RESEARCH-ARTICLE

AI in Digital Education: A Review

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AI in Digital Education: A Review

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Abstract

The explosive growth of generative artificial intelligence (GenAI) has not only reshaped the social value of "knowledge" and "learning," but intensified structural anxieties behind the sharp decline in higher education enrollment rates. Through quantitative analysis and thematic clustering methods, this study systematically reviewed 167 relevant papers between 2017 and 2025. Six research topics were highlighted: Educational Technology, Digital Literacy and AI, Teacher Education, Personalized Learning, Teacher Role Transformation, and Educational Equity and Ethics. The analysis identified research trends in AI in Digital Education, with in-depth exploration of typical applications including AI-driven personalized learning content recommendation systems, automated grading systems, automated evaluation and feedback mechanisms, learning analytics and re-recommendation systems, and conversational virtual tutors. Furthermore, the study identified challenges in AI applications within digital education and outlined future development directions for this field. It provides evidence for universities to redefine the value of education under the background of dealing with the double pressure of declining birth rate and online substitution.

CCS Concepts

• **Applied computing**; • **Education**; • **Computer-assisted instruction**;

Keywords

Artificial Intelligence, Digital Education, Intelligent Tutoring, Adaptive Learning, Human–AI Interaction

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1 INTRODUCTION

With the rapid proliferation of publicly available generative AI (GenAI) by the end of 2022, society's value judgments regarding "knowledge" and "learning" are undergoing reconstruction. From recruitment agencies using AI to screen resumes, to banks relying on AI to identify fraud, to law enforcement deploying predictive policing systems, AI has permeated key aspect of society's operation. In this context, the education sector is not immune. AI-driven online personalized teaching, intelligent learning companion systems, and adaptive learning platforms are reshaping traditional teaching paradigms, such as the long-standing authority of higher education and widespread anxiety among teachers, students, and even parents [1]. When AI can instantly and accurately answer almost any question, what is the meaning of learning [2]?

This technological revolution coincides with a precipitous drop in college enrollment. While existing research generally attributes this phenomenon to a sharp decline in the number of high school graduates due to declining birth rates, a growing number of scholars are beginning to focus on a neglected structural variable: AI-driven online personalized teaching is emerging as an "alternative to college education". On the one hand, the instant knowledge acquisition and skills training pathways provided by AI significantly weaken the signaling function of traditional academic qualifications; on the other hand, the long-standing exam pressure and academic burden within the standardized education system may be eroding students' intrinsic motivation to continue pursuing higher education. This review attempts to propose a new explanatory framework from the perspective of educational practice: GenAI is not a "technological threat" to higher education, but a "diagnostic tool" exposing its systemic fatigue [3].

This study selected 167 literature articles through a screening process to conduct thematic clustering analysis. By synthesizing perspectives from educators, technical experts, and policymakers, it examines typical applications of artificial intelligence in digital education. The research identifies challenges in AI integration within digital education and proposes future research directions.

2 METHODOLOGY & PAPER SELECTION

2.1 Sample Selection

We searched for articles from the Web of Science (WoS) core collection database. Based on "AI", "Digital" and "Education", we searched for articles in the Title, Author Keywords, and Keywords Plus. The search formula is: (TI=(AI) OR AK=(AI) OR KP=(AI)) AND (TI=(Digital) OR AK=(Digital) OR KP=(Digital)) AND (TI=(Education) OR AK=(Education) OR KP=(Education)).

2.2 Analysis

Through a literature search process, we retrieved 187 articles published between 2017 and 2025. We limited the document types to research papers and review articles, 176 documents (159 articles + 19 reviews) were selected. We conducted descriptive analyses, including annual publication and citation count analysis, country and source region analysis, and journal co-citation analysis.

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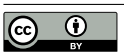

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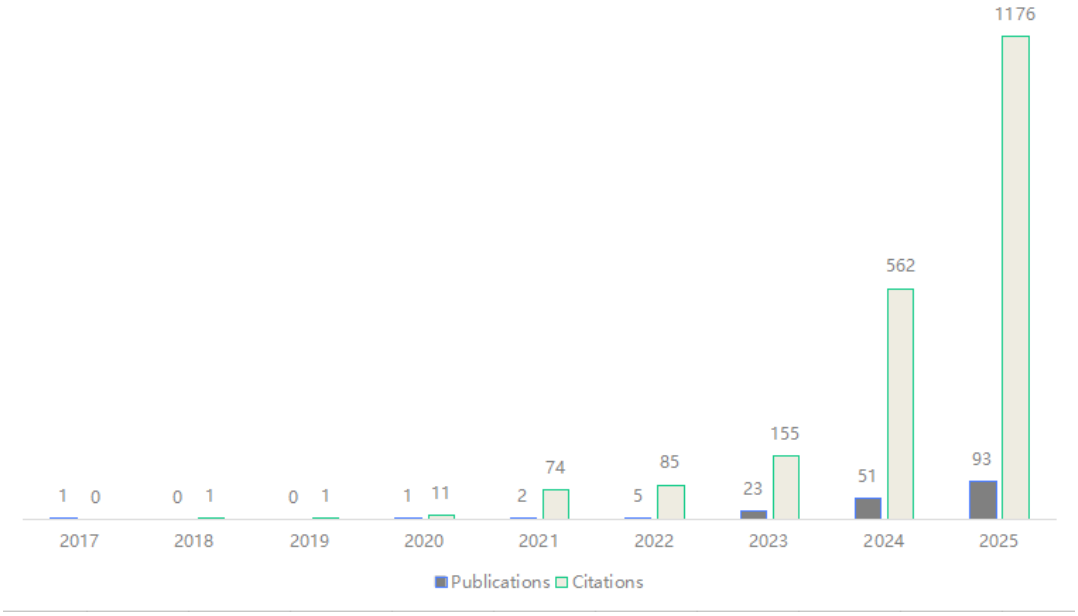

Figure 1: Publications & Citations (2017-2025)

Table 1: Topics from the Literature

Topics	Year			Total
	2023	2024	2025	
Educational Technology	13	33	58	**104**
Digital Literacy and AI	5	6	8	**19**
Teacher Education	1	2	9	**12**
Personalized Learning	2	4	6	**12**
Teacher Role Transformation	1	4	4	**9**
Educational Equity and Ethics	1	2	8	**11**
Total	**23**	**51**	**93**	**167**

Note: Author's calculations

3 DESCRIPTIVE ANALYSIS

3.1 Publications & Citations

The number of publications and citations is shown in Figure 1. As can be seen from Figure 1, the number of publications was low from 2017 to 2022, and the number of citations did not exceed 100. However, starting in 2023, the number of citations reached 155, in 2024 it reached 562, and in 2025 it exceeded 1000. This indicates that this topic has received increasing attention from scholars in recent years. Our subsequent research will focus on the period from 2023 to 2025.

3.2 Country & Journal Co-citation Analysis

Countries with more than 10 publications include China (51), the USA (28), England (15), and Germany (10). Which journals did they primarily reference? This article analyzed the top 30 most cited articles from 2023-2025, the main references with over 50 citations came from 5 journals, all of which started publishing in 2023, as shown in Figure 2.

3.3 Topics from the Literature

To explore the development of AI in Digital Education research, this study analyzed 167 related papers published between 2023 and 2025. Literature covers 6 topics, as shown in Table 1.

From these six topics, the integration of AI into education is an inevitable trend. After scholars have discussed the advantages of AI in personalized learning for students, the liberation of teachers from tedious and repetitive work brought about by the transformation of teachers' roles, and reflections on educational equity and ethics, more scholars are now researching how to better integrate

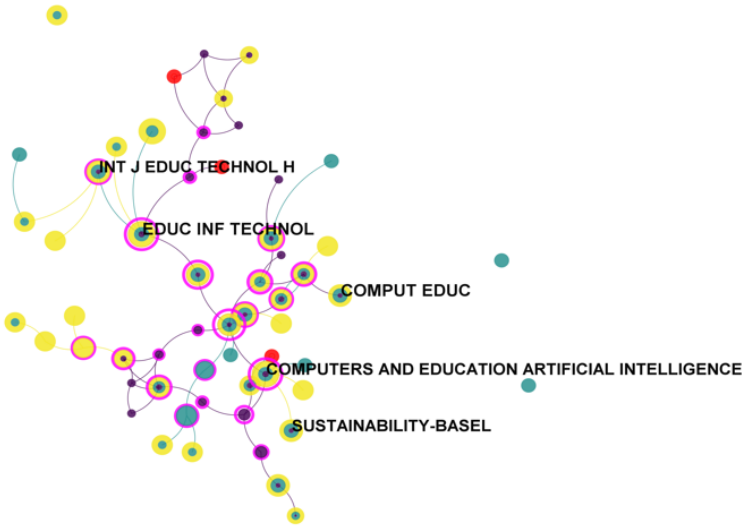

Figure 2: Journal Co-citation Analysis (2023-2025)

AI into digital education through the optimization of educational technology.

4 APPLICATIONS OF AI IN DIGITAL EDUCATION

Artificial intelligence in digital education typically follows a cyclical process: AI first delivers tailored learning content to students, then automatically evaluates learning outcomes, identifies weak areas through assessment, provides targeted guidance, and finally reformulates personalized learning recommendations based on data [4]. Next, we outline five key applications of AI in digital education.

4.1 AI-Powered Personalized Learning Content Recommendation

The AI platform generates customized videos and practice questions based on students' prior knowledge and academic performance, with difficulty levels matching individual needs. The system strategically schedules the most challenging chapters during students' peak concentration periods in the morning, while reinforcing mastery through familiar content to maintain confidence and facilitate completion of recommended materials [5].

4.2 Automated Grading System

Through assignments, students consolidate their knowledge. The repetitive task of teachers grading homework can be replaced by automated evaluation systems, freeing educators from handling massive workloads and allowing them to focus on higher-order assessments. AI can complete scoring, plagiarism detection, and error categorization within seconds: one for students detailing error types and improvement strategies, and another for teachers providing real-time insights into class performance and learning dynamics [6].

4.3 Automated evaluation and feedback Precision Intelligent

Tutoring Upon receiving evaluation results of students' learning outcomes, the intelligent tutoring system can provide targeted guidance. For instance, it offers micro-explanations for conceptual errors, step-by-step prompts for calculation mistakes, and demonstrates paragraph frameworks for writing structure issues. The conversational interface allows students to ask "why" questions, with the system providing analogical explanations based on their knowledge gaps rather than simply repeating standard answers [7].

4.4 Learning Analysis and Re-recommendation

After completing a learning cycle, we compiled all collected data. This data reveals both individual progress trajectories and class-level variations. The platform automatically tailors the next personalized learning content based on these insights, to complete the closed-loop cycle [8].

4.5 Conversational Virtual Tutor The four steps outlined above exemplify

AI integration in digital education. Through conversational virtual tutors, students can simply input their needs when encountering difficulties, triggering personalized learning content delivery, self-paced assignment evaluation, intelligent tutoring modules, and learning analytics with re-recommendations. These tutors can also detect students' frustration and proactively provide stress relief. This system empowers even students reluctant to raise hands in class to access instant private tutoring support, while maintaining a seamless human-computer interface throughout the closed-loop process [9].

5 CHALLENGES

The development of AI applications in digital education also faces challenges, such as: Prejudice spreads, Resource Gap, Teacher role diluted, Digital divide and equity, Privacy and academic integrity.

5.1 Prejudice spreads

When training data is predominantly composed of white middle-class students, algorithms tend to underestimate the needs of other groups, creating 'hidden exclusion'. More insidiously, when the system's recommendation paths go wrong, teachers and students often fail to notice the bias of persist and grow [10].

5.2 Resource Gap

High-quality, finely-grained, and ethically annotated educational data is scarce. Moreover, the computing power, software licenses, and dedicated technical teams required to build AI platforms represent a heavy burden for many schools, potentially leaving resource-constrained regions behind in the race [11].

5.3 Teacher role diluted

The more automated scoring and intelligent Q&A systems become user-friendly, the more likely it is for a classroom to become a mismatch between AI-led instruction and teacher observation. Without clear division of labor, teachers' emotional support, value guidance, and generative classroom interactions will be quietly weakened, the depth of learning will be undermined [12].

5.4 Digital divide and equity

In the same region, well-funded schools can take the lead in deploying the latest models, while disadvantaged schools struggle with unstable basic networks. The gap extends beyond hardware to a stark divide between 'data-rich' and 'data-poor' schools. The former continuously feed the system with data to generate better recommendations, while the latter fall into a vicious cycle where 'less data leads to poorer models and worse outcomes [13].

5.5 Privacy and academic integrity

Personalized learning requires continuous collection of sensitive data such as answer processes, facial expressions, and mouse movements. Any leakage or commercialization of this information could have irreversible consequences for minors. Moreover, the 'plagiarism temptation' of generative AI might lead students to bypass cognitive challenges, while teachers would struggle to distinguish original work from machine-generated content, which is a challenge to academic integrity [14].

6 FUTURE RESEARCH DIRECTIONS

The next step for AI in education is not to pursue "higher precision" single-point models, but to answer a simple question: how to create a sustainable "trio" of teachers, students and algorithms? The following topics deserve research resources.

6.1 Teacher-AI collaboration framework

There is a need to develop practical collaboration protocols and interface standards that clearly assign tasks: machines handle high-frequency, low-decision tasks (such as initial assignment approvals and resource recommendations), while teachers focus on low-frequency, high-decision tasks (like value guidance and emotional support). Research could measure changes in teachers' cognitive load, job satisfaction, and classroom interactions after collaboration, rather than solely focusing on student performance [12].

6.2 Explainable and dry budgeting

Even if the 'black box' model is accurate, it will weaken the professional authority of teachers. In the future, the training goal should be embedded with 'explanation' so that the system can present the decision basis in the language familiar to teachers (concept map, error distribution heatmap), and allow teachers to override or fine-tune the recommendation with one click, forming a closed loop of 'human-machine co-decision [15].

6.3 Policy and public governance

The current reality of technological advancement outpacing governance progress has become entrenched. Future research could collaborate with policymakers through joint experimentation: Establishing an Education Algorithm Impact Assessment (EIA) process requiring pre-launch submission of bias testing and risk mitigation reports; Creating independent audit repositories permitting third-party synthetic data testing of models; Developing an "AI Education Public Welfare Cloud" for resource-scarce regions through subsidies and open-source model integration to bridge access gaps. Only when these initiatives form a synergistic ecosystem will artificial intelligence truly become an educational infrastructure that amplifies teachers' value, respects student dignity, and narrows rather than widens inequalities [13].

7 CONCLUSION

The rise of generative artificial intelligence has reshaped knowledge acquisition pathways and compelled the education sector to reassess the transformative impact of AI on Digital Education. Through a thematic clustering approach, this study systematically analyzed 167 relevant papers. Cluster analysis revealed six primary topics: Educational Technology, Digital Literacy and AI, Teacher Education, Personalized Learning, Teacher Role Transformation, and Educational Equity and Ethics, identifying research trends in AI applications within Digital Education. However, persistent challenges including bias propagation, resource disparities, diluted teacher roles, digital divide and equity issues, privacy concerns, and academic integrity remain barriers to large-scale AI adoption in Digital Education. The implementation of AI in digital education has established a closed-loop system encompassing personalized recommendations, automated assessments, targeted tutoring, and data-driven re-recommendation. Current trends in Digital Education future research focus on establishing an 'AI-teacher collaboration framework' that is interpretable, intervenable, and ethically auditable, along with studies on topics such as interpretability, budget transparency, and policy and public governance.

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