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The Impact of Artificial Intelligence on Education in Indonesia: A Systematic Literature Review of Applications, Challenges, and Future Development Directions

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Abstract

Artificial Intelligence (AI) has become a transformative force in education globally, including in Indonesia, by offering solutions to improve teaching, learning, and education management. This study aims to provide a comprehensive overview of the application of AI in Indonesian education through the Systematic Literature Review (SLR) approach combined with bibliometric analysis. This study identifies the various applications of AI used in Indonesian education, the challenges faced in their implementation, and the direction of research and policy development that can strengthen the integration of AI in the education sector. Based on an analysis of 74 articles published between 2022 and 2026, key findings show that generative AI, such as ChatGPT, is becoming one of the most widely applied technologies in higher education, particularly in language learning and academic writing. The main challenges faced are infrastructure gaps, the digital readiness of teachers, and policies that are not comprehensive. Future research is suggested to focus on national policy development, practice-based training for teachers, and the development of more adaptive and inclusive AI technologies. This study provides important insights for policymakers and education practitioners in designing more effective AI adoption strategies in Indonesia.

Keywords: Artificial Intelligence (AI), Indonesian Education, Systematic Literature Review (SLR), AI Applications, Education Challenges

Introduction Section

Background & Problem Statement

In recent years, the adoption of Artificial Intelligence (AI) in education has gained increasing attention around the world, including in Indonesia. As countries strive to innovate and find solutions to educational challenges, AI is considered a promising technology to improve learning experiences, improve teaching efficiency, and manage education systems (Chan & Zary, 2019) From primary education to higher education, AI has been integrated in various forms, such as adaptive learning systems, AI-based assessments, and personalized learning tools. Although interest in this technology continues to grow, the implementation of AI in Indonesian education is still in its infancy, with challenges related to infrastructure, teacher readiness, and the ethical implications of AI adoption (Almagharbeh et al., 2025).

The rapid development of AI technology in the field of education requires a systematic and comprehensive review to map the evidence and existing applications. The existing literature on AI in education in Indonesia is still scattered and has not been consolidated. Therefore, a Systematic Literature Review (SLR) combined with bibliometric analysis is needed to synthesize and assess the existing evidence, given the rapid development nature of AI in education (Page, Moher, et al., 2021; Zupic & Čater, 2014) A bibliometric approach is essential for tracking trends, identifying key research themes, and analyzing collaborative networks in this area. This study aims to provide a clear mapping of AI applications in Indonesia, evaluate their impact, and highlight the direction of research development that can strengthen policies and practices in the future.

Research Gap

There are several gaps in the existing literature regarding the application of AI in education in Indonesia. First, existing studies are often spread across different levels of education (e.g., primary, secondary, and tertiary education) and AI technologies (e.g., generative AI, machine learning, adaptive systems), making it difficult to assess the overall landscape of AI use in education. In addition, although many studies claim the positive impact of AI on education, there is still a lack of strong evidence regarding its effectiveness, particularly regarding tangible outcomes such as improved academic performance, teacher efficiency, and student engagement (RQ3). Furthermore, although ethical issues, data privacy, and governance challenges are often mentioned, there is still a lack of recommendations that can be implemented practically in

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the context of Indonesian education (Harsanti et al., 2025) Finally, although interest in AI in education is growing, the trend of publication and collaborative networking (e.g., co-authorship, institutional partnerships) has not been systematically mapped, so there is still a gap in understanding the evolution of this field over time (RQ5).

Research Objectives & Questions

The main objective of this study is to conduct a systematic review and bibliometric analysis related to the application of AI in education in Indonesia, with a focus on identifying trends, challenges, and directions for future research development. This study aims to synthesize the existing evidence regarding the impact of AI, its application in various educational contexts, and the obstacles faced in its implementation. The research questions that are the basis of this study are as follows:

RQ1: What are the different forms and types of AI applications used in Indonesian education at various levels and educational contexts?

RQ2: What are the main challenges and obstacles in the application of AI in Indonesian education?

RQ3: What is the evidence of the impact of the use of AI on teaching practices, learning outcomes, and educational equity in Indonesia?

RQ4: What are the directions for research development and policy recommendations to strengthen the integration of AI in Indonesian education?

RQ5: How has AI research in education evolved in Indonesia over time, especially regarding publication trends, research focus, and collaboration networks?

Research Methods

Study design

This study combines a Systematic Literature Review (SLR) design with bibliometric analysis to map AI applications, challenges, and development directions in Indonesia's education sector. It follows PRISMA 2020 guidelines and emphasizes transparency in search strategies (Page, McKenzie, et al., 2021; Page, Moher, et al., 2021; Rethlefsen et al., 2021).

Bibliometrics are used to map knowledge structures, such as keyword co-occurrence and collaborative networks, while SLR synthesizes themes on AI applications, challenges, and research/policy agendas (Donthu et al., 2021; van Eck & Waltman, 2013; Zupic & Čater, 2014) The study uses Scopus as the primary data source for standardized metadata, ensuring data consistency and replicability (Lim et al., 2024; Perianes-Rodriguez et al., 2016) For the process of filtering and selecting articles, it is carried out in conjunction, then for metadata management and descriptive data retrieval using Excel/manual extraction and Vosviewer for bibliometric analysis and visualization.

The search was conducted on December 10, 2025, through Scopus' *Advanced Search* feature , and all records were exported for bibliometric selection, extraction, and mapping purposes. (Aryawati et al., 2024; Donthu et al., 2021; Ullah et al., 2022) Boolean keywords and operators are designed to include a variety of terms describing AI as well as the Indonesian educational context. The search strategy was developed iteratively based on a preliminary review of the terms that appear most frequently in the literature. The search strings used are: *(TITLE-ABS-KEY (Ai in education* OR artificial intelligence in education*) AND TITLE-ABS-KEY (education* OR learning* OR teaching*) AND TITLE-ABS-KEY (Indonesia*)) AND PUBYEAR > 2021 AND PUBYEAR < 2027 AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (AFFILCOUNTRY , "Indonesia")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "ARTS")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))*

Screening and Selection

Studies are included if (i) they are relevant to AI in education/learning/teaching in the Indonesian context, and (ii) the full text is accessible for *the full-text eligibility* stage. (Kim & Kwon, 2025; Turmuzi & Tyaningsih, 2025; Waita et al., 2025) Studies are excluded if (i) not educationally related (e.g. AI in the non-education sector), (ii) the Indonesian context is not substantial, or (iii) the full text cannot be obtained at the eligibility stage. (Garzón et al., 2025; Kitchenham & Brereton, 2013)

References, title/abstract filtering, and full-text assessments were conducted using Covidence to ensure a documented audit trail of selection decisions, facilitate the handling of duplication, and track reasons for exclusion (Omiyi et al., 2025; Rethlefsen et al., 2021). The article screening process is carried out in stages: automatic deduplication, title and abstract filtering, full-text review, manual data extraction with Excel, and quality assessment to ensure the relevance and methodological completeness of articles related to the Indonesian educational context (De Silva et al., 2024) This process is performed by a single reviewer with a dubious decision reviewed before the final inclusion/exclusion decision, and the entire flow is reported via a PRISMA diagram. (McInnes et al., 2018; Waffenschmidt et al., 2019). Seen in figure 1.

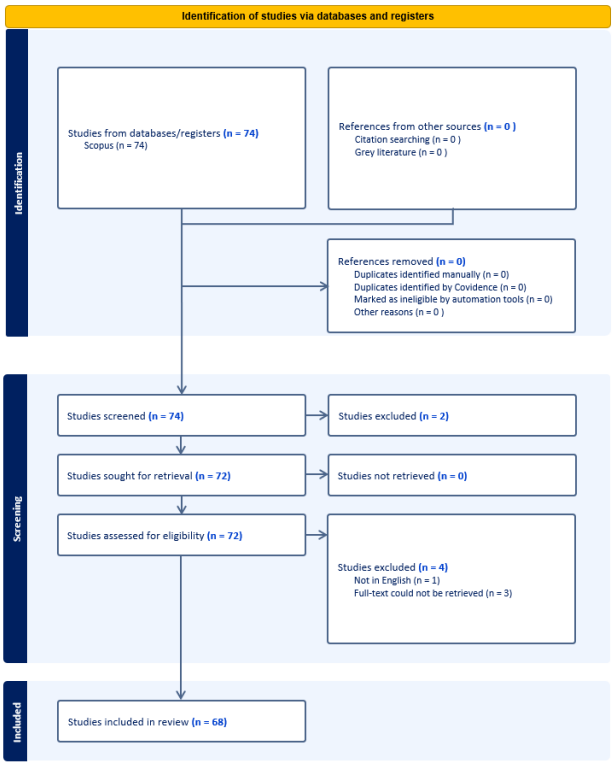

Figure 1. Systematic Review (PRISMA)

Data Extraction and Quality Assessment

Data extraction was carried out at two levels: (1) bibliographic metadata for bibliometrics (year, author, affiliation, source, abstract, keyword, DOI/EID) and (2) study characteristics for SLR (educational context, AI application, pedagogical objectives, methods, findings, challenges, recommendations)(Brimhall et al., 2025; Donthu et al., 2021; Kitchenham & Brereton, 2013; Zupic & Čater, 2014) The unit of bibliometric analysis is the record of articles and bibliometric entities, while for SLR, it is a study that passes full-text inclusion for thematic synthesis. (Donthu et al., 2021; Perianes-Rodriguez et al., 2016).

Bibliometric Analysis

Bibliometric analysis maps the AI research landscape in Indonesian education through keyword co-curation and collaborative networks.(Zupic & Čater, 2014) Mapping was carried out using VOSviewer with full counting and normalization of linkage methods.(Donthu et al., 2021; van Eck & Waltman, 2013).

Synthesis Tematik SLR

The SLR synthesis is grouped by theme: (i) AI applications (assessment, personalization, chatbot tutoring), (ii) challenges (bias, privacy, academic integrity, teacher readiness), and (iii) development direction (governance, AI literacy, curriculum design). QA results are used to prioritize evidence, with low-quality studies used as context (Awang Jambol et al., 2025; Mortlock & Lucas, 2024; Weidener & Fischer, 2023). QA results are used to prioritize evidence (e.g., core findings supported by medium–high quality studies), while low-quality studies are used in a limited way as a context without dominating the conclusions. (Alshakrah et al., 2019; Carney et al., 2016)

Results And Discussion

Results Bibliometrik

Descriptive—Research trends, sources, and actors

In the last two years, there has been a significant increase in the publication of AI research in Indonesian education, especially in high-quality journals (Q1 and Q2), reflecting the greater attention of the scientific community to this topic. As seen in Table 1, the publication trend shows a sharp spike from 1 article in 2022 to 47 in 2025. The main focus of this research is on adaptive learning technologies and AI for personalization, which aims to improve the learning experience of students at various levels of education. See Table 1.

Table 1. Distribution of publications per year (n=74)

Year	Number of articles
2022	1
2023	4
2024	21
2025	47
2026	1

Principal Research Affiliates

Yogyakarta State University has the largest research contribution with 6 appearances, followed by Jakarta State University with 5 appearances. State University of Malang, which focuses on Indonesian Language Education, appeared 4 times. Surabaya State University and Indonesian Education University were recorded 3 times each, while Sultan Ageng Tirtayasa University and Muhammadiyah University Surakarta appeared 2 times. Universiti Pendidikan Sultan Idris in Malaysia was also recorded 2 times, signaling international collaboration. The University of Indonesia and Gadjah Mada University were recorded 2 times each, showing their contribution albeit less. Overall, universities in Indonesia, especially those ranked at the top, have an important role in AI research in education. See that in Table 2

Table 2. Top affiliates (based on the frequency of appearances in the affiliate metadata)

Ranking	Affiliates	Number of appearances
1	Universitas Negeri Yogyakarta	6
2	Universitas Negeri Jakarta	5
3	Universitas Negeri Malang (Indonesian Language Education)	4
4	Universitas Negeri Surabaya	3
5	Universitas Pendidikan Indonesia	3
6	Universitas Sultan Ageng Tirtayasa	2
7	Universitas Muhammadiyah Surakarta	2
8	Universiti Pendidikan Sultan Idris (Malaysia)	2
9	Universitas Indonesia	2
10	Universitas Gadjah Mada	2

Network—Keyword co-occurrence

The VOSviewer keyword co-ocurence map shows the relationships between AI research topics in education. "Artificial Intelligence" is the main keyword, indicating the research focus on the application of AI in education, especially in technology-based learning. "Higher Education" stands out, reflecting the application of AI in colleges to improve learning effectiveness. "ChatGPT" also emerged as an important topic, signaling the use of AI chatbots in interactive learning. "Indonesia" shows a lot of research focused on the implementation of AI in Indonesian education, while "TPACK" reflects the integration of AI technology in learning. This map illustrates the interconnectedness of key topics in AI research for education, with a focus on higher education and personalization of learning.

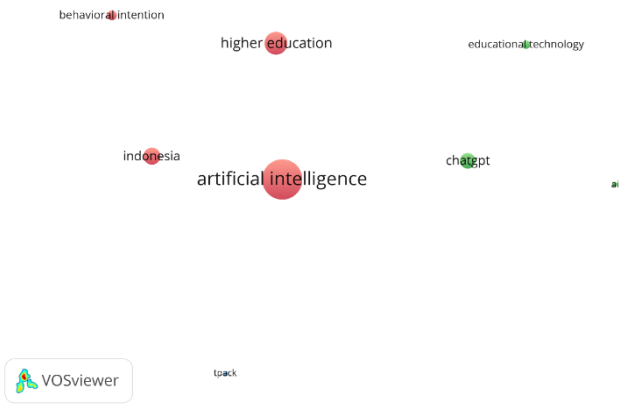

Figure2. Keyword co-occurrenceThe lengt

Overlay—Average publication year topic trends Principal Research Affiliates

The overlay map shows the distribution of major AI-related keywords in education and the average year of their publication. "Artificial Intelligence" is the dominant keyword with the latest publication in 2024-2025, reflecting the rapid development of this research. "Higher Education" also stands out, with a focus on research in higher education which will peak in 2024-2025. "ChatGPT" is emerging as a new topic in education in 2024, demonstrating the adoption of generative AI in interactive learning. "Indonesia" shows research that continues to grow, albeit with a lag compared to global trends. "TPACK" is also getting renewed attention in 2024, depicting the integration of technology and pedagogy in AI-driven learning. Overall, this map illustrates the rapid development of AI research in education, especially in adaptive learning and AI-based assessment.

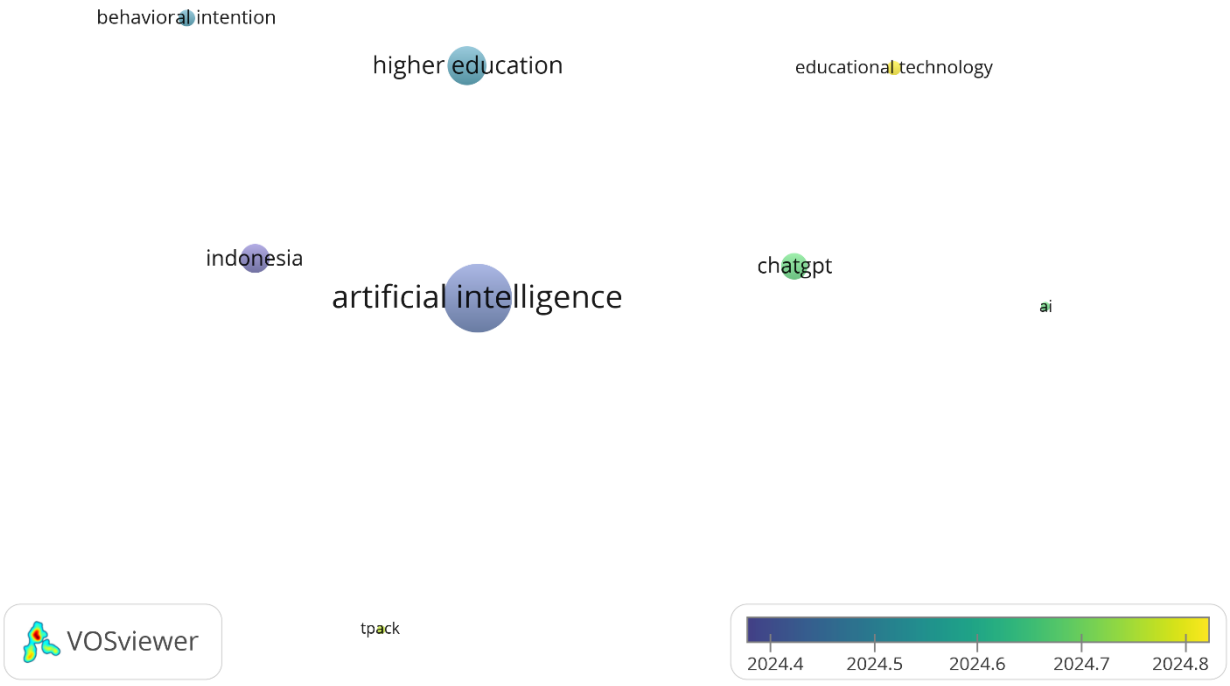

Figure 3. Overlay data—Time-Based Topic Trends (average publication year)

Results (Clearly Devided By RQ)

Table 3. Main data Included

No.	Title	Author (Year)	Journal Name	Country / Region	Author Affiliation
1	Assessing the Impact of AI-Driven Tools on Qur'anic Literacy: A Quasi-Experimental Study in Islamic Higher Education in Indonesia	Ridwan 2025	Journal of Cultural Analysis and Social Change	Indonesia (NTB)	UIN Mataram
2	Impact of Artificial Intelligence on Student Reliance for Exam Answers: A Case Study in IRCT Indonesia	Adiyono; Suwartono; Nurhayati; Dalimarta; Wijayanti 2025	International Journal of Learning, Teaching and Educational Research	Indonesia (Tanah Grogot, East Kalimantan)	STIT Ibnu Rusyd; Universitas Muhammadiyah Purwokerto; IKIP Siliwangi; UM Tegal
3	A Mixed-Method Study on the Effectiveness of Using ChatGPT in Academic Writing and Students' Perceived Experiences	Eka Apriani; Sholihatul Hamidah Daulay; Fitria Aprilia; Abdul Gafur Marzuki; Idi Warsah; Dadan Supardan; Muthmainnah 2025	Journal of Language and Education	Indonesia	IAIN Curup; UIN Sumatera Utara; Universitas Bina Darma; UIN Datokarama Palu; Universitas Al Asyariah Mandar
4	ChatGPT and Legal Education in Indonesia: Examining Readiness and Implications	Haekal Al Asyari; Hanif Abdul Halim; Rachelle Amadea Roselynn Nikita Tan 2025	Journal of Indonesian Legal Studies	Indonesia	Universitas Gadjah Mada; Utrecht University; University of Debrecen
5	Utilization of Big Data and Artificial Intelligence on Quality Education Management and its Implications on School Sustainability	Berkata; Rinto Alexandro; Basrowi 2024	International Journal of Data and Network Science	Indonesia (Palangkaraya, Central Kalimantan)	Universitas Palangka Raya; Universitas Bina Bangsa
6	Exploring Long-Term Impact of AI Writing Tools on Independent Writing Skills: A Case Study of Indonesian Language Education Students	Herman Budiyono et al. 2025	International Journal of Information and Education Technology	Indonesia (Semarang, Makassar, Malang)	Universitas Negeri Semarang; UM; others
7	Artificial Intelligence-Driven Learning Assessment in Faculties of Education: An Exploratory Study	Siti Choiriyah; Syahrul Ramadhan; Arif Nugroho; Heldy Ramadhan Putra Pembangunan; Fauzi Muharom 2025	Munaddhomah: Jurnal Manajemen Pendidikan Islam	Indonesia (Surakarta, Central Java)	UIN Raden Mas Said Surakarta; BRIN
8	"Do EFL Learners Need AI?": Exploring Learners' Perspectives on the Use of ChatGPT for Morphology and Syntax Learning Tasks	Ratna Dewanti; Ifan Iskandar; Yordan Yasin 2025	Forum for Linguistic Studies	Indonesia (Jakarta)	State University of Jakarta; University of Indonesia
9	Understanding the Artificial Intelligence Literacy between Novice and Experienced English Teachers in Indonesia	Nur Arifah Drajati; Dewi Cahyaningrum; Ellisa Indriyani Putri Handayani; Anis Handayani 2025	TEFLIN Journal, Vol 36(1), 44–60	Indonesia	Universitas Sebelas Maret; Universitas Negeri Yogyakarta
10	Artificial Intelligence in E-Entrepreneurship Training: Enhancing Digital Skills and	Amri Dunan; Bambang Mudjiyanto; Ahmad Budi Setiawan;	International Journal of E-Entrepreneurship	Indonesia	The National Research and Innovation Agency (Indonesia); The Regional

	Innovation Diffusion in Indonesia	Syarifuddin Syarifuddin; Rukman Pala; Muhammad Rustam; Dida Dirgahayu; Buyamin Buyamin; Mu'man Nuryana; Hartiningsih Hartiningsih 2025	and Innovation, Vol 15(1)		Research and Innovation Agency (Indonesia)
11	Muslim students' acceptance of artificial intelligence in Islamic religious education: an extended TAM approach	Nur Faizin; Muhammad Alfan; Abdul Basid; Mochammad Rizal Ramadhan; Siti Aisyah Panatik; Akhmad Nurul Kawakip 2025	Discover Education, 4:304	Indonesia (study context)	Universitas Negeri Malang; Universiti Teknologi Malaysia; UIN Maulana Malik Ibrahim
12	Integrating Chat-GPT in the Classroom: A Study on Linear Algebra Learning in Higher Education	Dilham Fardian; Didi Suryadi; Sufyani Prabawanto; Al Jupri 2025	International Journal of Information and Education Technology	Indonesia	Department of Mathematics Education, Faculty of Mathematics and Natural Sciences Education, Universitas Pendidikan Indonesia (UPI); Indonesian Didactical Design Research Development Center (PUSBANGDDRINDO), UPI :contentReference[oaicite:0]{index=0}
13	Factors Affecting Indonesian Pre-service EFL Teachers' AI Acceptance and Use	Anak Agung Putri Maharani; I Komang Budiarta; Ni Luh Putu Dian Sawitri 2024	International Journal of Learning, Teaching and Educational Research	Indonesia	Universitas Mahasaraswati Denpasar
14	AI-enhanced self-regulated learning: EFL learners' prioritization and utilization in presentation skills development	Sri Wuli Fitriati; Aldha Williyan 2025	Journal of Pedagogical Research	Indonesia	Universitas Negeri Semarang; Universitas Siliwangi
15	Integrating Principal Leadership and Teacher Roles with AI-Based 'Merdeka' Curriculum Innovation: The Quantitative Research	Halomoan Halomoan; Muhammad Hakiki; M. Agphin Ramadhan; Yayuk Hidayah; Jamal Fakhri; S. Nailul Muna Aljamaliah; Mustofa Abi Hamid 2024	TEM Journal	Indonesia	Universitas Negeri Padang; Universitas Muhammadiyah Muara Bungo; Universitas Negeri Jakarta; Universitas Negeri Yogyakarta; UIN Raden Intan Lampung; Universitas Pendidikan Indonesia; Universitas Sultan Ageng Tirtayasa
16	Unraveling Factors Affecting Engineering Students' Acceptance of Artificial Intelligence in the Context of a Blended Learning Environment	Muh. Hamkah; Heri Retnawati; Muthmainah Muthmainah; Muhammad Hakiki; Mustofa Abi Hamid; Hasruddin Hasruddin; M. Dahlan; M. Agphin Ramadhan; Muhammad Nurtanto; Indra Mutiara 2025	Online Learning (Issue 29 Vol 4)	Indonesia	Universitas Negeri Yogyakarta; Universitas Negeri Surabaya; Universitas Sultan Ageng Tirtayasa; Universitas Negeri Jakarta
17	Exploring Indonesian teachers' intention to use artificial intelligence in schools: the impact of digital leadership, digital	Hg Retno Harsanti; Niko Sudibjo; Stephanie Riady; Patricia Yu 2025	Cogent Social Sciences	Indonesia (Greater Jakarta/Jabo detabek: Jakarta,	National Taiwan Normal University (Taiwan); Universitas Pelita Harapan (Indonesia)

	readiness, and perceived usefulness			Bogor, Tangerang, Bekasi)	
18	Investigating the adoption of AI in higher education: a study of public universities in Indonesia	Helmiatin; Anto Hidayat; Muhammad Ridwan Kahar 2024	Cogent Education	Indonesia	Universitas Terbuka
19	AI in EFL education: teachers' competence and the roadblocks to teaching material development	Agnia Ilma; Zuliati Rohmah 2025	Cogent Education	Indonesia	Universitas Brawijaya
20	Harnessing self-efficacy: Mediating the connection between TPACK and AI intentions among teachers	Christina Ismaniati et al. 2025	Journal of Pedagogical Research	Indonesia	Yogyakarta State Univ.; Makassar State Univ.; SDN 140 Masumpu
21	The Role of AI in Enhancing Marketing Communication	Santi Isnaini, Afif Ikhwanul Muslimin 2024	Studies in Media and Communication	Indonesia	Universitas Airlangga, Universitas Islam Negeri Mataram
22	Creative AI in Education: The Role of Technological Dependence, Motivation, and Student Participation	Wan Jamaluddin Z; Nanang Supriadi; Suherman Suherman 2025	Revista de Estudios e Investigación en Psicología y Educación	Indonesia	Universitas Islam Negeri Raden Intan Lampung; University of Szeged
11	Assessing Text Comprehension Proficiency: Indonesian Higher Education Students vs ChatGPT	Juanda, Iswan Afandi 2024	XLinguae	Indonesia	Universitas Negeri Makassar, Universitas Timor
24	Defining the Role of Artificial Intelligence in Improving English Writing Skills Among Indonesian Students	Kaharuddin, Djuwairiah Ahmad, Mardiana, Ismail Latif, Burhanuddin Arafah, Ray Suryadi 2024	Journal of Language Teaching and Research	Indonesia	Universitas Islam Negeri Alauddin Makassar, Universitas Agama Islam Negeri Parepare, Hasanuddin University, Sembilanbelas November University of Kolaka
25	The Use of Unified Theory of Acceptance and Use of Technology to Analyze Students' Behavioral Interests in Utilizing Gemini AI	Riza Yonisa Kurniawan; Alayya Izza Mahfudhoh; Suci Rohayati; Retno Mustika Dewi; Putri Ulfa Kamalia; Mohamad Zuber Abd Majid 2025	International Journal of Information and Education Technology	Indonesia (East Java) & Malaysia	Universitas Negeri Surabaya; Universiti Kebangsaan Malaysia
26	Bridging Knowledge and Academic Integrity: AI Integration for TPACK Development in EFL Teacher Education Program	I Putu Indra Kusuma; Luh Gd Rahayu Budiarta; Anak Agung Putri Maharani 2025	LLT Journal: A Journal on Language and Language Teaching	Indonesia	Universitas Pendidikan Ganesha; Universitas Mahasaraswati Denpasar
27	Bridging AI and ELL in Indonesia and India: International Insights on Perceptions and Challenges	Anak Agung Putri Maharani; I Komang Budiarta; Ni Luh Putu Dian Sawitri; Harvinder Kumar Negi 2025	International Journal of Learning, Teaching and Educational Research	Indonesia & India	Universitas Mahasaraswati Denpasar; GLA University
28	Exploring Artificial Intelligence in Academic Essay: Higher Education Student's Perspective	Agung Rinaldy Malik, Yuni Pratiwi, Kusubakti Andajani, I Wayan Numertayasa, Sri Suharti, Arisa Darwis, Marzuki 2023	International Journal of Educational Research Open	Indonesia	Universitas Negeri Malang, Universitas Madako Tolitoli, Indonesia

29	Virtual Tutor, Digital Natives and AI: Analyzing the impact of ChatGPT on academia in Indonesia	Hendro Margono, Muhammad Saud, Mohammad Falahat 2024	Social Sciences & Humanities Open	Indonesia	Universitas Airlangga, Asia Pacific University of Technology and Innovation
30	Artificial Intelligence, Job Seeker, and Career Trajectory: How AI-Based Learning Experiences Affect Commitment of Fresh Graduates to Be an Accountant	Agung Maulana; Rakotoarisoa Maminirina Fenitra; Slamet Sutrisno; Kurniawan 2025	Computers and Education: Artificial Intelligence	Indonesia & Malaysia	Sunway Business School, Sunway University; Nusa Putra University
31	Artificial Intelligence Revolution in Indonesian Islamic Higher Education: How It Affects Students' Self-Efficacy, Creativity, and Learning Performance	Suci Megawati; Muhammad Alfarizi; Jauhar Wahyuni 2024	Journal of Educators Online	Indonesia	Universitas Negeri Surabaya; Bina Nusantara University
32	Scientific Knowledge Structures: Problematizing AI-Powered Translation Tools in EFL Academic Writing	Uswatun Qoyyimah; Debbie Bargallie 2025	LLT Journal: A Journal on Language and Language Teaching	Indonesia & Australia	Universitas Pesantren Tinggi Darul Ulum; Griffith University
33	EFL Students' Perception in Indonesia and Taiwan on Using Artificial Intelligence to Enhance Writing Skills	Tien Rafida; Suwandi Suwandi; Rusydi Ananda 2024	Jurnal Ilmiah Peuradeun	Indonesia & Taiwan	State Islamic University of North Sumatera; National Sun Yat-Sen University
34	The interconnection between digital literacy, artificial intelligence, and the use of E-learning applications in enhancing the sustainability of Regional Languages: Evidence from Indonesia	Uyu Muawanah; Arita Marini; Iva Sarifah 2024	*Social Sciences & Humanities Open*	Indonesia	State University of Jakarta
35	An Exploratory Study of Artificial Intelligence Adoption in Higher Education	Nagy, A. S., Tumiwa, J. R., Arie, F. V., Erdey, L. 2024	Cogent Education	Indonesia	University of Debrecen, Sam Ratulangi University
36	Challenges in Artificial Intelligence Development in Higher Education in China, India, and Indonesia: International Students' Perspectives	Mustopa; Nasikhin; Rikza Chamami; Hamidatun Nihayah; Muhammad R. Habibullah; Ahmad Manshur 2024	International Journal of Learning, Teaching and Educational Research	China, India, Indonesia	UIN Walisongo; UNU Sunan Giri Bojonegoro
37	Evaluating the Impact of AI on Critical Thinking Skills Among Higher Education Students by Combining the TAM Model and Critical Thinking Theory	Ninghardjanti, P., Umam, M. C., Subarno, A., Winarno, W., Langgi, N. R., Widodo, J. 2025	Frontiers in Education	Indonesia	Universitas Sebelas Maret
38	Towards Effective Artificial Intelligence-Driven Learning in Indonesian Child Education: Understanding Parental Readiness, Challenges, and Policy Implications	Sri Nurhayati, Taufikin Taufikin, Loso Judijanto, Safuri Musa 2024	Educational Technology & Policy	Indonesia	Institute of Teacher Training and Education Sciences (IKIP) Siliwangi, Cimahi, West Java, Indonesia
39	Determinants of Behavioral Intentions and Their Impact on Student Performance in the Use of AI Technology in Higher Education in Indonesia	Nurtanto, M., Nawanksari, S., Perdana, V.L., Syahrudin, H., Kholifah, N., Rohmantoro, D., Utami, I.S.,	Social Sciences & Humanities Open	Indonesia	Universitas Negeri Jakarta, Yogyakarta State University, Universitas Sebelas Maret, Universitas Tanjungpura, Sarjanawiyata Tamansiswa University

		Mutohhari, F., Abi Hamid, M. 2025			
40	Exploring the Use of Artificial Intelligence in Indonesian Accounting Classes	Fachrurrozie, Ahmad Nurkhin, Jarot Tri Bowo Santoso, Hasan Mukhibad, Christian Wiradendi Wolor 2025	Cogent Education	Indonesia	Universitas Negeri Semarang, Universitas Negeri Jakarta
41	AI-driven Competency Recommendations Based on Attendance Patterns and Academic Performance	Junaidi, Wahyono, Sembiring 2025	Computers and Education: Artificial Intelligence	Indonesia	Satya Wacana Christian University, University of Raharja
42	Navigating the Digital Writing Landscape: EFL Students' Perspectives on ChatGPT Utilization	Rahayu, A., Tarihoran, N., Rahmawati, E., Muslihah, E., Ma'mur, I., Anita 2025	International Journal of Learning, Teaching and Educational Research	Indonesia	State Islamic University of Sultan Maulana Hasanuddin
43	Challenges and Opportunities of Artificial Intelligence Adoption in Islamic Education in Indonesian Higher Education Institutions	Achruh, Muh Rapi, M. Rusdi, Ridwan Idris 2024	International Journal of Learning, Teaching and Educational Research	Indonesia	Universitas Islam Negeri Alauddin Makassar
44	Fostering AI Literacy in Elementary Science, Technology, Engineering, Art, and Mathematics (STEAM) Education in the Age of Generative AI	Relmasira, S.C., Lai, Y.C., Donaldson, J.P. 2023	Sustainability	Indonesia	The Education University of Hong Kong, Satya Wacana Christian University, University of Alabama at Birmingham
45	Navigating Uncertainty: The Interplay of Future Job Forecasting, Learning Agility, Responsiveness, and Adaptability	Encep Saefullah, Bambang Dwi Suseno, Nani Rohaeni 2024	Journal of Infrastructure, Policy and Development	Indonesia	Bina Bangsa University, Kota Serang, Banten
46	Redefining Education in the Digital Age: The Role of GPT Models in Academic Fraud and Logistics	Sangka, K. B., Pratama, R. D., & Hidayat, R. W. 2025	Human Behavior and Emerging Technologies	Indonesia	Sebelas Maret University, Sebelas Maret University
47	Measuring Artificial Intelligence Literacy: The Perspective of Indonesian Higher Education Students	Sari, D. K., Supahar, S., Rosana, D., Dinata, P. A. C., & Istiqlal, M. 2025	Journal of Pedagogical Research	Indonesia	Universitas Negeri Yogyakarta, Universitas Palangka Raya
48	Are They Literate on ChatGPT? University Language Students' Perceptions, Benefits and Challenges in Higher Education Learning	Sri Sarwanti, Yanti Sariasih, Laily Rahmatika, M. Monjurul Islam, Eka Mustika Riantina 2024	Online Learning Journal	Indonesia	Universitas Tidar, Universitas Muhammadiyah Surakarta, Universiti Pendidikan Sultan Idris, Sekolah Tinggi Ilmu Agama Islam Baturaja
49	Determining Factors Influencing Indonesian Higher Education Students' Intention to Adopt Artificial Intelligence Tools for Self-Directed Learning Management	Darmono, Rizal Justian Setiawan, Khakam Ma'ruf 2025	European Journal of Educational Research	Indonesia	Universitas Negeri Yogyakarta, National Chung Hsing University, Universitas Gadjah Mada
50	Measuring Teachers' Competencies for AI Integration: Development and Validation of the AI-TPACK in Vocational Education	Andri Setiyawan, Soeharto Soeharto, Tommy Tanu Wijaya, Lilla Korenova, Zsolt Lavicza 2025	Computers and Education Open	Indonesia	Linz School of Education, Johannes Kepler University Linz, Austria; Department of Mechanical Engineering, Universitas Negeri Semarang, Indonesia; Research Center for Education, National

					Research and Innovation agency (BRIN), Indonesia; Faculty of Education, Comenius University Bratislava, Slovakia
51	Understanding EFL Students' Adoption of Generative AI for English Learning: An Integrated UTAUT2 Model and Self-Determination Theory	Sri Surachmi W, Tri Agustini Solihati, Laily Rahmatika, Musdalifah, M Monjurul Islam, Sigit Haryanto 2025	Online Learning	Indonesia	Universitas Muria Kudus, Universitas Perjuangan Tasikmalaya, Universitas Muhammadiyah Surakarta, Universitas Muhammadiyah Enrekang, Universiti Pendidikan Sultan Idris
52	The correlation between ChatGPT use and learning autonomy among ESP students	Wahyu Diny Sujannah, Pratnyawati Nuridi Suwarso, Frida Unsiah 2025	Cogent Education	Indonesia	Study Program of English Language Education, Department of Language Education, Faculty of Cultural Studies, Universitas Brawijaya, Indonesia
53	Amotivation in AI Injected EFL Classrooms: Implications for Teachers	Dian Toar Y. G. Sumakul, Fuad Abdul Hamied 2023	Indonesian Journal of Applied Linguistics	Indonesia	English Education Study Program, Faculty of Language and Literature Education, Universitas Pendidikan Indonesia, Bandung, West Java, Indonesia
54	Enhancing Conflict Resolution Skills through Artificial Intelligence-Based Problem-Based Learning in Civic Education at Indonesian Primary Schools	Nadziroh, Sunarso, Suyato 2025	Educational Process: International Journal	Indonesia	S3 Civic Education Study Program, Faculty of Social and Political Sciences, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia
55	How AI-Driven Personalization Shapes Green Purchasing Behavior Among Youth in Java Island	Feliks Prasepta Sejahtera Surbakti, Hotma Antoni Hutahaean, Maria Magdalena Wahyuni Inderawati, Jovan Moreno Madjid, Leonard Edward Sely, Yann-May Yee 2025	Sustainability	Indonesia	Department of Industrial Engineering, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia; Department of Industrial and Systems Engineering, Chung Yuan Christian University, Taoyuan City, Taiwan
56	AI product knowledge as moderator of trust and attitude in usage intention: a study of Indonesian postgraduates	Nanang Suryadi, Rizka Zulfikar, Yudhita Valen Prasarry, Muhammad Fajrul Islam F 2025	Cogent Social Sciences	Indonesia	Management Department, Faculty of Economics and Business, Universitas Brawijaya, Malang, Indonesia; Management Department, Faculty of Economics and Business, Universitas Islam Kalimantan Muhammad Arsyad Al Banjari, Banjarmasin, Indonesia; Accounting Department, Universitas Bina Nusantara, West Jakarta, Indonesia
57	Student utilization and perceptions of AI technology for academic purposes: a mixed-method analysis	Rakhdiny Sustaningrum, Mikaela Haldaka 2025	Cogent Education	Indonesia	Faculty of Economics and Business, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia
58	Assessing students' readiness for artificial intelligence-based project learning to strengthen local wisdom values in Indonesia	Sutrisno Sutrisno, Abdul Azis, Mohammad Bhanu Setyawan, Dinie Anggraeni Dewi,	Cogent Education	Indonesia	Universitas Muhammadiyah Ponorogo, Ponorogo Regency, East Java, Indonesia; Universitas Muhammadiyah Makasar,

		Yayuk Hidayah, Muhammad Hakiki, Mustofa Abi Hamid, Radinal Fadli 2025			Makasar City, Indonesia;, Universitas Muhammadiyah Ponorogo, Ponorogo Regency, East Java, Indonesia; Universitas Pendidikan Indonesia, Bandung, Indonesia; Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; Universitas Negeri Surabaya, Surabaya, Indonesia; Universitas Sultan Ageng Tirtayasa, Serang City, Indonesia; Universitas Lampung, Bandar Lampung City, Indonesia
59	Responsible AI in Indonesian higher education: A survey in sports education and public health programs	Syahruddin Syahruddin, M. Sahib Saleh, Mailizar Mailizar, Muhammad Syahrul Saleh, Akhmad Habibi, Turki Mesfer Alqahtani 2025	Social Sciences & Humanities Open	Indonesia	Fakultas Ilmu keolahragaan, Universitas Negeri Makassar, Makassar, Indonesia; Department of Mathematics Education, Universitas Syiah Kuala, Banda Aceh, Indonesia; Graduate School of Education, Korea University, Seoul, Republic of Korea; Master of Educational Technology, Universitas Jambi, Jambi, Indonesia; e-Learning Centre, Jazan University, Saudi Arabia
60	AI Literacy and Gender Bias: Comparative Perspectives from the UK and Indonesia	Tunjungbiru et al. 2025	*Education Sciences*	United Kingdom & Indonesia	Universitas Indonesia; Anglia Ruskin University; PNJ; BINUS
61	Integration of Artificial Intelligence in Islamic Higher Education: Comparative Responses between Indonesia and Thailand	Fatah Syukur; Ahmad Maghfurin; Uswatun Marhamah; Phaosan Jehwae 2024	*Nazhruna: Jurnal Pendidikan Islam*	Indonesia & Thailand	UIN Walisongo; STAI Walisembilan; Fatoni University (Thailand)
62	Digital Transformation Model of Islamic Religious Education in the AI Era: A Case Study of Madrasah Aliyah in East Java, Indonesia	Wedi et al. 2025	*IJLTER*	Indonesia (East Java)	UM; UMM
63	From Nervous to Fluent: The Impact of AI Chatbot-Assisted Assessment on English Reading Anxiety and Performance in Indonesia	Wiyaka et al. 2024	*Theory and Practice in Language Studies*	Indonesia	UPGRIS; UDINUS
64	Exploring Indonesian EFL Pre-Service Teachers' Experiences in AI-Assisted Teaching Practicum: Benefits and Drawbacks	Wulandari & Purnamaningwulan 2024	LLT Journal	Indonesia	Sanata Dharma University
65	Indonesian Teachers' Roles in Designing and Utilizing AI-Powered Animated Videos: A Case Study on Classroom Practices and Character Development	Nafri Yanti, Arono, Fina Hiasa, Febi Junaidi, Noermanzah, Rio Kurniawan 2025	International Journal of Learning, Teaching and Educational Research	Indonesia	Universitas Bengkulu, Bimacita Global

66	Implementation of Artificial Intelligence in Indonesia	Yusriadi Yusriadi; Rusnaedi; Nurintan Asyiah Siregar; Suci Megawati; Geminastiti Sakkir 2023	*International Journal of Data and Network Science*	Indonesia	STIA Puangrimaggalatung; Universitas Labuhanbatu; Universitas Negeri Surabaya; Universitas Negeri Makassar
67	Generative AI as a Cognitive Co-Pilot in English Language Learning in Higher Education	Muhammad Zaim; Safnil Arsyad; Budi Waluyo; Havid Ardi; Muhd. Al Hafizh; Muflihatuz Zakiyah; Widya Syafitri; Ahmad Nusi; Mei Hardiah 2025	*Education Sciences* (MDPI)	Indonesia (multi-institution)	Universitas Negeri Padang; Universitas Bengkulu; Walailak University (Thailand)
68	AI Integration in Biology Education: Comparative Insights into Perceived Benefits and TPACK among South African and Indonesian Pre-service Teachers	Lindelani Mnguni, Prasart Nuangchalerm, R. Ahmad Zaky El Islami, Doras Sibanda, Moleboheng Ramulumo, Indah Juwita Sari 2024	Asia-Pacific Science Education	South Africa, Indonesia	South Africa: University of South Africa, University of KwaZulu-Natal, North-West University; Indonesia: Universitas Sultan Ageng Tirtayasa

The 68 studies studied on the use of AI in education in Indonesia, most focused on generative AI, such as ChatGPT, for language learning and academic writing, as well as the application of AI in Islamic religious education for Qur'anic literacy (Ridwan, 2025) and curriculum development (Haekal Al Asyari, 2025). Predictive AI is also used to assess students' abilities, as researched by Junaidi et al.(2025a) which highlights recommendations based on academic attendance and performance patterns. Other studies, such as those conducted by Nurtanto et al. (Nurtanto et al., 2025) discuss the challenges in AI adoption, particularly the influence of digital leadership on teachers. Several studies have also explored the application of AI in improving writing skills and self-learning (Sutrisno et al., 2025), Overall, AI is used to improve students' academic skills, teaching practices, and educational management, although challenges related to AI literacy and digital readiness are still the main focus of the research..

RQ1: What are the forms and types of application of AI in the Indonesian education sector at various levels and educational contexts?

The application of artificial intelligence (AI) in Indonesia's education sector shows rapid and diverse development across levels, ranging from primary education to higher education, with implementation forms that include generative, analytical, adaptive, and predictive AI. A general pattern suggests that colleges are becoming major innovation hubs, followed by middle and elementary schools that are beginning to integrate AI in curriculum, assessment, and project-based learning (Fitriati & Williyan, 2025; Relmasira et al., 2023; Zaim et al., 2025)

1. Application of AI in Learning and Teaching.

Generative AI dominates in the context of higher education, especially in the teaching of language and academic skills. Study by Eka Apriani et al. (2025) and Rahayu et al. (Rahayu et al., 2025) show that ChatGPT significantly improves students' academic writing skills through improved idea organization, grammar, and writing cohesion, while Grammarly and Quillbot help with feedback efficiency and reflective writing (Apriani, Daulay, et al., 2025; A. R. Malik, Pratiwi, Andajani, Numertayasa, Suharti, & Darwis, 2023; Rahayu et al., 2025). Similarly, research by Dewanti et al.(Dewanti et al., 2025) and Fitriati & Williyan (Fitriati & Williyan, 2025) affirm ChatGPT's role as a learning partner that supports morphology, syntax, and presentation skills learning in the context of EFL, increasing students' self-confidence and self-regulation (Dewanti et al., 2025; Stuart & Williams, 2025; Kusuma et al., 2025). However, many studies warn of the risk of cognitive dependence and decreased creativity due to use without pedagogical supervision (Budiyono et al., 2025; Sumakul & Hamied, 2023; Zaim et al., 2025).

2. AI for Assessment and Learning Evaluation

In the context of assessment, AI plays a role in accelerating correction and enriching formative feedback, especially through analytical and evaluative AI. Choiriyah et al. (Choiriyah et al., 2025) found that AI-driven assessment systems in educational faculties were able to cut assessment time by up to 90% without sacrificing the reliability of results (Choiriyah et al., 2025; Juanda & Afandi, 2024; Qoyyimah & Bargallie, 2025). The study of Juanda & Afandi (2024) shows that ChatGPT surpasses college students in the ability to summarize and analyze academic texts, marking the potential of AI in

text-based automated assessment, while research by Nadziroh et al. (2025) affirms that AI-enhanced problem-based learning (AI-PBL) significantly improves the conflict resolution and empathy skills of high school students (Fitriati & Williyan, 2025; Juanda & Afandi, 2024; Nadziroh et al., 2025). Thus, AI in the field of assessment is not only an automation tool, but also a means of adaptive feedback that enriches the affective and social dimensions of learning.

3. AI in Education Management and Governance

The application of analytical and predictive AI is widely used at the institutional management level to support data-driven decision-making. The Nusa study (2024) shows that the integration of big data and AI improves the efficiency of secondary school quality management and contributes to school sustainability through data-driven policies (Arroisi et al., 2025; Sangka et al., 2025). At the university level, Junaidi et al. (2025b) developed a machine learning-based competency recommendation system that analyzes academic attendance and performance data more accurately than the manual approach, while research by Harsanti et al. (Harsanti et al., 2025) confirmed that digital leadership and digital readiness of teachers are important factors in the readiness of institutions to adopt AI (Harsanti et al., 2025; Junaidi et al., 2025a; Setiyawan et al., 2025). In general, AI in management helps with administrative efficiency, but the infrastructure and digital literacy gap is still a major obstacle in non-urban areas.

4. AI for Personalization and Learning Adaptation

At the primary and secondary levels, AI is starting to be used for adaptive and personalized learning. Study by Relmasira et al. (2023) shows that the application of AI-driven STEAM education is able to develop AI literacy and critical thinking skills through collaborative and reflective activities, while Nadziroh et al. (2025) highlighting the effectiveness of AI-based PBL in strengthening social and ethical values in high school students (Nadziroh et al., 2025; Relmasira et al., 2023; Sutrisno et al., 2025). At the college level, a study by Zaim et al. (Zaim et al., 2025) and Surachmi et al. (2025) found that ChatGPT and Grammarly function as cognitive co-pilots, strengthening students' learning independence and reflective abilities through cognitive scaffolding. However, the risk of dependency remains high if it is not accompanied by strong pedagogical supervision and digital ethics.

5. Differences Across Levels and Fields of Study

The distribution of AI application shows clear differences between levels: primary education focuses on AI literacy and creativity (Relmasira et al., 2023), secondary education focuses on adaptive learning and character (Yanti et al., 2025), while higher education prioritizes academic writing, research, and professional development (Apriani, Hamidah Daulay, et al., 2025; Drajati et al., 2025; Harsanti et al., 2025). In the field of study, the largest dominance is in EFL (English as a Foreign Language), followed by Islamic education, education management, and STEM (Faizin et al., 2025; Fitriati & Williyan, 2025). This trend shows that the linguistic context and religious ethics are becoming the main laboratories for testing AI integration in Indonesia.

6. National Challenges and Implications

Although the results show many benefits such as increased efficiency, learning autonomy, and learning effectiveness, all studies consistently highlight digital access gaps, low teacher training, and ethical issues and AI dependence as the main obstacles (Budiyono et al., 2025; Drajati et al., 2025; Harsanti et al., 2025). These challenges are reinforced by Indonesia's broad geographical context, where digital infrastructure differences between urban and rural areas lead to inequities in implementation (Arroisi et al., 2025; Relmasira et al., 2023; Sutrisno et al., 2025). Therefore, the success of the implementation of AI in Indonesia depends not only on technology, but also on education policies, the readiness of educators, and the continuous integration of digital ethics. Overall, the form and type of AI adoption in Indonesia's education sector reflects the transition phase from experimental adoption to systemic integration, with the dominance of generative AI in the realm of language learning and analytics in education management. Adaptive and predictive AI is being piloted at the primary and secondary school levels with positive results on social and cognitive skills. However, the success of implementation still depends heavily on human factors, institutional readiness, and equitable distribution of digital infrastructure throughout Indonesia.

Table 4. Application Map (RQ1), which groups AI applications and subthemes in education by education/context level and related study examples:

Application/Subtheme	Level/Context	Sample Study (EID/DOI)
Adaptive Learning	Higher Education (University)	Ridwan (2025) - "Assessing the Impact of AI-Driven Tools on Qur'anic Literacy" (DOI: 10.64753/jcasc.v10i3.2405)
AI-Based Assessment	Higher Education, Islamic Religious Education	Haekal Al Asyari et al. (2025) - "ChatGPT and Legal Education in Indonesia" (DOI: 10.15294/jils.v10i1.19338)
Personalize Learning with AI	Primary and Secondary Education, Higher Education	Eka Apriani et al. (2025) - "A Mixed-Method Study on the Effectiveness of Using ChatGPT in Academic Writing" (DOI: 10.17323/jle.2025.17913)

AI for Academic Writing	Higher Education (EFL and Language Education)	Ratna Dewanti et al. (2025) - "Do EFL Learners Need AI?" (DOI: 10.30564/fls.v7i4.8762)
AI in Education Management	Secondary Education, Higher Education	Berkata et al. (2024) - "Utilization of Big Data and Artificial Intelligence" (DOI: 10.5267/j.ijdns.2024.1.023)
AI in Technology-Based Teaching	Higher Education, Teacher Education	Siti Choiriyah et al. (2025) - "Artificial Intelligence-Driven Learning Assessment" (DOI: 10.31538/munaddhomah.v6i3.1937)
AI for Language Learning	Language Education (EFL, TESOL)	Anak Agung Putri Maharani et al. (2025) - "Bridging AI and ELL in Indonesia and India" (DOI: 10.26803/ijlter.24.4.22)
AI for Self-Regulated Learning	Higher Education (EFL Class)	Sri Wuli Fitriati et al. (2025) - "AI-enhanced self-regulated learning" (DOI: 10.33902/jpr.202530647)
AI for Writing Skills Improvement	Higher Education (EFL)	Kaharuddin et al. (2024) - "Defining the Role of Artificial Intelligence in Improving English Writing Skills" (DOI: 10.17507/jltr.1502.25)
AI in Career Education	Higher Education (Accounting, Entrepreneurship)	Agung Maulana et al. (2025) - "Artificial Intelligence, Job Seeker, and Career Trajectory" (DOI:10.1016/j.caeai.2025.100413)

RQ2: What are the main challenges and barriers in implementing AI-based solutions in the Indonesian education system?
The application of artificial intelligence (AI) in Indonesian education faces complex and intertwined obstacles between aspects of infrastructure, human resources, policies, ethics, and academic culture. Various studies show that although AI has opened up more personalized, adaptive, and efficient learning opportunities, the level of readiness of the Indonesian education system is still far from optimal due to digital inequality, low technology literacy, and the absence of comprehensive regulations for AI governance in educational institutions (Harsanti et al., 2025; Mustopa et al., 2024; Relmasira et al., 2023)

1. Infrastructure Limitations and Inequality of Digital Access
The most fundamental obstacles lie in the limitations of technological infrastructure and access gaps between regions. Research by Sutrisno et al. (Sutrisno et al., 2025) found that most schools outside Java do not have adequate infrastructure, such as stable internet networks, modern computer labs, and integrated AI-based learning platforms. As a result, the use of AI in non-urban areas is often superficial, for example, only using Google Assistant or ChatGPT for task training without the support of a full adaptive learning system (Mustopa et al., 2024; Sutrisno et al., 2025). In addition, Relmasira et al. (2023) highlights that at the elementary school level, the limitations of hardware and teachers with AI competence cause technology integration to still be demonstrative, not substantive (Hidayat, 2022; Nadziroh et al., 2025; Relmasira et al., 2023). This creates a two-layer digital divide: the gap between regions (rural-urban) and between institutions (public-private), which deepens the inequality in the quality of national education (Mustopa et al., 2024; Sutrisno et al., 2025).

2. Low Literacy and Readiness of Human Resources (HR)
HR readiness is a key factor that often hinders effective AI adoption. A study by Drajati et al. (Drajati et al., 2025) shows that teachers in Indonesia generally have a positive perception of AI, but do not understand enough how to integrate it pedagogically and ethically. Harsanti et al. (Harsanti et al., 2025) reinforce these findings by showing that teachers' digital readiness is still low, especially in the pedagogical dimension (AI for assessment and curriculum design). Setiyawan et al. , through the development of the AI-TPACK model, found that only 40% of vocational teachers have adequate technology, pedagogy, and content integration capabilities to use AI effectively in the classroom. On the other hand, Zaim et al. (Zaim et al., 2025) and Kusuma et al. (Kusuma et al., 2025) show that prospective teacher students also face difficulties in understanding AI conceptually and tend to use it only as a linguistic tool, such as Grammarly or ChatGPT, without reflective comprehension. This condition shows a digital pedagogical competency gap that hinders the transformation of AI-based learning at all levels of education.

3. Education and AI Governance Policies That Are Not Comprehensive
At the system level, AI implementation in Indonesia has not been supported by an integrated national policy. Mustopa et al. (2024) and Hidayat et al. (2024) highlights that AI-related policies in higher education are still institutional, lacking ethical standards, data security, and national pedagogical guidelines. Faizin et al. (Faizin et al., 2025) found that in faith-based madrassas and schools, the ambiguity of AI policies often raises moral dilemmas related to the use of AI in the process of religious learning and interpretation. In addition, educational institutions are often reactive to technological innovation, adopting AI only after external pressures or global trends, without the readiness of training systems or evidence-based evaluations (Faizin et al., 2025; Helmiatin et al., 2024; Mustopa et al., 2024). As a result, AI in Indonesia is developing without strong policy coordination between the Ministry of Education and Culture, research institutions, and

schools, which hinders the formation of a consistent and ethical educational innovation ecosystem (Drajati et al., 2025; Harsanti et al., 2025; Relmasira et al., 2023).

4. Issues of Ethics, Data Security, and Academic Plagiarism

Ethical and data security issues are a major concern in almost all studies examining AI in the Indonesian context. Budiyono et al. (Budiyono et al., 2025) found that many college students use AI to produce academic writing without understanding the boundaries between assisted writing and academic dishonesty. Rahayu et al. (Rahayu et al., 2025) also reported the emergence of cognitive dependence on AI, where students lose critical and reflective thinking skills due to using ChatGPT too often as a substitute for the independent thinking process. Zaim et al. (Zaim et al., 2025) assert that although ChatGPT can be a cognitive co-pilot, without clear ethical guidance, AI instead gives rise to new academic biases, especially in the context of the originality of the work. In addition, Faizin et al. (Faizin et al., 2025) and Malik et al. (2023) shows that most educational institutions in Indonesia do not have data security protocols in place, so the personal data of AI users such as student assignments, voices, or texts has the potential to be misused by third-party platforms.

5. Cultural Resistance and Trust to AI

Cultural factors have also slowed down the adoption of AI in schools and universities. Nadziroh et al. (2025) and Yanti et al. (Yanti et al., 2025) found that some teachers in public schools still view AI as a threat to teaching authority and teacher professionalism, rather than as a collaborative partner. In the context of EFL, Sumakul & Hamied (2023) identify the phenomenon of amotivation, in which students become passive because they feel that human interaction is being replaced by machines. Meanwhile, Fitriati & Williyan (Fitriati & Williyan, 2025) reported that some students are still skeptical of the credibility of AI in providing academic feedback due to the lack of "emotionality" and local context in AI responses. These cultural barriers show that the success of AI implementation is not only determined by technological readiness, but also by the transformation of humanistic mindsets and pedagogies in the Indonesian education system (Harsanti et al., 2025)

6. Social Gaps, Gender, and Digital Justice

In addition to the geographical dimension, the research also highlights social and gender gaps in AI adoption. Amri Dunan et al. (2025a) found that women and college students with low socioeconomic backgrounds use AI less often because they feel incompetent and fear of algorithmic errors. Harsanti et al. (Harsanti et al., 2025) and Drajati et al. (Drajati et al., 2025) added that low perceptions of digital capabilities often make these groups passive users of technology, exacerbating the digital divide between populations. On the other hand, the research of Sutrisno et al. (Sutrisno et al., 2025) shows that schools in disadvantaged areas tend to rely on traditional peer tutoring models because they are not yet able to access licensed AI learning tools. This inequality shows that although AI has the potential to improve educational equity, in practice, the technology can actually widen the gap if it is not accompanied by inclusive redistributive policies (Mustopa et al., 2024).

Overall, the main challenges in the implementation of AI in Indonesia's education system are systemic and multidimensional: limited infrastructure and access, low digital literacy of teachers and students, weak national policies, and ethical issues and trust in technology. These obstacles show that AI-based education transformation cannot rely solely on technology procurement, but requires an integrative ecosystem that includes: (1) capacity building for teachers and education personnel through pedagogy-based AI training, (2) strengthening ethical regulations and educational data privacy, (3) equitable distribution of digital infrastructure throughout Indonesia, and (4) curriculum reform to foster technology literacy and awareness ethical from an early age.

Without these strategic steps, AI has the potential to become a tool for reproducing educational inequality, not a transformative solution for the future of learning in Indonesia (Mustopa et al., 2024).

Table 5. Barrier Taxonomy (RQ2) which shows the categories of barriers in AI adoption in education in Indonesia, along with relevant evidence, context, and study examples:

Barrier	Evidence	Context	Case Study
Infrastructure & Digital Divide	Limited access to technology and internet connectivity in some areas of Indonesia, which hinders the equitable implementation of AI.	Remote areas, basic to higher education	Sutrisno et al. (Sutrisno et al., 2025) - Research on the readiness of students and teachers to learn with AI technology.
Human Resources (Teacher Readiness, AI Literacy)	Many teachers do not yet have the skills to use AI technology for teaching.	Elementary school to college	Hendro Margono et al. (2024) - Research on the adoption of AI in Indonesian schools, particularly the challenges faced by teachers.
Governance / Education Policy	The lack of policies supporting the implementation of AI in the curriculum and education in Indonesia.	Formal education, national policy	Haekal Al Asyari et al. (Asyari et al., 2025) - A study on the readiness of Indonesian legal education in adopting AI.

Ethics, Privacy, Bias	Concerns about student data collection, privacy, and potential bias in AI systems that could affect learning outcomes.	Higher education, use of AI in evaluation	Sangka et al. (Sangka et al., 2025) - Research on the role of AI in education and its impact on academic integrity.
Costs & Sustainability	The high cost of AI implementation and the uncertain sustainability of the technology for long-term use.	Indonesian schools, universities	Berkata et al. (2024) - Research on the use of Big Data and AI for sustainable education management.
Cultural/ Religious Sensitivity	Differences in the acceptance of AI technology in religious education, especially in relation to traditional values and religious teachings.	Religious education, Islamic schools	Nur Faizin et al. (Faizin et al., 2025) - Research on Muslim students' acceptance of AI use in Islamic religious education.

RQ3 – What is the impact of the use of AI on teaching practices, learning outcomes, and educational equity in Indonesia?
The application of artificial intelligence (AI) in Indonesian education has shown a significant positive impact on pedagogical effectiveness, student learning outcomes, and teacher work efficiency, although these effects still vary according to the level of education, field of study, and technological readiness of institutions. In general, AI has been proven to be able to enrich teaching practices, accelerate assessments, and support more personalized learning, but challenges still arise in terms of technology dependency, access gaps, and pedagogical readiness of teachers (Apriani, Hamidah Daulay, et al., 2025; Stuart & Williams, 2025; Harsanti et al., 2025).

1. The Impact of AI on Teaching Practice and Pedagogical Innovation
AI has shifted the traditional teaching paradigm towards a more interactive, reflective, and data-driven model. Study by Eka Apriani et al. (2025) and Rahayu et al. (Rahayu et al., 2025) found that the use of ChatGPT in academic writing learning improves the quality of teaching by providing automated feedback, contextual text examples, and real-time correction of grammar. Fitriati & Williyan's research (Fitriati & Williyan, 2025) reinforces these findings by showing that AI-enhanced self-regulated learning increases students' independence in presentation and self-evaluation, while encouraging lecturers to change their teaching approach from instructor-centered to facilitator-centered. In the context of language teachers, Kusuma et al. (Kusuma et al., 2025), Setiyawan et al., (Setiyawan et al., 2025) and Drajati et al. (Drajati et al., 2025) found that AI integration helps the development of Technological Pedagogical Content Knowledge (TPACK) and increases teachers' confidence in designing innovative technology-based learning

In addition, AI enables data-driven instruction, where teachers can use learning analytics to assess student progress and tailor learning interventions. Study by Junaidi et al. (2025b) and Blessing et al. (2024) shows that AI algorithms that analyze students' attendance and academic performance help lecturers make more accurate decisions about remedial strategies, which ultimately improves the efficiency of classroom management.

2. The Impact of AI on Learning Outcomes and Academic Performance
Various studies show that the use of AI has a positive effect on students' cognitive and affective learning outcomes, especially in language-based learning, STEM, and civic education. Rahayu et al. (Rahayu et al., 2025) and Zaim et al. (Zaim et al., 2025) showed that students who used ChatGPT in a targeted manner experienced an increase in academic writing post-test scores of up to 25–40%, as well as a significant improvement in the aspects of sentence structure and text coherence. Relmasira et al. (2023) emphasized that the integration of AI-driven STEAM education in elementary schools improves students' critical thinking skills and creativity through project-based collaborative and exploratory activities.

In the realm of character education and civic education, Nadziroh et al. (2025) found that the application of AI-based problem-based learning improves students' conflict resolution and empathy skills, with a strong social-emotional impact on collaborative behavior. Similar results were found by Yanti et al. (Yanti et al., 2025) and Sutrisno et al (Sutrisno et al., 2025) who reported that AI-based animated videos strengthen the learning of values and character in high school. Even in the context of the assessment, Choiriyah et al. (Choiriyah et al., 2025) and Juanda & Afandi (2024) show that AI-assisted assessment improves assessment reliability and accelerates formative feedback without reducing the quality of teacher evaluation (Choiriyah et al., 2025; Stuart & Williams, 2025; Juanda & Afandi, 2024).

However, some studies warn of negative effects in the form of decreased critical thinking skills and creativity when AI is used passively. Budiyono et al. (Budiyono et al., 2025) and Malik et al. (2024) found the existence of cognitive offloading, where students rely too much on AI to compose ideas and writing structures without reflective thinking. This phenomenon shows that the success of AI is highly dependent on pedagogical design and the active role of teachers as facilitators of critical learning.

3. The Impact of AI on Teacher Efficiency and Performance
AI has been proven to improve teachers' time and workload efficiency through the automation of administrative processes and assessments. Choiriyah et al. (Choiriyah et al., 2025) reported that AI-based grading systems cut task correction time by up to 90%, while Harsanti et al. (Harsanti et al., 2025) shows that teachers who have high digital leadership are able to optimize the use of AI for student performance analysis and learning outcome reporting. On the other hand, Blessing et al. (2024) noted that Big Data Analytics helps school principals evaluate teacher performance and develop evidence-based

education quality policies. However, this increase in efficiency is not always followed by an increase in pedagogical competence. Many teachers only use AI for administrative tasks or automated assessments, not as a tool for reflection or learning innovation. As a result, the role of AI is often limited as a technological assistant, not a pedagogical partner (Drajati et al., 2025; Kusuma et al., 2025; Setiyawan et al., 2025).

4. The Impact of AI on Education Equity and Inclusion

One of the most strategic impacts of AI is its potential to improve equity in access to education, especially for students with geographical and socioeconomic limitations. Relmasira et al. (2023) show that AI-powered STEAM modules in elementary schools help students from rural areas understand science concepts through interactive visualization without the need for a physical laboratory. Amri Dunan et al. (2025b) added that online-based AI entrepreneurship training helps students from weak economic backgrounds develop digital and entrepreneurial skills without location restrictions.

However, some studies highlight that AI technology can also widen the digital divide if access and literacy are uneven. Harsanti et al. (2025) and Mustopa et al. (2024) emphasized that institutions in rural areas and madrassas face limited devices, internet connections, and teacher training, so AI tends to be used in a limited way. This condition shows that without affirmative policies, AI has the potential to strengthen structural inequalities between developed and disadvantaged regions.

5. Social and Ethical Impact on the Learning Process

From a social and ethical perspective, AI contributes to changing teacher-student relations and learning culture. Nadziroh et al. (2025) found that AI in civic education strengthens students' social awareness and empathy through context-based ethical simulations. However, Sumakul & Hamied (2023) warn of an amotivation effect when AI replaces the role of human interaction in EFL classrooms. Meanwhile, Faizin et al. (2025) highlight religious teachers' concerns about the ideological and moral bias of AI in providing religious responses, suggesting that AI integration still requires adaptation of local values Overall, the impact of AI use on education in Indonesia is twofold: positively, AI strengthens data-driven teaching practices, improves cognitive and affective learning outcomes, and promotes teacher efficiency; but negatively, AI also poses new challenges related to cognitive dependence, ethical bias, and digital inequality. The effects of AI on educational equity are still contextual: AI expands access in developed areas, but it has not yet touched areas with low infrastructure. Therefore, AI has the potential to be a catalyst for national education transformation only if it is supported by strong technological literacy, inclusive policies, and humanistic pedagogy that ensures that technology serves humans, not replaces them (Eka Apriani et al., 2025; Harsanti et al., 2025; Relmasira et al., 2023)

RQ4: What are the future development directions and research opportunities to strengthen the integration of AI in the education sector in Indonesia?

The latest research map shows that the development of AI in education in Indonesia is moving towards consolidation and systemic integration. The focus of research is now shifting from ad-hoc implementation to sustainable strategic integration in policies, pedagogical practices, and research ecosystems. While AI has been shown to improve teacher learning outcomes and efficiency, many studies emphasize the importance of robust national strategies, including ethical frameworks, industry-academic collaboration, and teacher capacity building, to ensure equitable and ethical adoption of AI (Drajati et al., 2025; Harsanti et al., 2025; Mustopa et al., 2024).

1. Development of National Policies and Governance of Educational AI

The cross-institutional study emphasizes the importance of a national policy framework for AI in education, including data privacy regulation and the protection of students' digital rights. Mustopa et al. (2024) and Helmiatin et al. (2024) show that AI adoption in public universities has not been coordinated, thus requiring clear policies. Faizin et al. (2025) emphasize the importance of policies based on local and religious values so that AI technology can be adapted to Indonesia's pluralistic and moralistic social context. In addition, Harsanti et al. (2025) and Setiyawan et al. (2025) propose the establishment of a National AI for Education Roadmap that integrates aspects of regulation, academic research, and technology implementation to ensure synergy across educational institutions and the Government. Future research is suggested to explore an educational AI governance model that aligns with digital security, algorithm transparency, and social inclusion, especially in the context of madrasas, pesantren, and schools in disadvantaged areas [(Faizin et al., 2025; Relmasira et al., 2023; Nadziroh et al., 2025)].

2. Industry–Education Collaboration and Innovation Ecosystem Development

Research trends show that collaboration between educational institutions, government, and the tech industry is a key pillar in accelerating the adoption of relevant and sustainable AI. Amri Dunan et al. (2025b) identify the success of industry-based AI-based entrepreneurship training that enhances students' digital skills and facilitates knowledge transfer between the private and academic sectors. Junaidi et al. (2025a) and Said et al. (2024) highlight the need for a university-industry partnership mechanism to develop AI-driven learning management systems (LMS) and predictive analytics in monitoring student academic performance in real-time.

Relmasira et al. (2023) and Sangka et al. (2025) emphasized that research partnerships with technology companies such as Google and IBM can expand AI innovation for STEAM education in primary and secondary schools, while building technology literacy from an early age. Going forward, a promising research direction is the development of AI Innovation Hubs on campuses and schools to integrate academic research, teacher training, and the development of locally-based AI solutions.

3. Teacher Training and AI-Pedagogical Competency Strengthening

Most of the studies in the dataset emphasize that teacher capacity is a key determinant of the success of AI adoption. Casal-Otero et al. (2023) and Drajati et al. (2025) found that increasing AI literacy among teachers can change teaching patterns from transmission-based to reflective and adaptive learning. Yuliandari et al. (2023) and Harsanti et al. (2025) shows that digital leadership and teacher readiness significantly predict teachers' intentions to use AI in schools. Setiyawan et al. (2025) developed an AI-TPACK model to measure the readiness of vocational teachers, and the results show that the integration of AI-based technology, pedagogy, and content can increase teaching effectiveness by up to 35% compared to traditional models.

The direction of future research development needs to focus on practice-based training, where teachers are trained not only to understand technology but also to use it to develop collaborative learning strategies, data-based assessments, and inclusive learning (Owolabi et al., 2025). In addition, research can be directed towards the design of AI-assisted teacher coaching platforms that utilize learning data to support teacher reflection and professional improvement in a sustainable manner (Fu et al., 2025).

4. Development of Algorithmic Ethics and Justice Framework

In the future, strengthening the AI Ethics Framework will be a priority for research and policy. Budiyono et al. (2025) and Zaim et al. (2025) highlight the urgent need to develop a national ethical framework to address the issues of digital plagiarism, overreliance, and algorithmic bias in automated scoring systems. Faizin et al. (2025) added that the ethical perspective of AI in Indonesia needs to include contextual religious and social values, not just imitating Western standards. Malik et al. (2023) and Rahayu et al. (2025) emphasized the importance of ethical literacy among students and lecturers so that the use of AI continues to uphold academic integrity and social responsibility (Budiyono et al., 2025; Zaim et al., 2025; Faizin et al., 2025)

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5. Contextual and Local AI Technology Research

A great opportunity for future research lies in the development of local AI that is sensitive to Indonesia's cultural, linguistic, and educational context. Zaim et al. (2025) underline that Generative AI in language learning must be adapted to idioms, local contexts, and national linguistic norms so as not to cause semantic distortions. Relmasira et al. (2023) added the importance of developing AI-powered educational datasets taken from Indonesian student data to avoid global bias. Amri Dunan et al. (2025a) and Sutrisno et al. (2025) also encourage cross-campus research collaboration in building AI datasets for inclusive learning that include students from various regions and socioeconomic backgrounds

Future research also needs to expand exploration on the integration of adaptive learning systems, speech recognition for regional languages, and AI-based accessibility tools for students with disabilities, so that AI can truly support inclusive and multilingual education in Indonesia (Relmasira et al., 2023).

6. Strengthening the National Interdisciplinary Research and Data Ecosystem

Many researchers emphasize the need to consolidate national research on educational AI through open data and collaboration between universities. Creation of a National Educational AI Repository to collect data on student learning outcomes, digital behavior, and learning preferences from across the province (Berkat et al., 2024). Cross-disciplinary research that connects the fields of education, data science, linguistics, and ethics to strengthen the scientific basis of national education AI policies (Mustopa et al., 2024)

This kind of research collaboration is expected not only to result in technological innovations, but also to strengthen evidence-based AI governance models that encourage transparency and accountability in the Indonesian education system (Harsanti et al., 2025)

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Table 6 The Future Research & Policy Agenda (RQ4) which groups research and policy agendas based on the source of recommendations, urgency, and implementability:

Agenda	Recommendation Source	Urgency	Implementability
Long-term research on the impact of AI in education	Ridwan (2025), Eka Apriani et al. (2025)	High	Moderat
Policy development for AI integration in the curriculum	Haekal Al Asyari et al. (2025), Siti Choiriyah et al. (2025)	High	Tinggi
Improving AI literacy among teachers	Nur Arifah Drajati et al. (2025), Ratna Dewanti et al. (2025)	High	Moderate
Research related to AI for equal access to education	Berkata et al. (2024), Sangkya et al. (2025)	High	low
Development of more adaptive and personalized AI technology	Herman Budiyono et al. (2025), Agung Maulana et al. (2025)	Moderate	High
Evaluation of AI-based education policies	Wiyaka et al. (2024), Sari et al. (2025)	Moderate	Moderate
Improvement of digital infrastructure in remote areas	Sutrisno et al. (2025), Mustopa et al. (2024)	High	low
International collaboration in AI research in education	Anak Agung Putri Maharani et al. (2025), Fatah Syukur et al. (2024)	Moderate	High
Enhanced development of AI policies for higher education	Helmiatin et al. (2024), Nurtanto et al. (2025)	Moderate	High
The application of AI in competency-based education assessment	Siti Choiriyah et al. (2025), Fachrurrozie et al. (2025)	High	Moderate

This table presents a research and policy agenda in the field of AI in education, with an emphasis on long-term research, integration of AI curriculum, and policy development that supports the application of AI in education. Several research recommendations related to equal access to education and infrastructure development in remote areas have high urgency, although their implementation is lower. Meanwhile, the development of AI literacy among teachers and policies for the integration of AI in the curriculum show high urgency and implementability.
RQ5: How has the evolution of AI research in education in Indonesia over time been reviewed from publication trends, research focus, and collaboration networks?

Table 7. Distribution of publications per year (n=74)

Year	n	%
2022	1	1,4
2023	4	5,4
2024	21	28,4
2025	47	63,5
2026	1	1,4

Table 1 shows the distribution of publications related to AI in education during the period 2022 to 2026. In 2022, only 1 article was published, accounting for 1.4% of total publications. The number of publications increased in 2023 with 4 articles or 5.4%. The peak number of publications occurred in 2025, with 47 articles covering 63.5% of total publications. In 2024, there were 21 articles (28.4%), while in 2026, there was again 1 article (1.4%). Overall, there was a significant surge in publications in 2025, indicating a growing interest in AI research in education.

Table 8. Top affiliations (based on frequency of appearance in affiliation metadata)

Ranking	Affiliate	Number of occurrences
1	Universitas Negeri Yogyakarta	6
2	Universitas Negeri Jakarta	5
3	Universitas Negeri Malang (Indonesian Language Education)	4
4	Universitas Negeri Surabaya	3
5	Universitas Pendidikan Indonesia	3
6	Universitas Sultan Ageng Tirtayasa	2
7	Universitas Muhammadiyah Surakarta	2
8	Universiti Pendidikan Sultan Idris (Malaysia)	2
9	Universitas Indonesia	2
10	Universitas Gadjah Mada	2

Table 9 shows the top affiliations based on frequency of appearance in affiliation metadata. Yogyakarta State University ranks first with 6 appearances, followed by Jakarta State University with 5 appearances. Next, Malang State University (Indonesian Language Education) recorded 4 appearances, while Surabaya State University and Indonesia University of Education each had 3 appearances. Several other universities, such as Sultan Ageng Tirtayasa University, Muhammadiyah University Surakarta, Sultan Idris Education University (Malaysia), University of Indonesia, and Gadjah Mada University, each recorded 2 appearances. This table reflects the major contributions of universities in Indonesia to AI research in education.

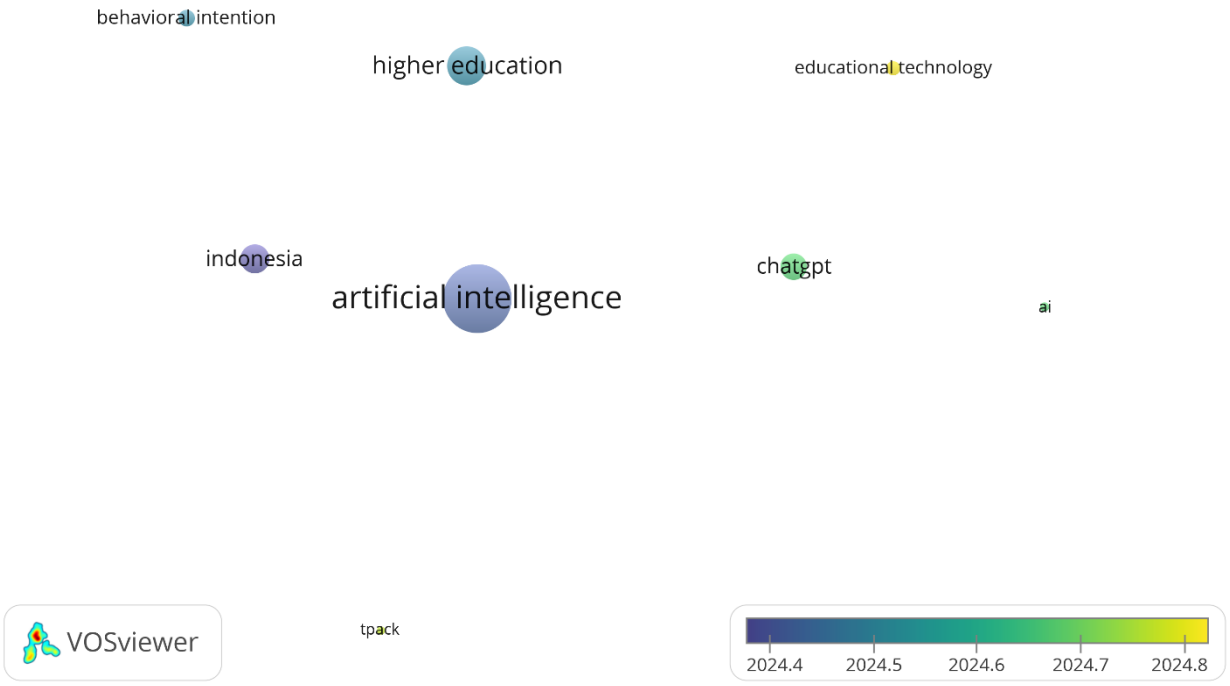

Figure 3. Keyword Co-occurrence Network (VOSviewer)

This image shows the keyword co-occurrence network related to the topic of AI in education. The main keywords that appear are "artificial intelligence", which is closely related to "higher education", "ChatGPT", and "educational technology". "Indonesia" also emerged as a keyword connected to research centers in the country. The relationship between keywords shows a strong focus on the use of AI in higher education as well as the application of ChatGPT in education. Darker colors on the timescale indicate the latest trends, with most publications focusing on 2024.

CONCLUSION

This study presents a comprehensive overview of the application and development of artificial intelligence (AI) in education in Indonesia. Key findings show that despite a surge in AI publications in education in 2025, research focus remains predominantly on higher education, with generative AI applications (e.g., ChatGPT) supporting language learning and academic skills. Key challenges include infrastructure limitations, the digital readiness of educators, and a lack of policies that support the comprehensive implementation of AI.

Although AI can improve educational equity, issues of digital access, inclusive policies, and competency gaps hinder the adoption of the technology. Based on these findings, the three priority agendas for AI development in Indonesian education are:

1. Developing comprehensive national policies related to AI in the curriculum and student data protection.
2. Improving digital literacy for teachers, especially in areas with infrastructure limitations.
3. Focusing on adaptive AI and personalization research in primary and secondary education.

This research provides an "evidence-informed roadmap" for AI development in Indonesian education, with the aim of ensuring fairness and quality in the national education system.

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