

Artificial Intelligence in Elementary Education: A Bibliometric Analysis and Systematic Literature Review

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Abstract: This study presents a bibliometric analysis and systematic literature review of AI in primary education by searching the Scopus database in August 2025. The initial search identified 619 articles, and after screening, 57 articles published between 2021 and 2025 were analyzed. The analysis was conducted using bibliometric analysis and the TCCM framework, which was applied to answer research questions and map research gaps. The findings show an increasing trend in publications each year, with the most articles published in 2025 ($n = 27$), while the peak in annual citations occurred in 2024 (with 561 citations). Keyword co-occurrence analysis formed five clusters, namely AI literacy and pedagogy; GenAI and personalization; student perceptions; AI literacy in elementary schools; and student behavior. The TCCM analysis identified various theories used, with TAM/UTAUT being the most frequently applied. In terms of context, the most frequent participants were elementary school students ($\approx 50\%$; 26 studies), followed by teachers, prospective teachers/students, a combination of students and teachers, and school management. In terms of characteristics, 15 main categories of factors were mapped, namely personal, intention, attitude, usage, usefulness, ease, pedagogical, and knowledge, which were the dominant categories. In terms of methods, survey-based quantitative designs were the most dominant ($n = 25$; 44.6%), with SEM-PLS as the analysis technique. Furthermore, this study synthesizes the latest evidence to describe research gaps and offers a future research agenda for advancing AI in the context of primary education.

Keywords: Artificial intelligence; PRISMA framework; TCCM (Theory, Context, Characteristics, Methods framework; Technology for education

Introduction

Artificial intelligence (AI) has advanced rapidly in recent years, dramatically changing the way we interact, learn, and work. AI is gaining popularity, including in the education sector, as a catalyst for data-driven decision-making and personalized learning (Kamalov et al., 2023; Vieriu & Petrea, 2025). In the United States, approximately 25% of K-12 teachers have used AI for lesson planning or delivery (Kaufman et al., 2025). A national survey by the Royal Society of Chemistry found that 44% of teachers in the UK have also used AI in their

teaching roles, indicating significant early adoption (RSC, 2024). While the discourse on AI in education often focuses on higher education, the trend of adoption in primary education is also gaining momentum, supported by improvements in global access, with approximately 40% of primary schools now connected to the internet (UNESCO, 2023). At the same time, the knowledge and research ecosystem for AI in education is growing rapidly, though the focus is more on higher education than on primary and secondary education (Guo et al., 2024). This situation raises a crucial need for

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a systematic understanding of the use of AI, its impacts, and limitations in the context of primary education.

In the context of basic education, particularly for elementary school students, cognitive development is still gradual and based on experience and requires a high level of emotional support, as well as a heavy reliance on the role of teachers, which requires a different approach than at other levels (Dewi & Elisa, 2025; Qiftiyah, 2020). AI promises potential solutions aligned with the needs of elementary school children, such as natural language processing (NLP)-based conversational agents to guide children's reading, writing, and speaking (Xu et al., 2021); intelligent tutoring systems to personalize learning based on cognitive level (S. Feng et al., 2021); and learning analytics to predict and monitor students' academic progress (Bem-Haja et al., 2025). With such promising potential, AI seems to be highly sought after for inclusion in both school and independent learning. However, this potential needs to be carefully weighed regarding the reliability of the AI model, the suitability of the resulting material to the child's developmental stage, and the teacher's readiness to integrate it with their pedagogical skills.

On the other hand, the AI ecosystem has complex implications for data governance and the ethics of its use (Stahl, 2025). Concerns about algorithmic bias, privacy, and the transparency of decision-making resulting from data collection are often widespread (Aker et al., 2021; Julien Kiese Bahangulu & Louis Owusu-Berko, 2025; Min, 2023). These concerns also arise regarding the use of AI, which risks making it more difficult for schools with adequate infrastructure to utilize it effectively, rather than making it easier (Vieriu & Petrea, 2025). In the context of primary education, the use of AI must prioritize the safety and best interests of students (Huang, 2023). Therefore, to determine whether the use of AI in educational contexts is truly consistent with the goals of comprehensive and holistic education, a comprehensive research mapping is necessary.

Despite the abundance of research on the benefits of AI in education, the current state of research on this topic remains fragmented due to various factors such as different study designs, small sample sizes, and diverse geographic and sociocultural contexts. This fragmentation undoubtedly makes it difficult to draw general conclusions that can then be relied upon to inform policy recommendations for governments. This knowledge gap underscores the need for a rigorous systematic review. Based on this gap, this article conducts a Systematic Literature Review (SLR) to synthesize scientific evidence on the use of AI in primary education contexts. SLR was chosen because of its systematic reliability, providing a transparent and replicable knowledge map, minimizing selection bias, and enabling the identification of research patterns

(Williams et al., 2021). Through standardized searches and explicit inclusion and exclusion criteria, this SLR study aims to: 1) identify research trends resulting from bibliometric analysis of AI literature in primary education contexts; 2) describe the main theories explored in the AI literature in primary education contexts; 3) describe the contexts used in the AI literature in primary education contexts; 4) describe the factors influencing the use of AI in primary education contexts; and 5) describe the research methodologies used in the AI literature in primary education contexts.

This study offers several novelties that make it important compared to previous SLRs on AI in education. First, existing SLRs focus on higher education or combine all levels. This study specifically focuses on basic education, which is often underrepresented in educational research despite its crucial role. Second, this study combines bibliometric mapping with in-depth qualitative synthesis using the TCCM framework, which allows for a deeper understanding of theoretical studies and pedagogical roles. Ultimately, the theoretical contribution of this study is expected to be the creation of a taxonomy of AI use in the context of primary education and a mapping of its pedagogical integration mechanisms, which can serve as the basis for a conceptual model of AI application. From a practical perspective, the results of this SLR are expected to produce in-depth recommendations that can be followed up by teachers, principals, parents, educational technology developers, and policymakers in creating AI-based schools that are safe and comfortable for students. Finally, this SLR is also expected to bridge the gap between the potential of AI and everyday learning practices in elementary schools, while providing clear direction for education innovators to develop their research and policies in the future.

Method

This study conducted a literature review to answer the research questions using a systematic literature review (SLR) methodology and bibliometric analysis. Overall, this study critically examines the implementation of artificial intelligence (AI) in elementary education and identifies research trends and emerging findings based on identified articles. The SLR methodology was chosen because it provides a comprehensive, easy-to-understand, and objective overview of the themes, trends, and clustering of published scientific articles in the field of AI in elementary education (Lim et al., 2022). A comprehensive literature search was conducted in the Scopus scientific database with the help of Harzing Publish or Perish. The search string was formed based on the research question to ensure that all articles were relevant to the implementation of artificial intelligence

(AI) in elementary education. The search string was formed based on the following keyword combination.

("Artificial Intelligence" OR "AI") AND ("elementary education" OR "primary education" OR "elementary school" OR "primary school"). The search was conducted in August 2025, with articles published between 2021 and 2025. To ensure relevance, the search

focused only on English-language articles that are accessible and understandable worldwide.

The inclusion and exclusion criteria were outlined to ensure that information irrelevant to the research topic was excluded from the data analysis process. The inclusion and exclusion criteria are outlined in Table 1.

Table 1. Inclusion and Exclusion Criteria

Inclusion criteria	Exclusion criteria
IC1: Articles must discuss the implementation of AI in the context of primary education (either in primary schools or for university students or prospective primary school teachers).	EC1: Articles must be non-English-language and published as book chapters.
IC2: Articles must be research results on the implementation of AI in the context of primary education.	EC2: Articles must examine AI but not specifically target primary education.
IC3: This article reports on factors supporting and inhibiting the implementation of AI in the context of primary education.	EC3: The article examines AI techniques not directly related to the context of primary education.
IC4: This article is well-researched and published in a Scopus-indexed journal or conference paper from 2021 to 2025.	

The selection process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. The selection steps included: (1) initial screening based on the title, (2) reviewing the abstract, and (3) reviewing the full text of the paper in detail. By following these steps, researchers can ensure the credibility and validity of the articles that pass the selection process, thereby ensuring the scientific acceptability of the research results.

The PRISMA protocol flowchart in Figure 1 shows that 57 studies were identified and selected for further analysis. The initial keyword search identified 619 articles in the Scopus database, with one article removed due to the same or a duplicate title. Next, the remaining 618 articles were screened, starting with non-articles, non-reviews, titles, abstracts, and full texts, resulting in 57 articles remaining for review.

After the article selection process was complete, the researchers compiled information from each article into a data extraction form in a Microsoft Excel spreadsheet. This included elements integrated with the TCCM framework: title, author(s), year of publication, number of citations, theory, context, characteristics, and methods.

The analysis was conducted using two main approaches: bibliometric analysis and TCCM. First, the bibliometric analysis was conducted to identify publication trends, including the most productive journals publishing AI in the context of primary education, along with their number of citations, and keyword co-occurrence analysis. This analysis was aided by VOSviewer software to visualize topic maps and thematic clustering of keywords.

Second, the analysis was conducted using the TCCM framework (theory, context, characteristics, and method). In the theory dimension, the study explores the theories used in the research, particularly those related to the acceptance of AI in the context of primary education. The context dimension maps the geographic context of the country, the research subjects or samples, the subjects studied, and the type of AI used. The characteristics dimension examines internal and external factors directly related to the use of AI in primary education. The Method dimension identifies the

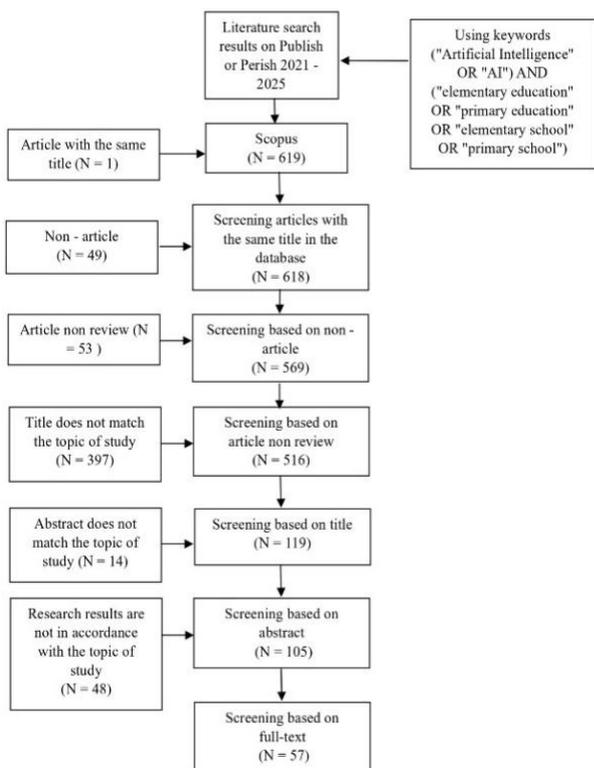


Figure 1. Systematic article selection process

research methods used, whether quantitative, qualitative, mixed methods, or developmental research. Both analyses were conducted with the ultimate goal of uncovering the evolution of AI knowledge in primary education and potential future research directions based on empirical patterns.

Results and Discussion

Artificial Intelligence in the context of primary education has emerged as a new research field due to the rapid development of technology. Figure 2 depicts the total number of articles published annually and the total number of citations received each year for 57 articles published between 2021 and 2025. The highest number of articles was published in 2025 with 27 articles, followed by 2024, 2023, 2022, and 2021. The highest number of total citations was in 2023 with 561 citations.

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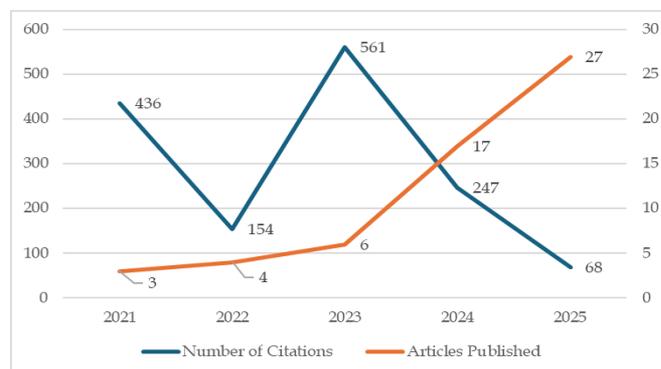


Figure 2. Number of citations and articles published between 2021 and 2025

Table 2. presents the bibliographic sources contributing to the articles analyzed. The journal/proceedings with the most articles on AI in the context of primary education was Sustainability Switzerland. This journal originates from Switzerland which is indexed by Scopus Quartile 1.

Table 2. Bibliographic Sources

Source Bibliography	Number of Articles
Sustainability Switzerland	6
ACM International Conference Proceeding Series, Education and Information Technologies	4
Computers and Education Artificial Intelligence	3
Education Sciences, Educational Process International Journal, Interactive Learning Environments, International Journal of Information and Education Technology, International Journal of Learning Teaching and Educational Research, Journal of Educational Computing Research	2
Acta Psychologica Sinica, Asian Journal for Mathematics Education, Bio Web of Conferences, Ceur Workshop Proceedings, Child Health Nursing Research, Computer Supported Collaborative Learning Conference CscI, Computers and Education, Educational Technology and Society, Educational Technology Research and Development, Eurasian Journal of Educational Research, European Journal of Education, Frontiers in Psychology, Icetm 2024 Proceedings of the 2024 7th International Conference on Educational Technology Management, IEEE Access,	1
International Journal for Lesson and Learning Studies, International Journal of Engineering Science and Information Technology, International Journal of Technology and Design Education, International Journal on Advanced Science Engineering and Information Technology, International Review of Research in Open and Distributed Learning, Jurnal Online Informatika, Ksii Transactions on Internet and Information Systems, Learning and Instruction, Procedia Environmental Science Engineering and Management, Proceedings of 2024 3rd International Conference on Artificial Intelligence and Education Icaie 2024, Psychology Research and Behavior Management,	1

Source Bibliography	Number of Articles
Sage Open, Social Sciences and Humanities Open.	

The publication of scientific articles is crucial for the development of various fields. Publication accelerates the dissemination of these fields. Understanding the development and evolution of a field through publications will undoubtedly provide a deeper

understanding of the subject, object, and the identification of the relationships between authors. The following are the top five published articles in the field of AI in the context of elementary education based on their citation scores.

Table 3. Top Five Published Articles Based on Their Citation Scores

Year	Title	Author	Article	Number of Citations
2021	Perceptions of and Behavioral Intentions towards Learning Artificial Intelligence in Primary School Students	Ching Sing Chai, Pei-Yi Lin, Morris Siu-Yung Jong, Yun Dai, Thomas K. F. Chiu and Jianjun Qin	Educational Technology and Society	283
2023	Generative AI and ChatGPT in School Children’s Education: Evidence from a School Lesson	Jussi S. Jauhiainen, and Agustín Garagorry Guerra	Sustainability Switzerland	194
2023	Exploring the AI competencies of elementary school teachers in South Korea	Keunjae Kim and Kyungbin Kwon	Computers and Education Artificial Intelligence	160
2021	Why and What to Teach: AI Curriculum for Elementary School	Seonghun Kim, Yeonju Jang, Woojin Kim, Seongyune Choi, Heeseok Jung, Soohwan Kim, and Hyeoncheol Kim	35th Aaai Conference on Artificial Intelligence Aaai 2021	147
2022	AI-Based Learning Style Prediction in Online Learning for Primary Education	Bens Pardamean, Teddy Suparyanto, Tjeng Wawan Cenggoro, Digdo Sudigy, and Andri Anugrahana	IEEE Access	107

The next step in the bibliometric analysis was to analyze keyword co-occurrence within the content of each article. This analysis can be used to monitor frequently researched topics (H. G. Kim et al., 2024). The findings of this study, displayed in Figure 3, show that the concept of artificial intelligence in elementary education forms a complex and interconnected network. The term "artificial intelligence" is the primary keyword connecting several other keywords, such as AI literacy, AI education, instructional design, behavioral intention, and primary or elementary school. This indicates that artificial intelligence is positioned as a keyword that encompasses various aspects of its application in learning at the elementary education level.

The network analysis in this study also revealed five main clusters representing different research focuses. The first cluster (yellow-green) focuses on the study of AI literacy and education, encompassing keywords such as AI literacy, AI education, instructional design, and pedagogy. This cluster appears to represent research on school curriculum development,

instructional design, and learning models that effectively utilize AI in elementary schools. The second cluster (red) focuses on generative artificial intelligence and ChatGPT, which are directly related to primary school teachers, personalized learning, and primary mathematics education. This cluster clearly demonstrates a high level of interest in the use of Gen-AI, especially ChatGPT, to support personalized learning and technology integration by elementary school teachers. The third cluster (blue) links primary or elementary education with student perceptions through keywords such as perception, metaphor, and drawing. This focus illustrates a qualitative approach to understanding students' views on AI, explored both directly through questionnaires and interviews and indirectly through metaphorical writing and drawings. The fourth cluster (purple) relates to artificial intelligence literacy, artificial intelligence education, and elementary school, highlighting the study's focus on introducing AI from the elementary school level, including its relevance to literacy. The fifth cluster (light

teachers/students, students and teachers, and school management. Figure 5 shows that there were significantly more studies involving students (50%, 26 studies). This clearly indicates that the use of AI can impact student learning and achievement. Furthermore, post-COVID-19, students increasingly used mobile phones and artificial intelligence to complete assignments given during online learning (Rachman & Donald, 2025).

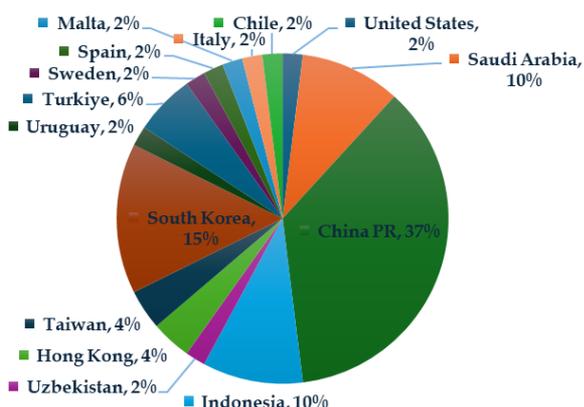


Figure 4. Geographic distribution by country

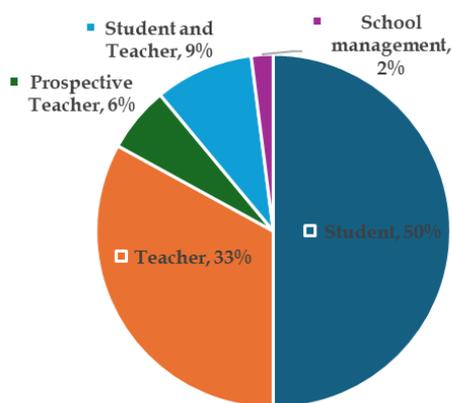


Figure 5. Distribution of participants in the studies

The results indicate that there were only a few articles directly linking AI to subjects. It was identified that there were only four subjects that were directly linked to AI, including mathematics with 6 studies as the most (Alsohaimi et al., 2025; K. Kim & Kwon, 2023; Li & Noori, 2024; Qiu et al., 2025; Ye et al., 2025; Yim, 2024),

followed by science with 4 studies (Almohesh, 2024; Castro et al., 2025; Lestari et al., 2024; Mazı & Yıldırım, 2025) and language with 4 studies (Dai et al., 2024; Y. Feng & Wang, 2023; K. Kim & Kwon, 2024; Tai & Chen, 2024) as well as social studies with only 1 study that linked it directly (Kuzu et al., 2025). Finally, the context identified in this study is through the perspective of the type of AI used. The most frequently used type of AI was ChatGPT, with nine studies, while AI such as AI-Robot, CoolE Bot, Ernie 3.5, and SquirrelAI were each only used in one study.

Several variables were identified as indicators of AI acceptance in the context of primary education. Based on the analysis of various articles, these key factors were divided into 15 categories: personal, intention, attitude, usage, usefulness, ease of use, ease of learning, social, technological, pedagogical, anxiety, accessibility, knowledge, experience, and others. The list of key factors and sub-factors, consisting of elements with similar phrases, was grouped and presented in Table 5.

In the field of AI in the context of primary education, various research methods and instruments have been used, such as case study analysis, SEM modeling, and regression analysis, as presented in Table 1. The analysis also revealed that primary data collection using survey-based quantitative methods was the most popular methodology, followed by interviews and qualitative methods. Appropriate research methods are fundamental to conducting academic research to ensure its scientific acceptance. Figure 6 shows that quantitative research methods (n = 25; 44.6%) are the most widely used methods for AI research in the context of primary education, followed by qualitative and mixed methods research methods, each with 11 studies (19.6%), and development research with nine studies (16.1%). In the predominant survey-based quantitative design, questionnaires are the primary instrument for measuring user acceptance of AI, particularly in the context of basic education, such as user perceptions, intentions, and experiences (Almohesh, 2024; Chai et al., 2021; Chung et al., 2025; Darmawan et al., 2024; Jang et al., 2022; Qiu et al., 2025; Qiu & Ishak, 2025; Yao & Abd Halim, 2023) These instruments are often adapted from theoretical models such as UTAUT or TAM and then modified to suit the local context.

Table 5. Characteristics of Factors and Sub-Factors

Main Factor	Sub-Factor
Personal	Gender, age, educational background, major, intrinsic motivation, career motivation, prior knowledge, adaptability, social anxiety
Intention	Behavioral intention, acceptance-willingness
Attitude	Attitude toward AI, perceptions using metaphors and images, optimism, satisfaction, discomfort, insecurity, self-confidence, behavioral problems, behavioral disorders, perceived trustworthiness, ethical awareness
Use	AI usage process, advantages and disadvantages of AI use

Main Factor	Sub-Factor
Usability	Perceived usefulness, perceived value, perceived ease of use, service quality, service efficiency, accessibility, scientific validity, pedagogical relevance
Ease of use	Perceived ease of use, discomfort of use, user-friendliness expectations
Ease of learning	Facilitating conditions, technical support, school infrastructure, technological resources, institution selection, tiered training, regional training, certification system, workforce management, teacher recommendations, adaptive learning material development
Social	Social impact, social influence, social support, social reduction, co-learning, collaboration, AI for social good
Technology	Assistive technology, intelligent teaching, intelligent learning tools, intelligent support
Pedagogy	Pedagogy, instructional design, learning models, curriculum, AI courses and instruction, supporting teaching and learning, teacher understanding and skills
Anxiety	Social anxiety, concerns about distraction
Accessibility	Accessibility, school infrastructure, technical support, technology resources
Knowledge	AI knowledge, digital literacy, critical data literacy, computational thinking, AI thinking, AI literacy, data literacy, understanding of AI, transferability of skills
Experience	Experience teaching AI
Other	TPACK, mental models, cognitive factors. Fraud

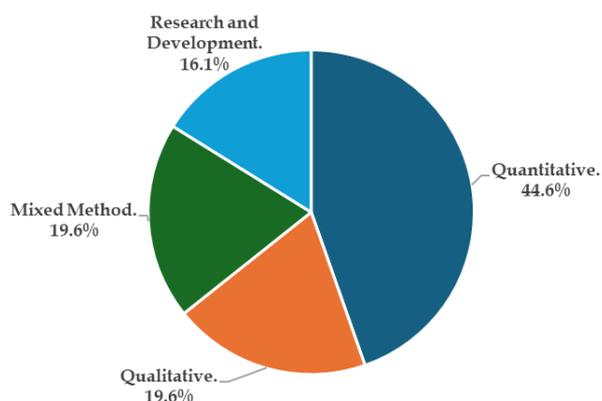


Figure 6. Research Design

In terms of data analysis techniques, especially data derived from quantitative designs, SEM is the most

widely used inferential statistical data analysis technique in AI articles in the context of elementary education (Almohesh, 2024; Castro et al., 2025; Chai et al., 2021; Darmawan et al., 2024; Lin et al., 2021). Meanwhile, in qualitative designs, interviews and observations are the instruments used to gather data, particularly to assess the usability and acceptance of AI. Interestingly, some studies still do not explicitly state their methodology, despite indications of using narrative qualitative analysis. This lack of methodological transparency will undoubtedly be a weakness that needs to be addressed in the future. Furthermore, the proportion of qualitative and mixed methods research remains low, even though these approaches have the potential to uncover many factors that cannot be explored through surveys.

Table 6. Research Methods, Including Instruments and Data Analysis Techniques

Method	Instrument	Data Analysis Technique
Quantitative	Questionnaire, test	SEM-PLS test, regression, t-test, ANOVA, mean, and median.
Qualitative	Observation, interviews, and focus group discussions	Content analysis
Mixed Methods	Mixed methods research combines aspects of qualitative and quantitative analysis.	

In an effort to capture the wave of acceptance or adoption of AI in the context of primary education, this study analyzed 619 initial articles in Scopus in August 2024 and then generated 57 articles using the PRISMA protocol. These articles were then extracted for TCCM-based and bibliometric analysis with the help of VOSViewer. In terms of publication trends, it shows an annual increase in the publication of articles on AI in primary education, with the most articles (n=27) published in 2025. Meanwhile, the number of citations each year peaked in 2024 (561). This indicates that the use of AI in primary schools is growing relatively rapidly, with previous studies being widely cited for subsequent research. This also establishes a common

pattern where initial research is influential, being cited, and triggering a wave of subsequent publications on more advanced research topics.

In terms of journals publishing articles, Sustainability (Switzerland) emerged as the most productive journal publishing articles on AI in primary education. The top five articles with the highest citations can be grouped into three axes, including: 1) elementary school teachers' AI competencies, the introduction of generative AI, especially ChatGPT, and students' perceptions and intentions regarding using AI. Keyword co-occurrence analysis shows results in the form of five large clusters consisting of AI literacy or education studies related to pedagogy, GenAI/ChatGPT

directly related to elementary school teachers, students' perceptions and intentions through metaphors and images, the introduction of AI from elementary school, and students' intentions and behavior, indicating that AI at the elementary school level is a multidimensional area that requires cross-theme synthesis. The bibliometric findings and keyword co-occurrence of this topic will form the basis for interpreting the results further through the TCCM framework.

In the theoretical dimension, Vygotsky's sociocultural theory, item response theory, linguistic theory in the context of language learning, task-technology fit (TTF) theory, social cognitive career theory, and TAM/UTAUT/TPB to explain technology acceptance, CTML for multimedia structuring and cognitive load, and TPACK for the integration of technology, pedagogy, and content competencies are all some of the many frameworks that exist in this dimension. However, not all articles analyzed explicitly and operationally narrate the theories used, resulting in many studies stopping at measuring attitudes or intentions without bridging the gap between learning processes and outcomes. Given the characteristics of elementary school, which are heavily influenced by the role of teachers, task structure, and institutional support, a conceptual model is needed that links technology acceptance with learning processes that have implications for achievement outcomes, so that it does not stop at indicating "whether AI is used or not" (Siagian & Artha, 2023). In other words, the theoretical foundation needs to be enriched, not simply selected, so that variables across models such as usability, cognitive load, engagement, and social support can be integrated into a logical and coherent explanation. The geographic map of the context dimension shows that China and South Korea contribute to AI research publications in the context of primary education, with the largest number of participants being students (approximately 50%, 26 studies), followed by teachers, prospective teachers/university students, student-teacher combinations, and school management. In the context of directly linking AI to subjects, only a small portion of the analyzed studies did so, including links to mathematics (n=6), science (n=4), language (n=4), and social studies (n=1). This finding suggests that for nearly five years, AI research in primary education has focused solely on the general acceptance of AI, which could create a research gap for the future. In terms of the type of AI used, ChatGPT is the most widely used AI, with 9 studies compared to other systems such as CoolE Bot, Ernie 3.5, and SquirrelAI (each with n=1). This landscape certainly implies the dominance of centralized contexts such as geographic context and type of AI. This imbalance risks creating the perception that AI can only be used by developed countries. Furthermore, this imbalance in AI

types also risks creating the perception that effective AI is solely focused on LLM-based AI.

In terms of characteristics, the analysis identified 15 main factors in AI in elementary education. The general trend shows a strong emphasis on the study of acceptance or intention and the process of use, while learning outcomes (achievement, transfer, higher-order thinking) are rarely positioned as primary research outcomes. Elementary school students, who are still in the Zone of Proximal Development (ZPD), a developmental stage that has not yet reached full maturity, certainly need assistance in using AI (Poehner & Lantolf, 2021). Students' interactions with technology will also be emotionally charged (curious, happy, but can be anxious or frustrated when AI makes mistakes), so feedback needs to be taken into account by teachers to calibrate their trust in AI through easy-to-understand explanations (Mohammed & Khalid, 2025). Since elementary school students' self-regulation is still developing, security and privacy must be taught as knowledge and efficacy, while accessibility should be guaranteed through features with simple navigation (Kumar et al., 2019). The implication is that in the future these variables need to be operationalized as measurable constructs and linked causally to the sustainability of use and academic impact, especially in the elementary school realm.

In terms of methods, quantitative research was the most widely used (44.6%), followed by qualitative and mixed methods (19.6 each), and development research (16.1%). The dominance of quantitative research methods is evident in the instruments used, with almost all studies using questionnaires/surveys developed from theories such as TAM, UTAUT, and TPB, with SEM-PLS and descriptive analysis as the most frequently used techniques. This quantitative research method is commonly used to measure students' acceptance or intention to use AI, which is also in line with the characteristics dimension, which tends to display factors related to students' acceptance or intention. However, because the instruments often consist of closed-ended questions completed by elementary school students, this raises the question, "Do children understand the questions or statements correctly?" Therefore, validity, reliability, and pilot testing are necessary. Meanwhile, qualitative and mixed methods, although not as widely used as quantitative methods, can delve deeper into teacher or student perceptions, emotions, and challenges that are difficult to uncover through surveys (Mejeh et al., 2023).

The first research gap relates to the theories used in the analyzed studies. The dominant theories used are TAM, UTAUT, and TPB, which are commonly used to analyze technology acceptance (Yacob et al., 2025). Future research should expand the use of these theories

to explain why and how elementary school students continue to use AI and how this process can lead to learning outcomes. Further research could utilize Self-Determination Theory (SDT) to model students' psychological needs and Self-Regulated Learning (SRL) to measure student engagement in AI (Yang et al., 2025). Another theory related to psychology and emotion is Cognitive Load Theory, which can be used to distinguish intrinsic, extrinsic, and cognitive load factors when students learn with AI (Duran et al., 2022). On the other hand, similar to trust and risk, Protection Motivation Theory and Technology Threat Avoidance Theory are relevant for modeling the privacy, security, and ethical use of AI, which are rarely researched, especially in the context of primary education (Alqahtani, 2022; Haag et al., 2021). Equally important, the scarcity of mediation-moderation models that link the theories used to cognitive/affective processes and their implications for learning outcomes.

The second research gap relates to the context dimension. The strong contribution of AI research in primary education in China PR and South Korea needs to be balanced and expanded to developing countries as well. Furthermore, the diversity of school contexts also presents a gap in future research, such as urban and rural, public and private schools, as well as the varying policies of each region. The sample/subject context also needs to be expanded, not just students but also teachers, principals, and parents to map the ecology of AI adoption decision-making. Especially at the elementary school level, students still greatly need guidance in using AI, including parental guidance at home (Rizaldi et al., 2021). Regarding the type of AI used, ChatGPT's dominance needs to be challenged by other types of AI, such as Google Gemini, MetaAI WhatsApp, etc., or other non-chatbot-based AI, so that pedagogical recommendations have many alternatives.

The third research gap relates to the characteristics and network keyword co-occurrence dimensions. While the factors have been broadly mapped into 15 categories, comprising a wide variety of primary factors, learning outcome variables are rarely considered a primary factor in AI research in primary education. Future research should also measure learning outcomes such as higher-order reasoning and authentic learning behaviors alongside acceptance/intention, as emphasized in the network keyword co-occurrence, namely behavioral intention. The development of instruments such as AI literacy scales and teacher AI competencies also needs to be accompanied by construct validity and reliability so that the results can be used in future research. Moving forward, it is crucial to shift the focus of characteristics from "is it used" to "what is its impact," with manifestations linked to learning outcomes, not just intention or acceptance.

The final research gap relates to the method dimension. It is clear that existing research still focuses on quantitative research methods, followed by qualitative and mixed methods. Future research opportunities include strengthening classroom-based or quasi-experimental research and longitudinal research. Longitudinal research, in particular, is useful for the sustainability of AI use or retention of learning outcomes because its measurement examines changes over time (Shepard & Rose, 2025). Furthermore, transparency in article writing also needs to be improved by including open data, code, and instruments, which could encourage replication and modification across regions.

Conclusion

This SLR and bibliometric analysis shows that AI research in basic education from 2021 to 2025 is growing rapidly but is still centered on survey studies on the acceptance/intention to use AI with the TAM/UTAUT/TPB framework. The research context is dominated by students in several East Asian countries, with the roles of teachers, parents, and schools in developing countries still rarely studied. The types of AI studied are also not yet diverse and many focus on LLMs such as ChatGPT, so evidence of their impact on learning processes, emotions, and outcomes is still limited. These findings suggest that policies and practices for the use of AI in primary schools need to be carefully designed and evidence-based, rather than simply following trends. The resulting research map can be used to: guide teacher training, develop ethical guidelines and student data protection, and design AI procurement and evaluation programs that are more equitable for various types of schools. In this way, AI can be integrated pedagogically and safely to truly improve the quality of learning in primary education.

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Author Contributions

The authors in this research are divided into the executor and the advisor. Mohammad Hilfi Azra Dzikrulloh contributes in the conceptualization, methodology of the research, writing, and editing; Fina Fakhriyah and Khamdun contributes in the conceptualization, methodology of the research, and reviewing.

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Conflicts of Interest

The authors declare no conflict of interest.

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