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Navigating The Landscape of AI-Powered Personalized Learning in Primary Education: A Systematic Literature Review

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ABSTRACT

The integration of AI has brought about a significant transformation in primary education; however, the existing literature remains fragmented. This study aims to map the landscape of AI-powered personalized learning through a comprehensive literature review. The methodology employed is a systematic literature review, adhering to the PRISMA protocol, conducted in the Scopus database. Of the 114 documents identified, 33 selected scientific articles were analyzed using bibliometric techniques and content analysis with the help of VOSviewer and R Studio. The results of data analysis show a sharp spike in scientific production in 2025, with a total of 24 articles, an increase of up to 12 times compared to the annual average in the previous period. Indonesia leads the global contribution with a total of 7 related publications. The analysis of intellectual networks confirms the research focus on technological modalities for adaptive learning that cater to the unique needs of students. However, field implementation still faces significant challenges, including low teacher self-efficacy, limited infrastructure, and data privacy risks. The study concludes that strengthening the professionalism of educators and establishing a secure digital ecosystem are absolute prerequisites for technological success. Implication: Stakeholders need to restructure teacher training to focus on the interpretation of AI data.

Keywords: AI, Personalized Learning, Basic Education, Systematic Literature Review

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INTRODUCTION

The development of artificial intelligence (AI) in the past decade has brought significant changes to various sectors, including basic education (Mannuru et al., 2023; Rifky, 2024). AI is no longer understood solely as a technology of the future, but has become an integral part of a digital learning ecosystem that influences the way students and teachers teach, as well as how educational institutions design learning experiences (Anwar et al., 2025; Nguyen & Tuamsuk, 2022; Selwyn, 2022). In the context of basic education, AI offers excellent potential to deliver personalized, adaptive, and responsive learning to the individual needs of learners (Strielkowski et al., 2025). AI-based personalized learning enables the learning system to adjust content, tempo, and learning strategies based on cognitive, affective, and

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student learning behavior data, making the learning process more meaningful and effective (Fortuna et al., 2025; Sin & Barkhaya, 2024).

The urgency of studying AI-powered personalized learning in primary education is growing as the demand for quality education in the 21st century increases (Cakraningtyas et al., 2025; Syawaludin, 2025). Elementary school lays the foundation for the development of literacy, numeracy, critical thinking, and lifelong learning skills (Anwar et al., 2025; Kotsis, 2025). Therefore, the use of AI at this level must be comprehensively understood, not only in terms of technological innovation, but also from pedagogic, ethical, and policy perspectives (Barrera Castro et al., 2025). Recent literature suggests that AI contributes to increased learning engagement, formative assessment accuracy, and data-driven decision-making support for teachers (Akintolu & Oyekunle, 2025; Lagos-Castillo et al., 2025). However, on the other hand, AI integration also poses serious challenges related to teacher readiness (Filiz et al., 2025; X. Wang et al., 2023), technology access gaps, as well as the risk of algorithmic bias and violation of student data privacy (Sun, 2023).

Although the potential of AI in personalized learning has been widely discussed, the main problems still faced are the fragmentation of research findings and inconsistencies in the conceptual frameworks used (Merino-Campos, 2025). Existing studies often focus on the context of secondary or higher education, while studies that specifically examine basic education are still relatively limited and dispersed (Rasheed et al., 2023). Furthermore, the diversity in methodologies, variables, and success indicators used across these studies hinders the ability to draw comprehensive and definitive conclusions regarding the effectiveness and implications of AI-powered personalized learning in elementary schools (Amoako et al., 2024; Saleem et al., 2025).

These problems require a systematic approach to mapping, synthesizing, and critically evaluating relevant scientific findings. Without a structured synthesis, education stakeholders risk adopting AI technology partially, out of context, or even counterproductively, to basic education goals. Therefore, a Systematic Literature Review (SLR) is an important methodological solution to address the need for a comprehensive understanding of the AI-powered personalized learning landscape, including implementation patterns, supporting and inhibiting factors, and pedagogical and ethical implications.

Several previous studies have proposed conceptual and empirical solutions for the application of AI in personalized learning (Castro et al., 2024; Murtaza et al., 2022). The importance of a systematic framework for integrating AI with learning design principles has been emphasized (Weng et al., 2024), and it has been demonstrated that AI-based personalization can enhance learning outcomes when supported by valid data and transparent adaptive models (Murtaza et al., 2022). In the context of basic education, the role of AI in supporting inclusive learning through adaptive systems that can accommodate differences in students' abilities and learning styles has also been highlighted (Aslam et al., 2024; Essa et al., 2023).

Additionally, a data-driven decision-making approach is a key solution for optimizing AI in elementary school classrooms. Research demonstrates that AI-based learning analytics can enable teachers to monitor students' learning progress in real-time and design more targeted pedagogical interventions (Jackaria et al., 2024). However, the effectiveness of this solution is highly dependent on teachers' competence in understanding and utilizing data, as well as on the availability of adequate technological infrastructure (Alieto et al., 2024). Studies identified within the Scopus database further confirm that without continuous professional training and a focus on teacher digital literacy, the potential of AI is unlikely to be optimally utilized in the basic education ecosystem (Lagos-Castillo et al., 2025; Topali et al., 2025).

Although the literature has discussed various aspects of AI and personalized learning, significant research gaps remain, particularly in systematic synthesis focused on basic education. Research to date has typically addressed ethical, technological, or policy concerns in isolation, rather than integrating them into a comprehensive conceptual framework (de Villiers et al., 2023; Yang & Wibowo, 2022). Analysis within the Scopus database indicates that there are still limited studies that explicitly address how AI-powered personalized learning is navigated as an ecosystem involving students, teachers, curriculum, technology, and educational policy (Aihua & Cheng-Chung, 2025; Topali et al., 2025). It is this gap that underscores the importance of SLR to identify existing research patterns, consistency, and gaps.

Based on this exposure, the purpose of this study is to conduct a Systematic Literature Review using the Scopus database to map the AI-powered personalized learning landscape in primary education. This study is specifically geared towards answering three main research questions: (RQ1) what are the publication trends and intellectual structures of AI-related research for learning personalization in elementary schools; (RQ2) what are the dominant AI modalities used to support learning personalization at the elementary school level in the current scientific literature; and (RQ3) what are the benefits and strategic solutions for implementing AI-Powered Personalized Learning in Primary Education. This research provides both theoretical benefits by offering a comprehensive conceptual framework and practical benefits for stakeholders in designing teacher professional development. The novelty lies in integrating trend analysis, technology mapping, and solution-oriented studies of teacher readiness in one comprehensive SLR framework focused on the most recent high-quality scientific articles.

RESEARCH METHOD

This research employs a Systematic Literature Review (SLR) methodology to identify, assess, and interpret key findings related to AI-driven personalization in primary schools (Sauer & Seuring, 2023). The identification phase was conducted through a direct search in the Scopus database using a specific Boolean query string: ((“artificial intelligence” OR “AI” OR “machine learning” OR “intelligent tutoring systems” OR “generative AI”) AND (“personalized learning” OR “adaptive learning” OR “individualized instruction” OR “tailored learning”) AND (“elementary school” OR “primary school” OR “primary education” OR “K-6” OR “madrasah ibtidaiyah”)). This initial identification phase yielded a total of 114 documents for further screening. The search was focused on articles from the last decade to ensure the relevance of the findings to the current digital era.

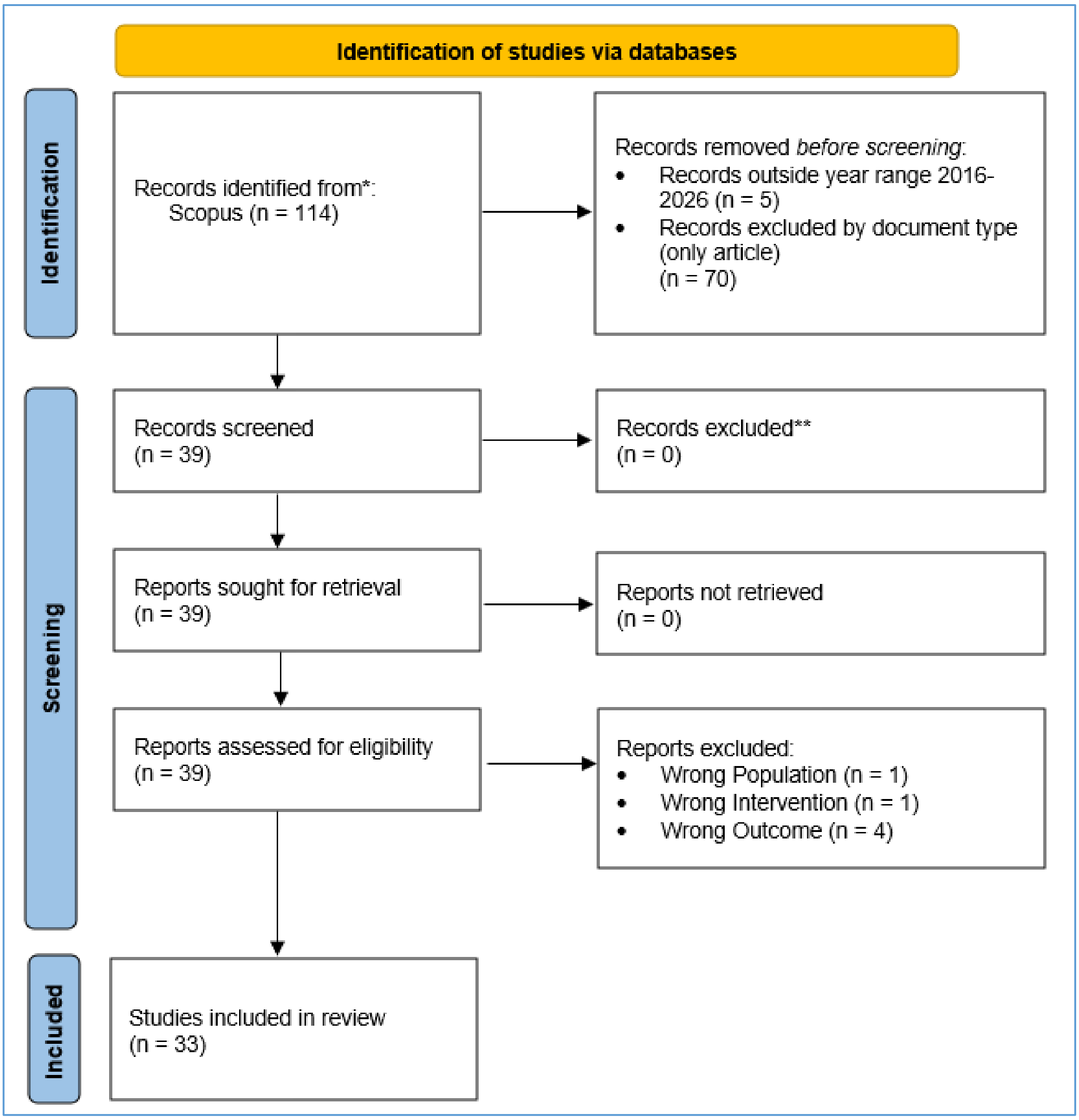


Figure 1 PRISMA flow diagram of the study selection process

The selection process strictly followed the PRISMA protocol to ensure transparency and reproducibility in the literature filtering phase (Page et al., 2021). From the initial 114 documents, 39 articles were identified as potentially eligible for an intensive full-text assessment after screening titles and abstracts. Upon rigorous evaluation, six articles were excluded based on specific criteria: one for the "wrong population," one for the "wrong intervention," and four for the "wrong outcome." Consequently, 33 articles were finalized for inclusion, providing a robust data foundation for exploring AI-based personalization in elementary settings.

Data analysis and synthesis were conducted using a combination of bibliometric and content analysis techniques to address the research questions. The study utilized VOSviewer for initial network visualization and R Studio (Biblioshiny) for advanced mapping of thematic evolution and research trends (Aria & Cuccurullo, 2017). This approach enables a systematic exploration of the current literature landscape, identifying the proximity of AI study topics to primary education practices. By integrating these computational tools, the research provides an argumentative roadmap for identifying research gaps and future directions in pedagogical transformation.

RESULTS AND DISCUSSION

RQ1: What are the publication trends and intellectual structure of AI research for learning personalization in elementary school?

Annual Scientific Production

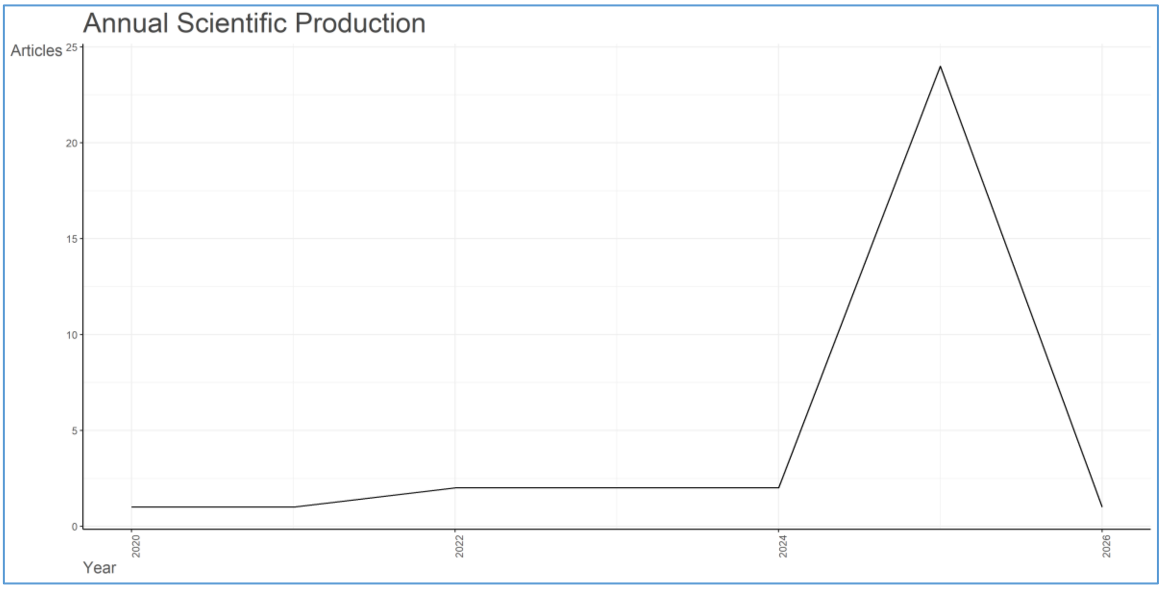


Figure 2 Annual scientific production trend (2020–2026) (Source: Biblioshiny analysis)

Based on Figure 2, the annual trend in scientific production regarding AI for personalizing learning in elementary schools exhibits a contemporary growth pattern. The data visualization confirms that the peak of publication occurs significantly in 2025 with a total of 24 scientific articles indexed by Scopus. The increase in the number of documents is drastic when compared to the period from 2020 to 2024, which produced an average of only one to two articles per year. The data represent a global urgency in integrating artificial intelligence technology to address pedagogical challenges at the current primary education level.

Innovation Diffusion Theory, as developed by Everett Rogers, serves as the primary foundation for understanding the speed of adoption of AI technology, as evident in the surge of 2025 data. The adoption of this digital innovation is strengthened by findings that the development of AI-based learning companions has now become a new standard for solving math problems in elementary schools (Kuo et al., 2026; Taşdelen & Bodemer, 2025). This future learning standard is also emphasized by evidence that personalized learning materials through generative AI can significantly improve students' motivation and academic performance (Kim & Kim, 2025; Liu et al., 2025; Zaini et al., 2025). This growth of literature concludes that AI technology has reached a critical phase in the basic education ecosystem, where the integration of technology is no longer an option but rather a fundamental necessity to support the individuality of students.

Most Relevant Sources

Table 1 Top 10 most relevant sources or journals by document count

No.	Sources	Articles
1	COMPUTERS AND EDUCATION	2
2	COMPUTERS IN THE SCHOOLS	2
3	EDUCATIONAL PROCESS: INTERNATIONAL JOURNAL	2
4	INTERNATIONAL JOURNAL OF ADVANCED COMPUTER SCIENCE AND APPLICATIONS	2
5	APPLIED COGNITIVE PSYCHOLOGY	1
6	COGENT EDUCATION	1
7	COMPUTERS AND EDUCATION: ARTIFICIAL INTELLIGENCE	1
8	DATA	1
9	DATA AND METADATA	1
10	EDUCATION AND INFORMATION TECHNOLOGIES	1

(Source: Biblioshiny analysis)

Based on table 1, the identification of the most relevant publication sources shows the dominance of highly reputable educational technology journals. The journals *Computers and Education* and *Computers in the Schools* occupy the top position as the primary forums that publish the most research on AI in elementary schools. The distribution of articles in these journals shows consistency in publishing findings related to intelligent tutoring systems and adaptive learning over the past decade. The focus of publications on these sources provides strong scientific validity to the development of technology-based learning, personalization theory, and practice for early childhood.

Cognitive Load Theory, as proposed by John Sweller, is a key theoretical reference often discussed in various articles published in major journals. The application of this theory to digital instructional design is supported by research designed to facilitate word problem-solving without overstraining students' working memory through generative AI-based learning environments (Tayeh, 2025; D. Wang et al., 2025). Furthermore, concerns regarding working memory and learning efficiency highlight the need for elementary school teachers to utilize AI-based digital textbooks to navigate complex curricula more straightforwardly (Al-Karasneh et al., 2025; Cardenas-Cobo et al., 2025; X. Wang & Wei, 2025). The complexity of this learning medium underscores the importance of selecting credible journal sources in disseminating AI best practices that strike a balance between cognitive load and pedagogical effectiveness in the classroom.

Most Relevant Authors

Table 2 Top 10 most relevant authors by number of documents published

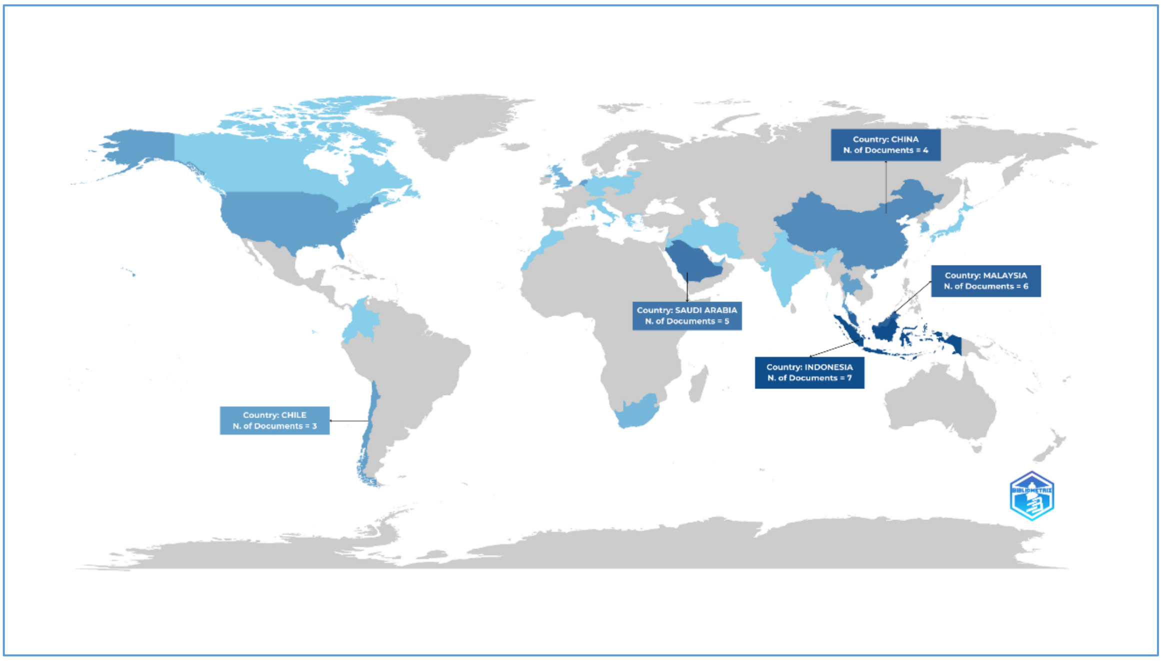
No.	Authors	Articles	Articles Fractionalized
1	CHEN G	2	0,41666667
2	ABINAYA M	1	0,5
3	ACAMPORA G	1	0,14285714
4	ACKERMANS K	1	0,2
5	AKINTOLU M	1	0,5
6	AL-BARAKAT AA	1	0,16666667
7	AL-KARASNEH SM	1	0,16666667
8	ALALI RM	1	0,16666667
9	ALBAHIRI MH	1	0,33333333
10	ALHAJ AAM	1	0,33333333

(Source: Biblioshiny analysis)

Based on Table 2, the analysis of the most contributing authors reveals the profiles of key researchers who drive intellectual development in this field. The researcher, on behalf of Chen G, emerged as the most prolific author, with the most significant number of publications compared to other researchers in the Scopus dataset. The contribution of these authors is not only evident from the quantity of articles, but also from their focus on developing intelligent algorithms for learning evaluation. The distribution of the author's productivity shows the existence of a group of experts who consistently conduct experiments and develop AI modalities for primary education.

The TPACK (Technological Pedagogical Content Knowledge) framework, developed by Mishra & Koehler (2006), is the theoretical foundation underlying the intellectual contributions of these prolific writers. High technopedagogical knowledge enables experts to identify user needs for adaptive learning through a student-centered design approach(Ghaemi & Bahrami, 2025; Zhao et al., 2025; Zhu et al., 2025). Furthermore, students, as the main subjects of learning, are uniquely positioned in research that explores the influence of generative AI-assisted learning on reducing math anxiety at the elementary school level (Ponomariovienė & Jakavonytė-Staškuvienė, 2025; Shabir et al., 2025; Xu et al., 2025). The finding that such learning anxiety can be overcome through expert guidance concludes that collaboration between technology expertise and pedagogy is an absolute requirement for creating humanistic and practical AI innovations for children.

Country Scientific Production



(Source: Biblioshiny analysis)

Figure 3 Distribution of documents by country

Based on Figure 3, the geographical distribution of scientific production reveals a significant contribution from countries in the Asian and Middle East regions. Indonesia leads as the most prolific country in producing AI research for primary education, followed by Malaysia and Saudi Arabia with competitive frequency. The dominance of these developing countries shows that there is great ambition in making technological leaps (*leapfrogging*) to improve the quality of national education. This data illustrates that the issue of AI-based learning personalization is no longer just the domain of Western countries but has become a massive global agenda.

Lev Vygotsky's Social Constructivism Theory provides an in-depth perspective on why countries such as Indonesia and Malaysia are very active in technology research that functions as digital scaffolding. This digital scaffolding through AI technology is reflected in studies integrating AI in problem-based learning in elementary schools to improve conflict resolution skills (Alsohaimi et al., 2025; Lhafra & Otman, 2023; Wells & Auletto, 2025). These social and cognitive skills are also the focus of researchers developing recommendation systems to support student programming competence in non-Western elementary school environments (Abinaya & Vadivu, 2023; Annuš & Kmet', 2024; Xing, 2025; Yuan, 2024). These diverse educational environments prove that the global utilization of AI is a means to realize social learning that is more equitable for all students in various parts of the world.

RQ2: What are the dominant AI modalities used for learning personalization at the elementary school level in the current literature?

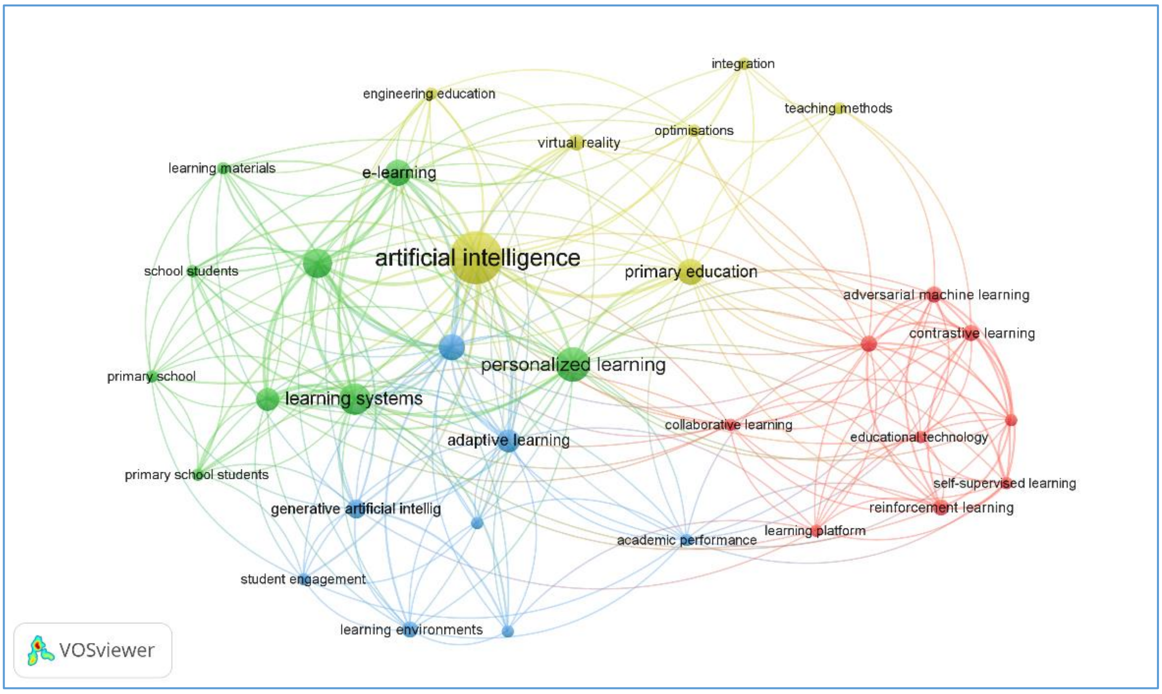


Figure 4 Co-occurrence Network Map of AI-related Keywords

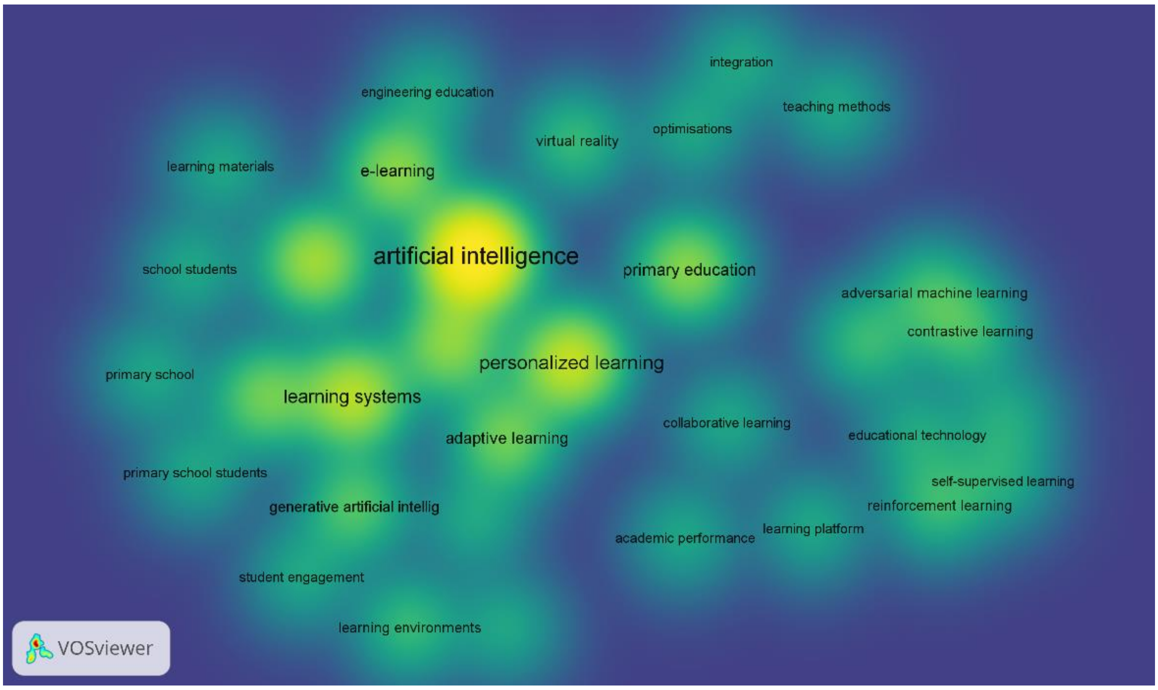


Figure 5 Heat map visualization of AI-related keywords

Figures 4 and 5 present a bibliometric mapping of the trends in artificial intelligence research in the education sector from different but complementary perspectives. Based on the network visualization in Figure 4, the keyword "artificial intelligence" appears as a central node that connects four main clusters, namely the primary education cluster (yellow), e-learning (green), adaptive learning (blue), and educational technology (red). This linkage is emphasized by the density visualization in Figure 5, where the "artificial intelligence" node has the most intense yellow intensity, followed by "personalized learning" and "primary education". This indicates that the current research focus is not only theoretical but has also been intensively concentrated on applying AI to personalize students' learning experiences, especially at the elementary school level.

The dominance of the topic of artificial intelligence in personalizing the learning experience aligns with Lev Vygotsky's Social Constructivist Theory, which emphasizes that the design of the learning environment must facilitate the unique needs of each individual through their social interactions. The focus on the unique needs of each individual is currently accommodated by AI technology through the provision of *digital scaffolding* that can automatically adjust the difficulty level of the material (Pardamean et al., 2022; Yu et al., 2022). The implementation of automatic adjustment of the difficulty level of material has been proven in various literature studies to minimize learning barriers and significantly increase students' cognitive involvement (Lee et al., 2020; Rungrat et al., 2021). Thus, the integration of students' cognitive engagement through AI-based systems is the primary key to transforming conventional learning models towards a more adaptive and inclusive future education ecosystem.

RQ3: What are the benefits and strategic solutions for implementing AI-Powered Personalized Learning in Primary Education?

Based on an analysis of 33 selected articles, the primary challenge in implementing AI in elementary schools is the technical and pedagogical readiness of educators. The results of the review revealed that the most significant obstacles included a lack of supporting infrastructure, ethical concerns related to student data privacy, and low teacher self-efficacy in operating adaptive systems. Most studies report that, despite the availability of technology, many teachers feel overwhelmed by the complexity of algorithmic navigation, which often conflicts with the rhythm of daily teaching. This phenomenon is complicated by the existence of a real digital competency gap, where AI literacy is often not part of the continuous professional training of teachers at the elementary school level.

Albert Bandura's Theory of Self-Efficacy is the primary foundation in understanding why these psychological and technical challenges arise among educators (Bandura, 2013). The self-efficacy of teachers in integrating AI technology is strengthened by findings that the level of technical support and ease of system modification greatly influences teachers' confidence (Yehya et al., 2025). Furthermore, rigid and difficult-to-modify systems actually reduce teachers' interest in using learning data analysis as a basis for instructional decision-making (Sundqvist et al., 2023). The decision to adopt AI in the classroom is also hampered by the still high administrative burden and the limitations of pedagogical knowledge in the context of digital technology (Shabir et al., 2025). This limited technopedagogical knowledge suggests that the challenge of AI implementation is not only a technical hardware problem but also a problem of improving professional competencies that must encompass an integrative, ethical, technical, and pedagogical understanding.

Table 3 Synthesis of Teacher Competency Challenges and Needs

Categories	Challenge Description	Related Authors
Technical & Infrastructure	Lack of compatible devices and stable connectivity.	Alsohaimi et al. (2025); Kim & Kim (2024)
Effectiveness & Pedagogy	Low teacher confidence in modifying AI algorithms.	Wells & Auletto (2025); Akintolu & Oyekunle (2025)
Ethics & Policy	Data Privacy Concerns and Algorithmic Bias in Children.	Al-Karasneh et al. (2025). Shabir et al. (2025)
Digital Competence	The Need for AI Literacy and Academic Data Management.	Nadziroh et al. (2024); Pardamean et al. (2024)

Based on Table 3, the synthesis of teacher competency challenges and needs reveals that integrating AI in elementary schools is a multidimensional process that requires a balance between system support and individual capacity. Technical challenges, such as limited infrastructure, require institutional commitment, while pedagogical barriers require the development of teachers' self-efficacy through field-practice-oriented training. The need for ethical literacy and data management skills is a new competency aspect that teachers must master to ensure the safety and effectiveness of learning personalization for students. The juxtaposition of this challenge data demonstrates that mastery of technology alone is insufficient without also strengthening the dimension of teacher professionalism in the era of disruption.

The findings of this study offer strategic implications for stakeholders in the field of basic education, particularly in the design of digital transformation policies. The first implication relates to the need to restructure the teacher training curriculum, which focuses not only on the operation of tools but also on the ability to interpret AI data for personalized learning. Effective personalization can only happen if the school provides infrastructure support and data privacy policies that provide a sense of security for teachers and parents. Data security is an absolute prerequisite for building a healthy digital ecosystem in madrasas and elementary schools. The ecosystem will trigger a more inclusive improvement in the quality of learning, where AI acts as an intelligent assistant that expands the pedagogical reach of teachers without eliminating the human element in education.

Although it provides a broad picture, this study has some limitations that need to be acknowledged. First, the databases used are limited to Scopus, so quality articles from other databases, such as Web of Science or ERIC, may not be fully covered. Second, most of the analyzed articles are newly published research (2016-2026), with a peak in 2025, so the long-term impact of AI implementation on early childhood psychology cannot be fully assessed. Third, this analysis focuses primarily on the content of the text, rather than conducting direct observations in the field to verify the practical efficacy of the technology.

Future research is expected to expand the scope of analysis with statistical meta-analysis methods to measure the effectiveness of each AI modality more quantitatively. Furthermore, additional research is needed to explore the ethical implications and long-term effects of using generative AI on the cognitive and social development of elementary school students. Longitudinal studies on changes in teacher workload after AI adoption are also highly recommended to provide more accurate recommendations for education policy development. The integration between AI technology and character values in Madrasah Ibtidaiyah is a promising research opportunity to realize the digitalization of education that remains characteristic.

CONCLUSION

This study has successfully conducted a systematic literature review to map *the landscape of AI-powered personalized learning* in primary education. The results of the study indicate that the trend of research publications is expected to experience a significant surge in 2025, with a substantial geographical contribution from developing countries such as Indonesia and Malaysia. Key findings confirm that the current intellectual focus of research is concentrated on the use of AI modalities for adaptive learning personalization, thereby facilitating the unique needs of students. However, its implementation is still hindered by practical issues, including gaps in teacher technopedagogical competency, infrastructure limitations, and ethical concerns about student data privacy. The study makes a significant theoretical contribution by providing a comprehensive conceptual map that integrates technological trends with field challenges, serving as a roadmap for a more inclusive pedagogical transformation. Given the limitations of studies that focus only on the Scopus database over a period of time, future research is recommended to expand the scope of the literature to other international databases and use meta-analysis methods to quantitatively measure the effectiveness of each AI modality, as well as conduct longitudinal studies to explore the long-term psychosocial impact of generative AI use on the cognitive and social development of primary school students.

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