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From Intelligent Tutoring to Generative AI: Rethinking Teaching and Learning in the Age of AI

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Abstract. Artificial intelligence (AI) has been used in education for several decades, but the public emergence of generative tools has prompted a reconsideration of how teaching and learning are organised. This paper traces the evolution of AI in education from early intelligent tutoring systems to contemporary generative models, and examines what this shift means for the roles of teachers and learners. The study is a narrative and critical review of peer-reviewed literature, foundational scholarship and policy guidance published mainly between 2011 and 2024, identified through academic databases and synthesised thematically around technological generations, capabilities and pedagogical implications. Three broad generations are identified: rule-based intelligent tutoring systems, which were narrow but reliable and pedagogically grounded; data-driven and adaptive systems, which scaled personalisation; and generative models, which are broad, open-ended and widely accessible but variable in accuracy. The transition expands what AI can do while shifting responsibility for judgement back towards teachers and learners. Recurring concerns include reliability, academic integrity, equity and the need for AI literacy. Rather than rendering teachers obsolete, the move from intelligent tutoring to generative AI makes their pedagogical role more important. The constructive path lies in combining the reach of generative tools with the rigour of earlier approaches, supported by AI literacy, redesigned assessment and a human-centred stance.

Keywords: Artificial intelligence; Intelligent tutoring systems; Generative AI; Pedagogy; AI literacy.

1. Introduction

Artificial intelligence (AI) is often discussed as though it had arrived in education only with the release of generative chatbots. In fact, AI has been applied to teaching and learning for several decades, evolving through distinct technological generations (Zawacki-Richter et al., 2019). Understanding this longer trajectory matters, because it shows that current debates about AI are less a sudden rupture than the latest stage in a continuing relationship between education and intelligent technology.

The earliest sustained effort took the form of intelligent tutoring systems, which sought to reproduce aspects of one-to-one tutoring through carefully engineered models of the learner and the subject domain (VanLehn, 2011). A later generation drew on machine learning and learning analytics to adapt instruction at scale (Chen et al., 2020). Most recently, generative models based on large language models have made a general-purpose, conversational form of AI freely available to teachers and students alike, capable of producing original text on almost any topic (Kasneci et al., 2023).

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This generative turn has unsettled established assumptions about authorship, assessment and the division of labour between human and machine. Because the new tools are open-ended rather than confined to a single subject, and because their output is fluent but not guaranteed to be correct, they pose questions that the narrower systems of earlier generations did not (Cooper, 2023). The result is a renewed, and at times anxious, discussion about what teachers and learners are for.

Against this background, the paper has three objectives: to trace the evolution of AI in education from intelligent tutoring systems to generative models; to compare the capabilities and limitations of these generations; and to consider what the transition implies for the roles of teachers and learners. The significance of the topic lies in the fact that how educators respond to generative AI will shape its effect on learning far more than the technology itself.

2. Research methodology

The paper adopts a narrative and critical review rather than a formal meta-analysis. This approach suits the aim of synthesising developments across more than a decade and across several research traditions, from the engineering of tutoring systems to the study of generative AI and its pedagogical reception, where the goal is conceptual understanding rather than the 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 “intelligent tutoring systems”, “artificial intelligence in education”, “generative AI”, “large language models” and “teaching and learning”. Priority was given to peer-reviewed articles and recognised reviews published mainly between 2011 and 2024, supplemented by foundational works and authoritative policy guidance (UNESCO, 2023).

The selected works were read and organised around three technological generations and their pedagogical implications. This interpretive synthesis allows the trajectory of the field to be characterised and its present challenges to be situated historically, but it does not claim the exhaustiveness or replicability of a review conducted under a strict systematic protocol, a limitation considered in the conclusion.

3. Results

The reviewed literature describes three broad generations of AI in education, compared in Table 1, followed by a discussion of what the transition between them implies for the roles of teachers and learners.

3.1 Intelligent tutoring systems: the first generation

Intelligent tutoring systems aimed to emulate the benefits of individual tutoring by combining a model of the subject domain, a model of the learner’s evolving knowledge, and a set of tutoring strategies that select hints and feedback as a student works through a problem (VanLehn, 2011). These systems were typically narrow, designed for a specific domain such as algebra or physics, and their behaviour was largely hand-engineered. Within those bounds, however, their effectiveness is well documented: meta-analytic evidence indicates that intelligent tutoring can

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raise attainment substantially above conventional instruction, approaching the gains associated with human tutoring (Kulik & Fletcher, 2016). Their strength lay in reliable, step-level guidance grounded in explicit pedagogical design (Holmes et al., 2019).

3.2 The data-driven and adaptive generation

A second generation moved from hand-built rules towards machine learning and learning analytics. Rather than encoding expert knowledge directly, these systems infer patterns from large volumes of learner data, using them to adapt content and sequence, to predict difficulties and to inform teachers (Chen et al., 2020). This approach extended personalisation to a wider range of subjects and made it easier to deploy at scale (Luckin et al., 2016). At the same time, reviews of the field noted a growing distance from explicit pedagogical theory and limited critical attention to the assumptions embedded in the data and algorithms (Zawacki-Richter et al., 2019).

3.3 The generative generation

The current generation is defined by generative models, principally large language models, which produce original text, explanation and dialogue in response to natural-language prompts. Unlike their predecessors, these systems are general-purpose rather than confined to a single domain, are interacted with through open conversation, and are freely accessible to anyone with an internet connection (Kasneci et al., 2023). Their fluency and breadth are unprecedented, but so are their limitations: the output is probabilistic and can be confidently incorrect, and the model does not "know" a domain in the structured way an intelligent tutoring system does (Cooper, 2023). The locus of reliability thus shifts from the system to the human who must evaluate what it produces.

3.4 Rethinking the roles of teachers and learners

Across these generations the role of the teacher changes in character rather than disappearing. With intelligent tutoring systems the teacher authored and supervised a reliable tool; with generative AI the teacher must instead guide students in using an unreliable but powerful one, designing tasks, modelling critical evaluation and interpreting results (Zhai & Nehm, 2023). For learners, the shift places a premium on AI literacy, the capacity to understand what these tools can and cannot do and to judge their output, alongside enduring concerns that uncritical reliance may weaken independent reasoning (Ng et al., 2021; Selwyn, 2019).

Table 1. A comparison of intelligent tutoring systems and generative AI.

Dimension	**Intelligent tutoring systems**	**Generative AI**
Scope	Narrow; a single subject domain	Broad; general-purpose
Knowledge basis	Hand-built expert and learner models	Patterns learned from large text corpora
Reliability	High within the domain; predictable	Variable; fluent but may be incorrect
Interaction	Structured, step-by-step guidance	Open-ended natural-language dialogue

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Accessibility	Specialist systems; limited reach	Freely available to a broad public
Teacher's role	Author and supervisor of the system	Designer, facilitator and critical guide

Read together, the three generations show both gain and loss. Each step has widened access and broadened the range of tasks AI can support, culminating in tools that any teacher or student can use without specialist infrastructure (Chen et al., 2020; Kasneci et al., 2023). Yet the same trajectory has moved away from the explicit pedagogical grounding and predictability of the earliest systems, transferring the burden of ensuring quality and integrity onto human users (VanLehn, 2011; Zhai & Nehm, 2023). The central tension is therefore between reach and rigour.

4. Discussion

The historical view suggests that generative AI represents both continuity and rupture. It continues a decades-long effort to support learning with intelligent technology, but it ruptures the assumption, built into intelligent tutoring systems, that the technology itself guarantees correctness. Where an intelligent tutoring system was narrow but dependable, a generative model is broad but fallible, and this reversal is the source of much current uncertainty (VanLehn, 2011; Cooper, 2023).

The constructive response is not to choose between the two but to combine their strengths. The reach and flexibility of generative tools can be paired with the rigour and explicit design of earlier approaches, for example by using generative AI within carefully structured tasks and by retaining human and system checks on accuracy (Holmes et al., 2019; Kulik & Fletcher, 2016). This implies redesigning assessment so that it values reasoning and process rather than easily generated products, and treating the critical use of AI as an explicit object of instruction (Zhai & Nehm, 2023).

Such a response depends on AI literacy for both teachers and learners. If students cannot judge when a generative tool is wrong, the breadth of these systems becomes a liability rather than an asset, and the benefits accrue mainly to those already equipped to use them well (Ng et al., 2021). Equity is therefore at stake: unequal access to devices, connectivity and the guidance needed to use AI critically risks widening rather than narrowing educational gaps (Selwyn, 2019).

Finally, the trajectory reframes rather than diminishes the role of the teacher. As reliability migrates from the machine to the human, the teacher becomes more important as a designer of learning, an interpreter of AI output and a guide to its responsible use. International guidance similarly emphasises a human-centred approach that keeps human agency, equity and oversight at the centre of adoption (UNESCO, 2023). The age of AI, on this reading, calls not for fewer teachers but for a renewed and more demanding conception of teaching.

5. Conclusion

The path from intelligent tutoring systems to generative AI is one of expanding reach accompanied by diminishing built-in reliability. Early systems were narrow, predictable and pedagogically grounded; today's generative models are broad, accessible and powerful but fallible. The central

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argument of this paper is that this shift makes the human role more, not less, important, and that the value of generative AI in education depends on combining its reach with the rigour of earlier approaches, supported by AI literacy, redesigned assessment and a human-centred stance.

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

Future research should examine, empirically and over time, how teachers and learners actually use generative AI in classrooms, how AI-literacy interventions affect outcomes, and how the dependable design principles of intelligent tutoring systems might be reintegrated with the flexibility of generative tools. Pursuing these questions will help ensure that successive generations of AI strengthen, rather than displace, the human relationships at the heart of education.

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