

## The Role of Artificial Intelligence in Education: Opportunities, Challenges, and Implications for Formal and Non-Formal Learning

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**Abstract.** Artificial intelligence (AI) has moved rapidly from a specialised research topic into a routine presence in classrooms, training programmes and self-directed study, a shift accelerated by the public release of generative tools. This paper examines the role of AI across both formal and non-formal education, with the objective of clarifying where the technology adds genuine pedagogical value, where it introduces risk, and what conditions are needed for responsible adoption. The study adopts a narrative and critical review of peer-reviewed literature, foundational scholarship and policy guidance published mainly between 2016 and 2024. Sources were identified through academic databases and synthesised thematically around application domains, reported benefits and recurring concerns, rather than through statistical meta-analysis. Four broad application areas emerge: personalised and adaptive learning; intelligent tutoring and automated assessment; generative AI for content creation and dialogue; and AI-supported non-formal and lifelong learning. Reported benefits include wider access, individualised pacing and reduced routine workload for educators. Persistent concerns cluster around academic integrity, algorithmic bias, data privacy, the digital divide, and a possible erosion of independent reasoning when learners over-rely on automated output. In conclusion, AI is best understood as an amplifier of pedagogy, rather than a replacement for teachers or human judgment. Its benefits are conditional on AI literacy, transparent governance, and equitable access. Non-formal settings, being flexible and learner-driven, are particularly well placed to exploit AI, provided the same ethical safeguards apply.

**Keywords:** Artificial intelligence; Generative AI; Non-formal learning; AI literacy; Educational technology.

### 1. Introduction

Artificial intelligence (AI) has shifted from a specialised branch of computer science into an everyday feature of how people teach, learn and train. Although intelligent systems have been studied in educational settings for several decades, ranging from early intelligent tutoring systems to learning-analytics engines, their reach long remained confined to well-resourced institutions and research laboratories (Zawacki-Richter et al., 2019; Holmes et al., 2019). Over the past few years, the maturation of machine learning and the wide availability of cloud-based services have brought AI-driven functionality to mainstream platforms used across formal and informal contexts alike (Chen et al., 2020).

The public release of large language models, and of conversational systems such as ChatGPT in particular, marked a turning point in this trajectory. For the first time a powerful generative tool

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became freely accessible to anyone with an internet connection, and educators encountered a technology that could draft essays, explain concepts, write code and hold a plausible dialogue on almost any subject (Kasneci et al., 2023). Institutional responses were initially polarised, oscillating between outright prohibition and enthusiastic adoption, as schools and universities struggled to reconcile the tool's evident utility with concerns about misuse (Cooper, 2023).

Much of the existing scholarship concentrates on formal higher education, where structured curricula and assessment make the effects of AI easier to observe and measure (Crompton & Burke, 2023). Considerably less attention has been paid to non-formal and lifelong learning, even though flexible, self-directed and modular forms of study may be especially compatible with adaptive and generative tools. This imbalance matters, because non-formal learning accounts for a large share of skills acquisition across the working population, and because the same tools that raise questions in classrooms also reshape how adults retrain and upskill.

Against this background, the present paper pursues three objectives: to map the principal domains in which AI is currently applied in education; to weigh the opportunities these applications offer against the risks they introduce; and to consider what their adoption implies for both formal and non-formal learning. The discussion is intended to be balanced rather than promotional, recognising that the value of AI in education depends less on the sophistication of the technology than on the pedagogical and ethical conditions under which it is used.

## **2. Research methodology**

This paper is based on a narrative and critical review of the literature rather than a formal meta-analysis. A narrative approach was chosen because the field is evolving quickly, because the relevant evidence spans several disciplines and publication types, and because the aim is conceptual synthesis rather than statistical aggregation of comparable trials.

Sources were identified through searches of major academic databases, including Scopus, Web of Science and Google Scholar, using combinations of terms such as “artificial intelligence”, “generative AI”, “education”, “adaptive learning” and “non-formal learning”. The review prioritised peer-reviewed journal articles and recognised systematic reviews published mainly between 2016 and 2024, supplemented by foundational books and authoritative policy guidance, notably that issued by UNESCO (2023).

Selected works were read and grouped thematically according to their primary application domain, the benefits they reported and the concerns they raised. This interpretive synthesis allows patterns to be drawn across heterogeneous studies, but it does not claim the exhaustiveness or replicability of a review conducted under a strict systematic protocol, a limitation revisited in the conclusion.

## **3. Results**

The reviewed literature converges on four broad domains of application, summarised in Table 1 and discussed below, followed by the benefits and concerns reported across them.

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### 3.1 Personalised and adaptive learning

Adaptive learning systems use data on a learner's responses, pace and errors to adjust the difficulty, sequence and content of what is presented next. Rather than delivering a single fixed pathway, these systems attempt to approximate the individual attention of a human tutor at scale (Luckin et al., 2016). Reviews of the field report that such personalisation can raise engagement and allow learners to progress according to their own needs, although the size of the effect varies considerably with the quality of implementation (Chen et al., 2020; Crompton & Burke, 2023).

### 3.2 Intelligent tutoring and automated assessment

Intelligent tutoring systems extend personalisation by modelling a learner's knowledge state and offering step-by-step guidance, hints and feedback as problems are solved. Closely related is the use of AI for assessment, where algorithms grade responses, detect misconceptions and generate formative feedback far more quickly than is feasible manually (Holmes et al., 2019). Zhai and Nehm (2023) argue that AI-based assessment has already become an established part of practice, shifting the educator's role towards interpreting machine-generated insight rather than producing every judgement directly.

### 3.3 Generative AI for content and dialogue

The most visible recent development is generative AI, in which large language models produce original text, explanations and dialogue in response to natural-language prompts. In education these tools are used to draft and adapt teaching materials, to provide on-demand explanations at different levels of complexity, to support brainstorming and to act as a conversational study partner (Kasneci et al., 2023). Early exploratory studies in specific subjects reveal both promise and clear limitations, including factual errors and uneven reliability that demand careful human oversight (Cooper, 2023).

### 3.4 AI in non-formal and lifelong learning

Beyond formal classrooms, AI increasingly underpins non-formal and lifelong learning. Recommender systems on open courses and skills platforms suggest content matched to a learner's goals, chatbots answer questions outside scheduled hours, and adaptive pathways support workplace training and reskilling. Because non-formal learning is typically voluntary, modular and self-paced, it aligns naturally with tools that personalise and are available on demand. International guidance nevertheless stresses that the safeguards governing formal education, concerning data protection, equity and human oversight, must extend to these settings as well (UNESCO, 2023; Ng et al., 2021).

Table 1. Principal domains of AI application in education, with reported benefits and risks.

| Domain                             | Typical tools and examples                         | Reported benefits                                                  | Principal risks                               |
|------------------------------------|----------------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------|
| Personalised and adaptive learning | Adaptive courseware; learning-analytics dashboards | Individualised pacing; early identification of struggling learners | Opaque algorithms; dependence on data quality |

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|                                     |                                                               |                                                             |                                                        |
|-------------------------------------|---------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------|
| Intelligent tutoring and assessment | Intelligent tutoring systems; automated and formative grading | Immediate feedback; reduced routine workload                | Errors in judgement; narrowing of assessable skills    |
| Generative AI                       | Large language models; conversational assistants              | Rapid content creation; on-demand explanation and dialogue  | Inaccuracy; plagiarism; weakened independent reasoning |
| Non-formal and lifelong learning    | Course recommenders; chatbots; reskilling pathways            | Flexible, on-demand access; support for self-directed study | Unequal access; limited oversight; data privacy        |

Across these domains the literature identifies a consistent set of benefits. AI can widen access to individualised support that was previously labour-intensive and therefore scarce; it can reduce the routine workload associated with marking and content preparation, freeing educators for higher-value interaction; and it can increase engagement by adapting to the learner (Chen et al., 2020; Holmes et al., 2019). In non-formal contexts these advantages are amplified by flexibility, since learners can obtain relevant guidance at the moment of need rather than according to a fixed timetable.

The same literature is equally consistent about the risks. The most frequently cited concerns relate to academic integrity and the possibility that ready access to generated answers erodes independent reasoning and effort (Kasneci et al., 2023). Algorithmic bias, opacity in how decisions are reached, and the privacy of the learner data on which these systems depend recur throughout the policy and research discussion (UNESCO, 2023). A structural concern is the digital divide: learners without reliable devices, connectivity or guidance risk being further disadvantaged, so that a technology promoted as a leveller may instead widen existing gaps (Selwyn, 2019; Crompton & Burke, 2023).

#### 4. Discussion

Taken together, these findings suggest that AI is most usefully understood as an amplifier of pedagogy rather than a substitute for it. The technologies reviewed perform best when they extend what skilled educators already do, by handling routine tasks and providing additional, timely feedback, and least well when they are expected to replace human judgement, motivation and relationship. Selwyn (2019) cautions against framing teaching as a function that can simply be automated, and the evidence reviewed here is consistent with that caution: the educator remains central, but the role shifts towards designing, supervising and interpreting AI-supported learning (Holmes et al., 2019).

The tension between the productivity of generative tools and the integrity of learning is unlikely to be resolved by prohibition. Because detection is unreliable and avoidance impractical, a more sustainable response is to redesign tasks and assessment so that they value processes, reasoning and application rather than easily generated products (Cooper, 2023; Zhai & Nehm,

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2023). This implies a move towards assessment that is more authentic and dialogic, and towards explicit instruction in how to use AI critically rather than covertly.

This points to AI literacy as a precondition for beneficial adoption. If learners and educators are to use these tools well, they need to understand what AI can and cannot do, how it can mislead, and how to evaluate its output (Ng et al., 2021). Without such literacy, the benefits accrue mainly to those who are already advantaged, reinforcing the equity concerns noted above. Embedding AI literacy across curricula, and crucially within non-formal and adult-learning provision, is therefore as important as the technical capability of the tools themselves (UNESCO, 2023).

The implications differ somewhat between formal and non-formal settings. Formal education offers structure and oversight but adapts slowly; non-formal learning is agile and learner-driven, making it a natural environment for personalised and generative tools, yet it often lacks the institutional safeguards that protect learners in formal systems. The challenge for non-formal provision is thus to retain its flexibility while adopting comparable standards of data protection, transparency and human oversight (UNESCO, 2023). Coherent governance, rather than ad hoc local decisions, is needed if AI is to support learning equitably across both domains.

## 5. Conclusion

AI is reshaping education across formal and non-formal settings, offering personalisation, efficiency and wider access while raising serious questions about integrity, equity, privacy and the place of human judgement. The central argument of this paper is that these tools are best treated as amplifiers of good pedagogy, dependent for their value on AI literacy, transparent governance and equitable access rather than on technical sophistication alone.

Several limitations should be acknowledged. As a narrative and critical review, this study is interpretive and does not claim the exhaustiveness of a systematic protocol; it draws on English-language sources; and, in a field advancing this rapidly, specific tools and findings date quickly even where the underlying issues persist.

Future research should therefore prioritise empirical, context-specific and longitudinal evaluation of AI in authentic settings, with particular attention to non-formal and lifelong learning, which remains comparatively under-studied. Investigating how AI-literacy interventions affect outcomes, and how governance can be implemented proportionately outside formal institutions, would be especially valuable. The task for educators and policymakers is not to resist AI nor to adopt it uncritically, but to shape its use so that it strengthens, rather than displaces, human learning.

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