations, such as inconsistent personalisation quality and difficulties integrating AI into existing curricula, present additional barriers (Jane et al., 2024). Furthermore, researchers caution that over-reliance on AI may diminish essential human dimensions of teaching, such as empathy, mentorship, and cultural responsiveness (Qushwa & Onia, 2024).

1.1. Research Gap

While the field of AI-powered personalised learning is vibrant and expanding, several gaps persist. First, there is limited empirical research on the long-term impacts of AI-driven personalisation across diverse educational contexts, including marginalised and underrepresented learner populations (Halkiopoulos & Gkintoni, 2024). Second, much of the existing literature focuses on technical efficacy rather than holistic educational outcomes, such as critical thinking, creativity, and socio-emotional development (Storey & Wagner, 2024).

Third, ethical frameworks for the use of AI in education remain underdeveloped, particularly in terms of student agency, algorithmic accountability, and equitable access (Bin et al., 2024). Finally, practical guidance for balancing AI tools with human pedagogical practices is lacking, leaving educators uncertain about how to integrate these technologies responsibly (Sayed et al., 2022).

1.2. Research Aim

This review aims to synthesise current knowledge on the promises and pitfalls of AI-powered personalised learning. Specifically, it explores how AI technologies are being implemented to enhance personalisation, the evidence supporting their efficacy, the ethical and practical challenges they raise, and emerging directions for research and practice. The goal is to provide a balanced, comprehensive understanding that can inform educators, policymakers, technologists, and researchers working at the intersection of AI and education.

1.3. Research Questions

The following research questions guide this study:

- What are the primary benefits and promises of AI-powered personalised learning as reported in recent literature?
- What ethical, technical, and practical challenges are associated with the implementation of AI in personalised learning environments?
- How can educators and institutions balance the use of AI with the preservation of essential human elements in teaching and learning?
- What gaps in current research and practice need to be addressed to advance the responsible integration of AI in education?

This review offers several novel insights. First, it integrates findings from recent empirical studies across multiple educational contexts, providing a panoramic view of how AI is shaping personalised learning. Second, it foregrounds ethical and human-centred considerations, moving beyond purely technical evaluations of AI tools. Third, it highlights practical strategies and emerging frameworks for the responsible integration of AI, offering actionable recommendations for stakeholders.

By addressing both the promises and pitfalls of AI-powered personalised learning, this review contributes to ongoing efforts to ensure that AI serves as a force for equity, inclusion, and pedagogical innovation in global education.

2. Methodology

2.1. Research Design

This study employs a structured narrative review methodology to examine the benefits and limitations of AI-powered personalised learning. A narrative review was chosen as it offers the flexibility to synthesise insights across multiple disciplines—including educational technology, computer science, cognitive psychology, ethics, and learning sciences—while the field itself continues to evolve rapidly.

To ensure rigour and transparency, the review employed a structured literature search and thematic synthesis, drawing on principles commonly used in scoping and integrative reviews. Unlike formal systematic reviews, which prioritise exhaustiveness and statistical synthesis (e.g., PRISMA-guided meta-analyses), the goal here was to develop a broad, critical understanding of how AI-driven personalisation is impacting education, highlighting both its technical innovations and its pedagogical and ethical dimensions.

2.2. Literature Search Strategy

To achieve a comprehensive and current overview of the field, the literature search focused on peer-reviewed academic sources published between 2022 and 2025. The following major databases were queried:

- Scopus
- Web of Science
- IEEE Xplore
- SpringerLink
- Google Scholar (for additional grey literature and conference proceedings)

The search employed Boolean keyword combinations, including:

- "AI-powered personalised learning"
- "adaptive learning systems"
- "Intelligent tutoring systems"
- "AI in education"
- "machine learning and education"
- "ethical AI in education"
- "AI and data privacy in learning"

In addition to the database search, backwards and forward citation tracking was performed on key articles to identify further relevant studies.

2.3. Inclusion and Exclusion Criteria

The following inclusion criteria guided study selection:

- Published in English, between 2022 and 2025.
- Peer-reviewed journal articles, conference proceedings, or systematic reviews.
- Focused on AI-powered personalised learning within formal or informal educational contexts (K-12, higher education, or adult learning).
- Addressed either empirical outcomes (e.g., learning gains, engagement, teaching efficiency) or conceptual/ethical analyses relevant to AI in education.

Exclusion criteria included:

- Studies focused solely on non-AI educational technologies.
- Studies lacking methodological transparency.
- Editorials, commentaries, or opinion pieces.
- Studies addressing AI applications outside the scope of learning personalisation (e.g., administrative automation).

2.4. Trustworthiness and Limitations

To enhance the trustworthiness of this narrative synthesis, priority was given to studies with clear methodological rigour, including large-scale empirical investigations (e.g., Xu, 2025; Ye et al., 2024) and systematic reviews (Halkiopoulou & Gkintoni, 2024). Diverse perspectives across different AI technologies, educational levels, and global contexts were deliberately included to provide a holistic understanding of the field.

Nevertheless, this methodology is subject to certain limitations:

- As a narrative review, this synthesis lacks the statistical rigour of a formal meta-analysis.
- There may be publication bias toward positive findings within the emerging field of AI in education.
- The review was limited to English-language publications, which may introduce language bias.
- Given the rapid pace of AI development, some findings may quickly become outdated, underscoring the need for ongoing review and monitoring.

Despite these limitations, this structured narrative review offers a timely and comprehensive synthesis of the current state of AI-powered personalised learning and provides a foundation for further inquiry.

3. Conceptual Foundations and Evolution of AI in Personalised Learning

The dream of tailoring education to individual learners is not new. Long before machines entered classrooms, educators imagined ways to adapt lessons to students' diverse abilities, interests, and needs. The introduction of AI has brought that dream closer to reality, though not without complications.

Personalised learning itself is a broad term, encompassing any approach that seeks to move beyond mass instruction (Rekha et al., 2024). Traditionally, teachers relied on differentiated instruction and small-group work, which required significant human effort. Today's AI-driven systems automate much of this adaptation by analysing student data in real time, adjusting both content and pacing accordingly (Wen et al., 2024).

Early adaptive learning systems were constrained by limited computing power and simplistic rule-based algorithms. They could modify quiz difficulty or suggest remedial content, but failed to capture the complexity of human learning (Halkiopoulou & Gkintoni, 2024). The field has since undergone dramatic shifts, thanks to advances in machine learning, natural language processing (NLP), and, more recently, large language models (LLMs) (Kumar & Srivastava, 2024).

Modern AI-powered learning platforms do much more than adjust multiple-choice quizzes. They can:

- Analyse patterns in student writing and problem-solving to diagnose misconceptions.
- Offer interactive explanations using conversational agents.
- Adapt instructional pathways to suit different cognitive and affective profiles (Yarlagadda, 2025).

These innovations are based on a conceptual shift: AI is no longer merely a tool for content delivery, but a partner in shaping learning experiences (Wen et al., 2024).

One example of this shift is the AI4EDU framework, which combines large language models (LLMs) with human-in-the-loop models, where AI serves as an intermediary among students, teachers, and educational systems (Wen et al., 2024). Here, AI does not replace human educators; instead, it enhances their capacity to meet individual needs at scale.

Another key milestone has been the integration of AI with cognitive science. Systems examined by Halkiopoulou and Gkintoni (2024) draw from cognitive neuropsychology, allowing for more sophisticated types of personalisation. For instance, such systems might adjust instruction based on a learner's working memory capacity or attentional patterns—capabilities unimaginable in earlier adaptive technologies.

Furthermore, AI is increasingly supporting multimodal learning. Adaptive platforms can vary the content format—text, video, or interactive simulations—based on both learner preferences and learning effectiveness (Kumar & Srivastava, 2024). This flexibility reflects an evolving understanding of learning styles and underscores AI's potential to foster more engaging educational experiences.

One of the most ambitious developments is the use of intelligent tutoring systems (ITS) powered by artificial intelligence (AI). Systems like Carnegie Learning employ advanced cognitive modelling and adaptive algorithms to offer personalised, step-by-step guidance (Iqbal et al., 2025). These tutors not only respond to student errors but also anticipate learning needs based on sophisticated pattern recognition.

Another frontier involves generative AI. Tools like GPT-powered chatbots are now being explored as on-demand tutors, providing real-time assistance and explanation (Leon, 2024). While promising, these applications raise questions about content accuracy, educational alignment, and the role of human educators (Al-Omari et al., 2025).

Three intertwined trends thus mark the conceptual evolution of AI in personalised learning:

- Increasing sophistication of AI models—from simple rules to deep learning and LLMs.
- Closer integration with insights from cognitive and learning sciences.
- A shifting vision of human-AI collaboration in education.

Together, these trends point toward a future where AI will not simply automate instruction but actively shape how learning unfolds for each student. However, as subsequent sections will show, realising this vision requires addressing profound challenges around ethics, equity, and the preservation of human agency in education.

4. Promises of AI-Powered Personalised Learning

4.1. Enhanced Learning Outcomes through Personalisation

The idea that students benefit from lessons tailored to their unique learning needs has intuitive appeal. However, for much of educational history, personalisation remained more aspiration than reality. Class sizes, rigid curricula, and limited teacher time made it challenging to customise instruction on any meaningful scale.

AI technologies are starting to change that. Systems equipped with machine learning algorithms and adaptive interfaces can now analyse each learner's behaviour, performance, and preferences in real time. Based on this continuous flow of data, they can adjust content, pacing, and instructional strategy dynamically (Rekha et al., 2024).

For example, AI-powered platforms, as described by Xu (2025), have demonstrated measurable improvements in learning outcomes. In a semester-long study, students exposed to personalised AI-driven instruction demonstrated significantly higher engagement, satisfaction, and academic performance compared to those taught through conventional methods. This was not simply a matter of delivering the duplicate content differently—AI enabled each student to follow a learning path tailored to their strengths and areas for improvement.

The benefits extend beyond academic performance. Personalised learning can boost motivation and self-efficacy—two factors strongly correlated with long-term educational success (Kamruzzaman et al., 2023). When students feel that lessons reflect their interests and needs, they are more likely to persist through challenges and invest effort in mastering complex concepts.

Recent work by Ye et al. (2024) offers a striking example of AI's potential in this space. Their system used large language models to generate customised mathematical reasoning chains and personalised explanations for students of varying proficiency levels. Across a sample of nearly 3,000 learners, the system achieved a 98.7% accuracy rate in problem-solving, significantly improving student comprehension and engagement. Notably, the gains were strongest among lower-performing students, suggesting that AI-powered personalisation may help narrow achievement gaps.

Personalisation also enhances learning by supporting diverse learning styles. Sayed et al. (2022) describe an adaptive e-learning platform that adjusts content presentation based on the well-known VARK framework, which encompasses visual, aural, reading/writing, and kinaesthetic modalities. Students using this system reported higher satisfaction and demonstrated stronger post-test gains, particularly those whose learning preferences had been poorly served by traditional instruction.

Importantly, the promise of AI-powered personalisation is not confined to technical subjects like math. Studies show that intelligent tutoring systems, conversational agents, and adaptive platforms can support learning across a wide range of domains, from language acquisition to science inquiry (Iqbal et al., 2025; Yarlagadda, 2025).

Of course, personalisation is no magic bullet. Its success depends on the quality of the underlying AI models, the richness of the data available, and the pedagogical soundness of the system design (Wen et al., 2024). When these factors align, however, AI-powered personalisation offers a powerful tool for fostering deeper, more effective learning.

4.2. Real-time Feedback and Adaptive Learning

Learning happens moment by moment. The ability to receive feedback in those moments—when a student is struggling with a math problem, misinterpreting a science concept, or hesitating in language practice—can make the difference between progress and frustration. For decades, the timeliness of feedback has been one of the most stubborn limitations in traditional classrooms. Even in well-resourced settings, no teacher can provide instant, tailored guidance to every student all the time.

AI-powered systems now make that level of support possible. By continuously tracking student interactions, AI can detect patterns of error, hesitation, or disengagement and respond in real time (Kamruzzaman et al., 2023). For example, in AI-enhanced e-learning environments, Internet of Things (IoT) devices such as cameras and microphones can capture engagement data, allowing AI to adapt lessons and offer immediate feedback based on both cognitive and behavioural signals (Kamruzzaman et al., 2023).

Concrete applications of this technology are already producing notable results. Sayed et al. (2022) describe an adaptive platform that combines visual, auditory, reading-kinesthetic (VARK) learning styles with intelligent scaffolding. The system dynamically adjusts the difficulty of exercises and provides feedback loops that encourage persistence and reflection. Pilot studies with primary school learners showed measurable improvements in academic performance and higher satisfaction, especially among students who had previously struggled in more rigid instructional settings.

Feedback is not only about correcting errors; it also supports adaptive learning paths. Luo (2024) developed the Adaptive Cognitive Enhancement Model (ACEM), an AI-driven framework that uses machine learning to personalise content and feedback according to individual cognitive profiles. By adapting both the pace and style of feedback to match each learner's needs, ACEM fosters deeper engagement and more sustained learning gains. Importantly, the model tracks learning progress longitudinally, adjusting feedback strategies as students develop over time (Luo, 2024).

One of the most potent aspects of AI-driven feedback is its potential to create dialogic learning experiences—interactive, conversational exchanges that promote understanding. Intelligent tutoring systems (ITS), such as those examined by Iqbal et al. (2025), are increasingly designed to engage students in back-and-forth dialogue rather than merely delivering answers. These systems interpret not only what the student knows, but also how they are reasoning, enabling richer, more personalised guidance.

Consider also the integration of deep reinforcement learning in adaptive learning environments. Sayed et al. (2022) report on a system that uses a Deep Q-Network (DQN) to refine feedback strategies dynamically. The system experiments with different forms of feedback—hints, prompts, encouragement—and optimises responses based on each learner's reactions. Results from a study on primary mathematics learners showed that those who received such tailored feedback exhibited more substantial gains in both skill mastery and confidence.

The capacity for instantaneous, personalised feedback represents one of the most transformative aspects of AI in education. It bridges a critical gap between the learner's immediate cognitive state and the instructional support they receive—something that even the most attentive human teacher struggles to achieve for an entire class simultaneously.

At the same time, the design of AI feedback systems requires careful thought. Feedback that is too frequent or too directive can undermine learner autonomy and metacognitive development (Wen et al., 2024). The most effective systems strike a balance, offering support when needed but also prompting reflection and self-regulation. Achieving this balance is a subtle art, one that demands not just technical sophistication but a deep understanding of how people learn.

In sum, the growing capacity of AI to provide real-time, adaptive feedback holds enormous promise for personalized learning. When well-designed, such systems can support learners with the correct information, at the right moment, in a way that fosters both competence and confidence.

4.3. Enhanced Teacher Efficiency and Decision-Making

If there exists one resource that educators invariably find to be insufficient, it is time. The demands of grading assignments, monitoring student progress, preparing tailored materials, and giving feedback quickly accumulate. AI-powered personalised learning tools are helping to alleviate some of that burden by automating routine tasks and offering richer insights to support informed teaching decisions.

AI-driven platforms provide automated grading for various types of assignments, including written responses and open-ended tasks. Tools that employ natural language processing (NLP) can evaluate essays and provide immediate, consistent feedback, saving teachers hours of manual effort (Harry, 2023). While these tools are not meant to replace human judgment entirely, they significantly reduce the time spent on low-level marking.

Beyond grading, AI systems excel at generating learning analytics. Teachers can gain fine-grained insights into each student's progress, engagement levels, and knowledge gaps (Silva et al., 2024). This level of analysis would be difficult, if not impossible, for a teacher to conduct manually for a large group of learners.

A practical example is provided by Saragih (2024), whose study of AI-powered educational solutions found that intelligent systems not only enhanced learning outcomes but also improved teacher productivity. Automated progress tracking enabled teachers to focus more on interactive instruction and student mentoring—activities where human expertise remains irreplaceable.

Similarly, Harry (2023) highlights how intelligent tutoring systems (ITS) and chatbots can handle frequent student queries. By fielding basic questions and guiding students through standard stumbling blocks, these tools free up teacher time for more complex instructional work. Teachers in AI-supported classrooms often report having more time and resources to conduct one-on-one interventions and design creative learning experiences.

Indeed, efficiency is not the sole objective. The actual value of AI is in improving the quality of instruction. With better data, teachers can make targeted interventions—adjusting groupings, revising materials, or providing extra support where needed (Silva et al., 2024). Instead of reacting to end-of-term assessments, educators can intervene proactively, supported by continuous AI-powered insights.

However, the human element remains vital. Jane et al. (2024) caution that AI should complement, not replace, the empathetic and contextual understanding that teachers bring to their work. In their study, blended approaches—where teachers used AI data to inform instruction but maintained personal connections with students—produced the strongest learning outcomes.

The takeaway? AI has the potential to improve teacher efficiency and decision-making significantly. However, the real promise lies not in automating teachers out of the picture, but in empowering them to focus on the deep, relational, and creative aspects of teaching that no machine can replicate.

5. Approaches and Technologies

5.1. AI Algorithms and Adaptive Learning Systems

Behind every AI-powered personalised learning experience operates a sophisticated network of algorithms that analyse data, detect patterns, and influence how content is delivered to each learner. These systems extend far beyond simple automation; they represent a fundamental shift in instructional design, wherein learning pathways are dynamically constructed to address individual learner needs.

At the core of most adaptive learning platforms are machine learning (ML) algorithms that continuously refine their understanding of each student. By processing rich interaction data—including clicks, response times, quiz outcomes, and, in some cases, gaze patterns—these algorithms build detailed learner profiles that inform content sequencing and

pedagogical adjustments (Rekha et al., 2024). Consequently, the learning experience evolves rather than remaining static.

For example, the adaptive learning systems described by Alawneh et al. (2024) utilise machine learning (ML) to transcend the limitations of traditional one-size-fits-all e-learning models. Their system dynamically adjusts both content sequencing and instructional pacing according to each student's mastery level and engagement indicators. This level of personalisation enables learners to progress at an optimised pace, challenged, yet not overwhelmed.

More advanced platforms incorporate deep learning techniques to model knowledge acquisition at a finer level of detail. Li and Leong (2024) proposed a hybrid approach that integrates Long Short-Term Memory (LSTM) networks, Bayesian Knowledge Tracing (BKT), and Reinforcement Learning (RL). The objective is to optimise learning pathways that not only adapt to past performance but also anticipate future learning needs. Their system demonstrated significant improvements in both predictive accuracy and knowledge mastery compared to earlier models.

Another promising development is the application of Deep Knowledge Tracing (DKT), which maps a learner's knowledge state across multiple concepts over time. This enables more nuanced personalisation by facilitating targeted interventions when students exhibit signs of conceptual drift or persistent misconceptions (Li & Leong, 2024).

Beyond individual algorithmic models, researchers are also exploring multi-modal adaptive systems. Sayed et al. (2022) developed a platform that adapts not only to the difficulty of content but also to the mode of presentation—text, audio, video, or interactive activities—based on learners' preferences and engagement data. The incorporation of a Deep Q-Network (DQN) enables the system to experiment with various instructional strategies and continuously refine them through real-time feedback.

While such systems hold considerable promise, they also introduce new complexities. The efficacy of AI-based adaptive learning systems is inherently dependent on the quality and diversity of training data. A lack of representation from specific learner populations within these datasets may inadvertently reinforce existing educational inequalities (Rekha et al., 2024).

Additionally, interpretability remains a significant challenge. As deep learning models become increasingly opaque, educators may struggle to understand the rationale behind specific recommendations (Wen et al., 2024). Ensuring that adaptive systems remain transparent and explainable is therefore essential for fostering teacher trust and supporting effective pedagogical integration.

Despite these challenges, progress in this domain is undeniable. AI algorithms are transforming personalised learning, evolving from basic content recommendation engines into sophisticated models of learner knowledge and behaviour. The next critical task is to ensure that these powerful technologies are implemented in ways that are equitable, transparent, and supportive of both learners and educators.

5.2. Intelligent Tutoring Systems and Feedback Mechanisms

When students encounter obstacles—whether solving an algebraic equation or constructing a written argument—receiving timely and targeted feedback can significantly enhance their learning trajectory. However, in large classroom settings, providing such individualised guidance consistently remains a persistent challenge. Intelligent tutoring systems (ITS) have emerged as a promising means to address this gap.

Contemporary ITS platforms extend well beyond static drills or answer keys. They engage students through dynamic, interactive dialogues, adjusting instruction in real time based on each learner's responses and reasoning patterns (Iqbal et al., 2025). Rather than operating as one-directional systems, these platforms continuously monitor student interactions with content, enabling adaptive guidance throughout the learning process.

A widely cited example is the Carnegie Learning system, which leverages cognitive modelling and adaptive algorithms to personalise instruction and direct targeted remedial efforts towards specific knowledge gaps (Iqbal et al., 2025). In this system, each student's action—whether correct or incorrect—is analysed, shaping subsequent instructional steps and adjusting the complexity of future content accordingly.

Feedback is central to the adaptive capabilities of ITS. High-quality platforms offer layered feedback, providing not only error correction but also strategic hints, conceptual breakdowns, and prompts that foster reflective thinking. In doing

so, they support the development of students' metacognitive skills alongside their acquisition of content knowledge (Wen et al., 2024).

Recent advancements further extend these capabilities. Sayed et al. (2022) describe a system incorporating a Deep Q-Network (DQN) to optimise feedback delivery. By systematically testing various strategies—ranging from encouragement and hints to challenge prompts—and adapting to student responses, the system tailors feedback to individual learner profiles. In a pilot study involving Grade 3 mathematics students, those receiving adaptive feedback demonstrated greater post-test gains and higher satisfaction, particularly among initially lower-performing learners.

Moreover, ITS platforms increasingly incorporate multi-modal feedback mechanisms. Visual cues, auditory explanations, and interactive simulations enable the systems to address diverse learning preferences (Sayed et al., 2022). Feedback is no longer restricted to binary correct/incorrect judgements but can now foster deeper conceptual understanding and engagement.

An emerging innovation is the integration of Generative AI (GenAI) within tutoring systems. Leon (2024) explores the deployment of GenAI-based chatbots that provide on-demand, personalised tutoring. These systems allow students to pose questions, receive explanations, and explore concepts through natural language conversations, effectively granting continuous access to personalised support. Nevertheless, this approach raises important concerns regarding content accuracy and alignment with instructional objectives (Leon, 2024).

One of the principal strengths of ITS lies in its capacity to provide continuous formative assessment. Teachers gain access to detailed data streams capturing each student's progress, misconceptions, and levels of engagement (Iqbal et al., 2025). This enables earlier and more effective instructional interventions, moving beyond reliance on traditional summative assessments.

However, the design of feedback mechanisms must be approached with caution. Excessively directive feedback may undermine learner autonomy, while insufficient support risks leaving students without adequate guidance (Wen et al., 2024). The most effective systems strike a careful balance, providing scaffolding when necessary while encouraging students to engage productively with challenging tasks.

As ITS and feedback technologies continue to evolve, they represent one of the most tangible avenues through which AI can enhance deep, personalised learning. The objective is not to replace educators, but rather to augment their capacity to support each learner's journey toward mastery.

6. Pitfalls and Challenges of AI-Powered Personalised Learning

The swift advancement of AI-driven personalised learning presents remarkable opportunities, yet it also introduces various risks and unresolved issues. Despite the advancements in customising content and enhancing results, these systems encounter considerable ethical, technical, and practical obstacles. The effectiveness of AI in education relies not merely on the development of superior algorithms but also on carefully navigating these challenges.

6.1. Ethical Concerns and Privacy Issues

One of the most critical concerns surrounding AI-powered personalised learning is the issue of data privacy. Such systems rely on the collection and analysis of extensive student data, including performance metrics, behavioural patterns, and, in some cases, biometric information (Kamruzzaman et al., 2023). In the absence of robust safeguards, this sensitive data is vulnerable to misuse or unauthorised access. This concern is particularly acute given that students, and minors in particular, represent a vulnerable population whose educational data warrants the highest standards of transparency and accountability.

Algorithmic bias presents an equally significant challenge. AI models trained on skewed or incomplete datasets risk perpetuating or even exacerbating existing educational inequities (Al-Omari et al., 2025). For example, an AI-driven tutoring system primarily trained on data from English-speaking students in well-resourced schools may fail to accurately interpret the responses or learning needs of students from diverse linguistic or socio-economic backgrounds. In such cases, rather than promoting educational equity, these systems risk reinforcing structural disparities.

Emerging efforts seek to address these challenges. Yang and Weng (2023) identify federated learning as a promising strategy; this approach enables model training to occur on local devices, thereby avoiding the need to transmit raw data to central servers and reducing associated privacy risks. Furthermore, they underscore the importance of constructing

diverse and representative training datasets to mitigate potential biases. Nonetheless, while these technical innovations make meaningful contributions to the solution space, they are insufficient in isolation. The development of comprehensive ethical frameworks and robust regulatory oversight must evolve in parallel to ensure that the adoption of AI in education proceeds in a manner that safeguards both privacy and equity.

6.2. Implementation Barriers and Technical Limitations

Beyond ethical considerations, practical barriers continue to impede the effective integration of AI technologies in classroom settings. A significant challenge lies in teacher readiness. Many educators lack adequate training in both the effective utilisation of AI tools and the interpretation of the data these systems generate (Jane et al., 2024). In the absence of sufficient professional development and institutional support, there is a substantial risk that AI will become an underutilised feature or, worse, a source of confusion and mistrust among educators.

Technical limitations also persist. While adaptive learning systems have shown notable progress, they still struggle to accommodate the full complexity of human cognition. Current AI models typically excel at procedural tasks, such as guiding mathematical problem-solving; however, they exhibit considerably less proficiency in fostering higher-order cognitive skills, including critical thinking and creativity (Cai & Liu, 2024). Additionally, AI's capacity to interpret emotional nuance remains limited, posing challenges in educational domains where social-emotional learning is a significant aspect.

Infrastructure constraints further exacerbate these challenges. In many regions, inconsistent internet connectivity and outdated technological infrastructure significantly restrict access to AI-powered learning solutions (Bin et al., 2024). If such disparities are not adequately addressed, there is a genuine risk that the deployment of AI in education will exacerbate, rather than ameliorate, existing digital divides.

6.3. Balancing AI with Human Teaching

Perhaps the most complex challenge is ensuring that AI complements, rather than supplants, human teaching. Empirical studies consistently demonstrate that the most effective learning outcomes are achieved through blended models, wherein AI facilitates scalable personalisation and feedback. At the same time, human teachers remain central to fostering relationships, providing mentorship, and cultivating deeper learning (Qushwa & Onia, 2024).

There is also growing concern regarding an over-reliance on AI. Should students come to expect immediate, tailored responses at every juncture, they may become less proficient in self-regulation and less resilient in the face of productive struggle—skills that are fundamental to lifelong learning (Silva et al., 2024). Accordingly, AI systems must be designed not merely to enhance efficiency, but to promote reflection, persistence, and resilience.

Researchers caution against the development of AI systems that optimise for narrow performance metrics, such as time-on-task or quiz accuracy, without accounting for broader educational aims (Halkiopoulos & Gkintoni, 2024). An excessive focus on readily quantifiable outcomes risks distorting instructional priorities in ways that may undermine deeper educational objectives.

In sum, the pitfalls and challenges of AI-powered personalised learning are inextricably linked to ethical considerations, technical limitations, and pedagogical values. Whilst these challenges should not inhibit innovation, they must not be disregarded. The development of responsible AI in education will necessitate collaborative engagement among researchers, educators, policymakers, and students themselves to ensure that such technologies genuinely serve the diverse and complex goals of human learning.

7. Future Directions and Research Opportunities

Artificial Intelligence (AI) powered personalised learning remains an evolving domain, characterised by the rapid advancement of technological innovations that outpace pedagogical theories, regulatory frameworks, and classroom practices. An examination of the current landscape reveals several critical directions for future endeavours. These opportunities encompass technical enhancements, ethical safeguards, and a more profound engagement with the realities of teaching and learning.

7.1. Building More Ethical and Transparent Systems

The question of ethics remains paramount. As Halkiopoulos and Gkintoni (2024) observe, future developments in AI must address not only performance but also fairness, transparency, and accountability. Designing systems that can

articulate their recommendations in a manner comprehensible to both educators and learners remains an urgent research priority. Without such explainability, trust in AI-supported learning will remain precarious.

Mitigating bias constitutes another critical area of focus. While technical approaches such as federated learning (Yang & Weng, 2023) can reduce privacy risks and decentralise data processing, broader efforts are required to ensure the use of diverse training datasets and culturally responsive system design. Researchers and developers must systematically evaluate AI models across a wide range of learner populations to prevent the reinforcement of existing educational inequalities (Al-Omari et al., 2025).

7.2. Expanding Empirical Validation

Despite considerable enthusiasm, much of the existing research continues to rely on short-term studies or evaluations conducted within controlled environments. There remains a pressing need for more large-scale, longitudinal research to examine the sustained impact of AI-powered personalised learning across a range of outcomes, not solely academic attainment, but also critical thinking, creativity, collaboration, and socio-emotional development (Storey & Wagner, 2024).

It is equally important that future studies place greater emphasis on student perspectives. How do learners experience AI-driven personalisation? In what ways does it influence their sense of agency, motivation, and trust in the learning process? Capturing the student voice will be essential to developing a holistic understanding of not only the technical efficacy of AI tools but also their broader impact on learner identity and autonomy.

Moreover, future research should investigate how AI tools operate within real-world classroom contexts, where teachers must manage multiple demands and where learners encounter a range of complex barriers to engagement (Halkiopoulou & Gkintoni, 2024). Contextually grounded research, conducted in authentic educational settings, will be vital in moving beyond proof-of-concept studies towards achieving sustainable and meaningful impact.

7.3. Enhancing Pedagogical Integration

AI should function as a partner in teaching, rather than as an isolated system. Future research must investigate how AI-driven insights can be more effectively integrated with human pedagogical judgment. Teachers require tools that support, rather than supplant, their professional expertise in promoting deep learning, student agency, and inclusive classroom cultures (Jane et al., 2024).

Professional development is crucial in this regard. Further research should investigate the most effective models for training educators to engage thoughtfully and critically with AI tools (Bin et al., 2024). Co-design approaches, wherein teachers play an active role in shaping how AI is implemented within educational contexts, represent a particularly promising avenue for fostering responsible and contextually relevant adoption.

7.4. Supporting Equitable Access

The potential of AI must not be confined to well-resourced schools equipped with cutting-edge infrastructure. Future research must address the challenge of delivering low-cost, scalable AI solutions that can function in bandwidth-constrained or resource-poor environments (Kamruzzaman et al., 2023). Investigating hybrid models that integrate offline functionality with periodic online updates may offer promising avenues for bridging access gaps.

Furthermore, future research must examine how AI-powered personalised learning can more effectively support inclusive education. Learners with disabilities, neurodiverse profiles, and those from marginalised communities frequently encounter systemic barriers to meaningful personalisation. While AI holds considerable potential to facilitate more flexible and adaptive learning experiences, this potential will only be realised if such systems are intentionally designed and rigorously tested to address the needs of diverse learner populations. Addressing this gap remains a critical priority for future work.

International collaboration can play a pivotal role in fostering more inclusive research by incorporating perspectives from underrepresented regions and contexts. The overarching goal must be to ensure that AI-powered personalised learning emerges as a genuinely global innovation—one that is accessible to all learners, rather than being confined to elite educational settings (Lata, 2024).

7.5. Balancing Innovation with Human Values

Ultimately, the field must continue to engage with fundamental questions regarding the nature of the learning that AI should be designed to support. As Qushwa and Onia (2024) emphasise, AI tools ought not to be developed solely to optimise narrow performance metrics. Future research should investigate how AI can be leveraged to facilitate collaborative learning, critical thinking, and ethical reasoning—essential competencies that enable learners to thrive in an increasingly complex world.

Achieving this will require sustained interdisciplinary dialogue among AI researchers, educators, ethicists, policymakers, and students themselves. It is only through such dialogue that AI-powered personalised learning can be shaped in ways that advance not merely technological capability, but also the broader goals of human flourishing.

8. Conclusion

AI-powered personalised learning represents a compelling new paradigm within education—one that moves beyond static, one-size-fits-all models towards dynamic and responsive learning experiences. The findings of this review suggest that AI technologies, particularly those utilising machine learning and large language models, have the potential to enhance learning outcomes, enable real-time feedback, and provide tools that support both students and teachers across diverse educational contexts (Wen et al., 2024; Xu, 2025).

However, this promise is accompanied by considerable challenges: including ethical concerns related to data privacy and algorithmic bias (Al-Omari et al., 2025); technical limitations in modelling the complexities of human learning; and the ongoing need to strengthen teacher agency, pedagogical alignment, and inclusivity (Jane et al., 2024).

The objective of this review has been to synthesise current research on AI-powered personalised learning, to highlight both its potential to transform educational practice and the pitfalls that must be addressed to ensure responsible and effective implementation. The review has focused on exploring how AI-driven systems are designed and deployed, the empirical evidence supporting their use, and the ethical, technical, pedagogical, and social considerations that will shape their future development.

8.1. Recap of Key Findings & Contributions

Key findings from this review include:

- AI-driven personalisation can significantly enhance learning outcomes, particularly when systems adapt in real time to individual needs (Ye et al., 2024; Xu, 2025).
- Intelligent tutoring systems and advanced feedback mechanisms offer continuous formative assessment and promote deeper learning (Iqbal et al., 2025; Sayed et al., 2022).
- AI tools can improve teacher efficiency and decision-making, freeing educators to focus on higher-order instructional tasks (Silva et al., 2024; Saragih, 2024).
- Major risks remain around data privacy, algorithmic fairness, equitable access, and explainability, requiring ongoing ethical oversight (Yang & Weng, 2023; Al-Omari et al., 2025).
- There is a critical need to incorporate student perspectives and address how learners experience AI-based personalisation—an area largely underexplored.
- The integration of AI with human teaching practices is essential; blended approaches that preserve teacher autonomy, human relationships, and inclusivity are most effective (Qushwa & Onia, 2024).
- AI's potential to support inclusive education for learners with disabilities, neurodiverse profiles, and marginalized communities must be a core priority for future research and design.

8.2. Practical Implications

For educators, the findings suggest that AI-powered tools can serve as valuable allies, provided they are employed strategically and with a clear understanding of their limitations. Teachers will require access to professional development and opportunities to participate in the co-design of AI systems that are aligned with sound pedagogical principles (Bin et al., 2024).

For policymakers, this review underscores the imperative to establish robust data privacy protections, ethical frameworks for AI governance, and policies that promote equitable access to advanced educational technologies (Al-Omari et al., 2025; Yang & Weng, 2023).

For developers and researchers, the findings highlight the importance of designing AI systems that are transparent, explainable, student-centred, and inclusive. Such systems must explicitly address the needs of diverse learners and uphold the principles of student agency (Halkiopoulou & Gkintoni, 2024).

8.3. Limitations

This review is constrained by its reliance on recent literature (2022–2025), a period characterised by rapid technological evolution. Emerging developments in AI may soon surpass some of the findings presented here. Furthermore, although the review sought to provide broad coverage of the field, it was not possible to capture the full depth of research across all domains or regional contexts. There remains a pressing need for more longitudinal studies and for research conducted within underrepresented settings, in order to assess the sustained impact of AI-powered personalised learning.

8.4. Suggestions for Future Research

Future research should prioritise the following areas:

- Conducting longitudinal studies in authentic classroom environments to evaluate a broader range of educational outcomes (Storey & Wagner, 2024).
- Developing and validating explainable AI models that can be trusted and understood by both teachers and learners (Wen et al., 2024).
- Placing greater emphasis on student voice—investigating how learners experience AI-driven personalisation and how it influences their sense of agency, motivation, and learning identity.
- Advancing the design of inclusive AI systems that support learners with disabilities, neurodiverse learners, and marginalised groups—moving beyond generic, one-size-fits-all approaches to personalisation (Kamruzzaman et al., 2023; Y et al., 2024).
- Fostering interdisciplinary collaboration among AI researchers, educators, ethicists, policymakers, and students to co-create future AI-powered learning ecosystems (Qushwa & Onia, 2024).
 - Ultimately, realising the full potential of AI-powered personalised learning will necessitate intentional, ethical, and inclusive design choices—grounded in the rich complexity of human learning and the diverse needs of students across the globe.
 - This review contributes to the field by offering a comprehensive synthesis of current research on AI-powered personalised learning, identifying critical challenges and opportunities, and providing a clear agenda to guide future ethical, inclusive, and pedagogically sound innovation.

Compliance with ethical standards

Disclosure of conflict of interest

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Statement of Ethical Approval

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