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Article Reviews

# Human-AI Educational Collaboration: Facing Learning Challenges in the Digital Age

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| Received: March 14, 2025 | Revised: June 6, 2025 | Accepted: June 15, 2025 | Online: June 30, 2025 |
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**Abstract**

Digital transformation in education has driven the integration of artificial intelligence (AI) as a key element in personalising learning, managing educational institutions, and supporting pedagogical decision-making processes. However, the application of AI also raises ethical challenges, access gaps, and fundamental changes in the role of teachers. This research aims to identify and classify the primary dimensions of human-AI collaboration in education through a qualitative approach, utilising a systematic literature review of 50 scientific articles published over the last five years. The articles were selected based on their thematic relevance from the Google Scholar and Scopus databases and analysed using NVivo software to cluster the dominant codes in the literature. The analysis resulted in four main components: Adaptive Learning with Artificial Intelligence (ALEAI), Artificial Intelligence in Education (AIED), Ethical Challenges in AI Education (EAIED), and Teacher Roles in AI-assisted learning (TRAIL). The findings indicate that AI has significant potential to enhance the efficiency and inclusivity of learning but also necessitates robust regulations in data protection, algorithm bias mitigation, and teacher training. This research contributes to the formulation of a conceptual framework for developing fair, ethical, and sustainable AI-based education policies.

**Keywords:** *Artificial Intelligence (AI), Adaptive Learning, AI-based Education, Ethical Challenges, Human-AI Collaboration, Role of Teachers.*

## INTRODUCTION

The development of technology in the digital era has brought about numerous changes in various sectors, including education. One of the most influential technologies in this transformation is artificial intelligence (AI). In recent years, AI has been widely adopted in various educational institutions as a tool to support learning and administrative processes (Dogan et al., 2023; Zhai et al., 2021). According to Zhao et al. (2021), AI can improve operational efficiency in educational institutions by assisting teachers in managing administrative tasks, such as assessment, student progress tracking, and learning data analysis, automatically. As a result, teachers have more time to focus on in-depth pedagogical aspects, such as personalised teaching and moral guidance, which are aspects that AI cannot replace (Wood et al., 2021).

AI can personalise students' learning experiences. It enables the development of curriculum and learning materials tailored to students' specific needs based on the analysis of real-time data (Liu & Ren, 2022). For example, AI can analyse students' learning patterns and provide immediate feedback, helping students overcome their weaknesses and optimise learning outcomes (Wood et al., 2021; Zellner, 2023). This approach enhances learning efficiency and effectiveness, thereby increasing student engagement and motivation (Fitria, 2023). According to Ma (2021), AI systems can also provide continuous assessment that supports project-based and collaborative learning. In this way, AI is not only a tool but also a vital partner in education, enabling more dynamic and adaptive learning.

However, as the application of AI in education becomes more widespread, critical questions arise regarding the role of the teacher. Traditionally, teachers have been the primary transmitters

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of information in the classroom (Oosrio et al., 2024). They are responsible for teaching the material, evaluating student learning outcomes, and providing moral and emotional support throughout the learning process (Hwang & Tu, 2021). However, with AI able to perform many tasks previously performed by teachers, such as providing feedback and compiling customised materials, concerns have been raised about whether AI will completely replace the role of teachers (Zhao et al., 2021). According to research conducted by Fitria (2023), although AI can automate some aspects of the teaching process, some elements in education cannot be replaced by technology. Teachers are still needed to provide context, support social interaction, and foster the development of critical thinking skills and creativity in students (Wood et al., 2021).

Furthermore, research indicates that AI is currently limited in its ability to handle the emotional aspects of education effectively. AI cannot understand students' emotional needs or establish personal relationships, which are often integral to the learning process (Priyahita, 2020). Teachers, on the other hand, can provide emotional and social support that is critical to student development (Fitria, 2023). Teachers also serve as behavioural and ethical models for students, something that cannot be programmed into an AI system (Zhao et al., 2021). In this case, AI serves as a tool that reinforces the role of teachers rather than replacing them (Kim et al., 2022). At the same time, AI enables the creation of new learning methods that were previously difficult without the help of technology. AI-based learning enables teachers to adopt more collaborative approaches, where students work together to solve problems, with AI support providing feedback and suggestions at every stage of the process (Gupta & Bhaskar, 2020; Zhao et al., 2021). For example, in language learning, AI can facilitate more interactive and realistic conversations through technology-based simulations, providing a more immersive learning experience (Fitria, 2023; Vall & Araya, 2023). Research indicates that collaborative learning facilitated by AI can enhance student engagement, improve learning outcomes, and foster the development of practical communication skills (Zellner, 2023; Zhao et al., 2021).

However, the application of AI in education also brings challenges. One of the biggest challenges is the readiness of teachers to utilise these technologies effectively. Numerous studies demonstrate that while AI has considerable potential in supporting learning, its successful implementation largely depends on teachers' ability to comprehend and utilise the technology (Ma, 2021; Wood et al., 2021). According to Zhao et al. (2021), teachers require adequate training to effectively utilise AI in a manner that optimally supports student learning. Without proper training, AI can be an additional burden for teachers, especially if they are unfamiliar with these new technologies (Wood et al., 2021).

Additionally, there are challenges related to the ethical use of AI in education. The use of AI in collecting and analysing student data raises concerns about data privacy and security (Wood et al., 2021; Zellner, 2023). Many parents and educators are concerned about how student data is used and stored, as well as whether students will become "products" of systems that are too focused on data and algorithms (Zhao et al., 2021). Therefore, it is crucial to establish clear guidelines for the use of AI in education, ensuring that these technologies are employed ethically and responsibly (Gupta & Bhaskar, 2020; Zhao et al., 2021).

The existing literature review still tends to be fragmented, focusing on the technical aspects of AI in learning. In contrast, others focus on ethics or pedagogical transformation but rarely integrate all four dimensions holistically. In addition, there are not many studies that systematically classify the contributions of the literature on the theme of human-AI collaboration, especially in the context of post-pandemic education that accelerates massive digitisation (Dogan et al., 2023; Zhao et al., 2021). To fill this gap, this study aims to synthesise the findings from 50 selected scientific articles through a systematic literature review approach and NVivo-assisted thematic analysis.

The main objective of this research is to identify the main conceptual dimensions of the

collaborative relationship between humans (especially teachers) and AI in the education system, which are grouped into four components of findings: Adaptive Learning with Artificial Intelligence (ALEAI), Artificial Intelligence in Education (AIED), Ethical Challenges in AI Education (EAIED), and Teacher Roles in AI-Assisted Learning (TRAIL). Thus, this article is expected to make a conceptual contribution to building a theoretical framework that can serve as a reference for the development of AI-based education policies that are more equitable, ethical, and contextually relevant.

## LITERATURE REVIEW

### Adaptive Learning with Artificial Intelligence (ALEAI)

AI-based adaptive learning refers to the system's ability to customise learning materials, pace, and approach according to each student's unique needs. The system operates through real-time data analysis and machine learning algorithms, enabling the deep personalisation of learning (Zhai et al., 2021). Ma et al. (2021) explain that AI allows learning systems to respond directly to student interactions, provide automatic feedback, and design flexible learning paths. Technologies such as intelligent tutoring systems and learning analytics have now been widely applied in various contexts, ranging from higher education to vocational training (Liu, 2023; Adeleye et al., 2023). In the context of online learning, these systems have been demonstrated to enhance learning motivation and support students with varying learning speeds (Fitria, 2023; Dogan et al., 2023).

However, the effectiveness of AI-based adaptive systems is highly dependent on the quality and quantity of data collected, as well as the algorithms used. In addition, challenges arise in terms of the system's openness in explaining its adaptation logic to both teachers and students, which is an important issue in creating transparent and accountable learning (Zhao et al., 2021; Tapalova, 2022).

### Artificial Intelligence in Education (AIED)

AI not only comes in the form of learning aids but also drives innovation in the development of the education system as a whole. AIED encompasses the implementation of AI in education management, curriculum development, automated assessment, and system efficiency improvement (Zellner, 2023; Kim et al., 2022). AI technologies are capable of processing large volumes of academic data to assist educational institutions in making strategic decisions, such as identifying dropout risk, detecting underperformance, and allocating teaching resources effectively (Grunhut et al., 2022).

AI also plays a crucial role in fostering more inclusive learning, particularly for students with special needs. Technologies such as speech-to-text, chatbots, and virtual learning environments have expanded access to learning, particularly in the context of the COVID-19 pandemic and its aftermath (Zulkarnain & Yunus, 2023; Wood et al., 2021). However, effective AIED development requires curriculum integration, infrastructure readiness, and human resource readiness to avoid inequalities in education quality.

### Ethical Challenges in AI Education (EAIED)

The application of AI in education raises several crucial ethical challenges. One of the most significant is algorithm bias, where AI system decisions may reflect the inequality of training data, resulting in unfair judgments or recommendations (Vall & Araya, 2023). Additionally, the issue of student data privacy is a significant concern, as many AI-based learning systems rely on the extensive processing of personal data (Grunhut et al., 2022). Sarwar (2024) emphasised that the importance of developing data protection policies and promoting algorithmic openness lies at the basis of ethical and trustworthy systems.

Equally important, ethical challenges also arise in the form of disparities in access to

technology. Students in regions with limited digital infrastructure often fall behind because they lack access to adequate AI services and tools (Gupta & Bhaskar, 2020). Therefore, systemic and policy-based solutions are needed to ensure that the use of AI in education does not deepen existing inequalities.

**Teacher Roles in AI-Assisted Learning (TRAIL)**

The role of teachers has undergone a significant transformation with the increasing adoption of AI technology in education. Instead of merely being information transmitters, teachers are now expected to act as facilitators, mediators, and evaluators in increasingly digital learning environments (Zulkarnain & Yunus, 2023). Fitria (2023) states that AI can reduce teachers' administrative workload, allowing them to focus on mentoring and strengthening students' affective and social aspects. However, many teachers still feel anxious about the possibility of being replaced by machines, a concern that is exacerbated by the lack of training and understanding of the technology (Wood et al., 2021).

In response to this challenge, teacher training is crucial for the successful integration of AI. The study by Adeleye et al. (2023) highlights the importance of a structured professional development plan to ensure that teachers not only utilise AI effectively but also comprehend the ethical, pedagogical, and social implications of its use. Teachers who possess a thorough understanding of AI will be better equipped to work with the technology to create meaningful learning experiences.

**RESEARCH METHOD**

This study employed a qualitative approach, utilising a systematic literature review (SLR) methodology in accordance with the PRISMA 2020 guidelines to identify the key dimensions of human-AI collaboration in education. A systematic literature review was selected because it provides a comprehensive synthesis of available empirical evidence and enables the identification of patterns and trends in research related to teacher role transformation in the AI era (Creswell & Creswell, 2018). This methodology ensures transparency, reproducibility, and high methodological quality through a systematic and rigorous approach to synthesising the literature.

**Literature Search Strategy**

A systematic search was conducted across five major academic databases: Scopus, Google Scholar, IEEE Xplore, DOAJ, and EBSCO Education Source. These databases were selected based on their relevance to the topic, indexing quality, and coverage of educational technology publications. The Boolean search string employed was: ("artificial intelligence" OR "AI" OR "machine learning") AND ("education" OR "learning" OR "teaching") AND ("teacher" OR "educator" OR "instructor") AND ("collaboration" OR "integration" OR "role"). Database-specific adaptations were implemented: Scopus used the TITLE-ABS-KEY format, Google Scholar employed a phrase-based search, IEEE Xplore focused on technical terminology, DOAJ utilised a subject heading approach, and EBSCO applied controlled vocabulary. The search was limited to publications from 2019 to 2024 in the English and Indonesian languages, focusing on peer-reviewed journal articles and reputable conference proceedings.

**Selection Criteria and Screening Process**

Inclusion criteria encompassed: (1) focus on AI implementation in formal education settings, (2) discussion of teacher role transformation in the AI era, (3) transparent research methodology with adequate sample size, and (4) publication in journals with an impact factor ≥0.5 or indexed in Scopus/WoS. Exclusion criteria included (1) technical AI development without educational context,

(2) poor methodological quality without clear design, (3) data or sample duplication with other publications, and (4) limited accessibility to the full text.

The selection process followed three systematic stages, as outlined in the PRISMA protocol. The identification stage yielded 1,247 articles from database searches, which were reduced to 892 articles after removing 378 duplicates through automated and manual processes. The screening stage was conducted by two independent reviewers (PR and RKF) on titles and abstracts using standardised screening forms, achieving inter-rater reliability (Cohen's κ = 0.84, substantial agreement). Disagreements were resolved through discussion with the consultation of a third reviewer when needed, resulting in 247 articles for full-text assessment. The eligibility stage employed the Modified Mixed Methods Appraisal Tool (MMAT), with a minimum threshold of 7/10, to ensure methodological quality, resulting in 50 high-quality articles that met all criteria for final analysis.

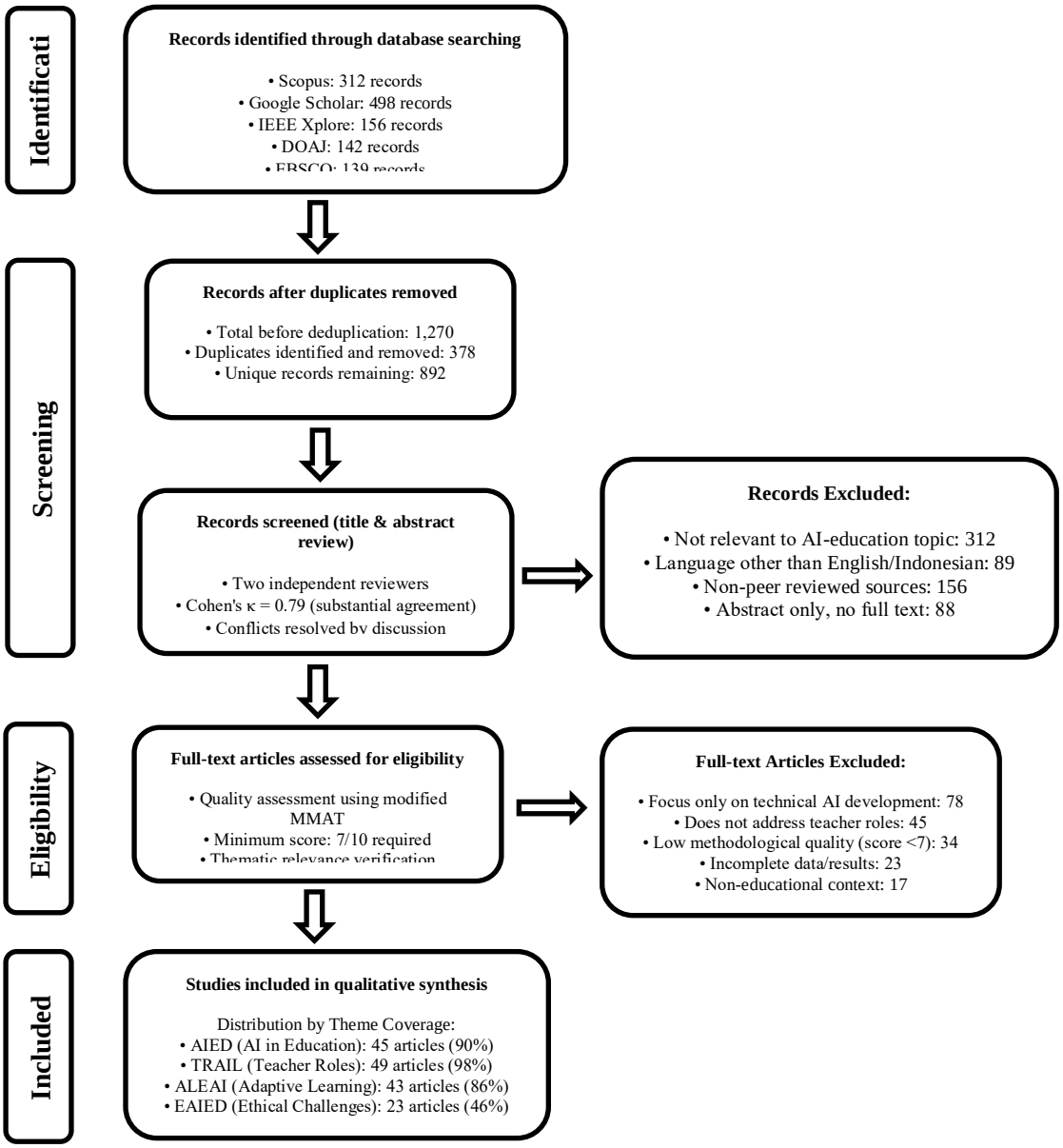


**Figure 1.** PRISMA Diagram (Systematic Review: Human-AI Educational Collaboration)
Source: Processed by Researcher

**Data Analysis and Synthesis**

Data analysis employed the six-phase thematic analysis framework developed by Braun and Clarke (2006), with assistance from NVivo 12 Plus software. The process began with data familiarisation through repeated reading of all articles, followed by the generation of initial codes using both inductive and deductive coding approaches. The third phase involved searching for themes through code collation to identify potential themes and perform thematic mapping. The fourth phase comprised reviewing themes for internal homogeneity and external heterogeneity assessment, followed by defining and naming themes with clear definitions and scope. The final phase produced reports through narrative synthesis, incorporating supporting evidence and integrating themes into a coherent framework.

Thematic saturation was systematically evaluated by monitoring the emergence of new code, theme stability, and theoretical sufficiency. Saturation was successfully achieved in the following studies: ALEAI (article #35, with no new codes in the final eight articles), AIED (article #41, with a stable theme definition), TRAIL (article #38, with a comprehensive role taxonomy), and EAIED (article #28, with sufficient ethical framework development). Coding validation was strengthened through triangulation, member checking with AI education experts, peer debriefing, and comprehensive audit trail documentation.

**FINDINGS AND DISCUSSION**

The thematic analysis of 50 scientific articles shows that the dynamics of collaboration between artificial intelligence (AI) and teachers in education can be grouped into four main components: Adaptive Learning with Artificial Intelligence (ALEAI), Artificial Intelligence in Education (AIED), Ethical Challenges in AI Education (EAIED), and Teacher Roles in AI-Assisted Learning (TRAIL). These four themes not only represent the dominant issues emerging in academic discourse, but also showcase the close interconnections between technology, pedagogy, and ethics in 21st century education.

**Table 1.** 50 Research Articles on the Role of AI in Global Education

| Author | Title | Index | Main Topic | Method |
|---|---|---|---|---|
| (Flores-Velásquez et al., 2024) | A Bibliometric Analysis of Research on Artificial Intelligence Technology Acceptance in Higher Education Teaching and Learning. | Scopus | AIED, TRAIL | QL |
| (Nagaraj et al., 2023) | An Analysis of Artificial Intelligence's Developing Role in STEM Higher Education | Scopus | AIED, ALEAI, TRAIL, EAIED | QL |
| (Zellner, 2023) | Asking the Correct Questions: What does it mean to educate and learn in the generative AI era? | DOAJ | AIED, ALEAI, TRAIL | CL |
| (Akbarani, 2024) | Artificial Intelligence in the Teaching of English | Google Scholar | AIED, ALEAI, TRAIL | QN |
| (Wang, 2019) | Artificial Intelligence Research Encourages Change in English Learning | Web of Science | AIED, ALEAI, TRAIL | CL |
| (Wu & Zhang, 2023) | Powered by Artificial Intelligence (AI), Innovation and Entrepreneurship Education (IAEE) | Web of Science | TRAIL | CL |
| (Sun, 2023) | Examining AI's Potential and | Web of | AIED, ALEAI, | CL |

| Author | Title | Index | Main Topic | Method |
|---|---|---|---|---|
| | Difficulties for Teaching English in College | Science | TRAIL, EAIED | |
| (Kolegova & Levina, 2024) | Artificial Intelligence as a Digital Instrument for Teaching Foreign Languages | ROAD | AIED, ALEAI, TRAIL | QN |
| (Zulkarnain & Yunus, 2023) | A Systematic Review of Primary Teachers' Views on the Use of AI Technology in Teaching and Learning English as a Second Language | Copernicus | AIED, ALEAI, TRAIL, EAIED | QL |
| (Vall & Araya, 2023) | Examining the Advantages and Difficulties of AI-Language Learning Resources | Copernicus | AIED, ALEAI, TRAIL, EAIED | CL |
| (Moukhliss et al., 2024) | Artificial Intelligence's Effects on Moroccan Research and Higher Education. | Scopus | AIED, TRAIL, EAIED | QN |
| (Fiialka et al., 2023) | Issues and Opportunities in Ukrainian Education using ChatGPT | Scopus | AIED, TRAIL, EAIED | QN |
| (Fitria, 2023) | Artificial Intelligence in Education (AIED): Is It Possible for AI to Take the Place of Teachers? | Google Scholar | AIED, ALEAI, TRAIL, EAIED | QL |
| (Rashmi, 2023) | Unlocking AI's Potential in Education: Opportunities and Difficulties | Copernicus | AIED, ALEAI, TRAIL | QN |
| (Wu, 2024) | AI-Powered Education: A Novel Approach to the "Business Data Analysis and Application" Course | Google Scholar | AIED, ALEAI, TRAIL, EAIED | CL |
| (Sarwar et al., 2024) | How Artificial Intelligence Will Affect Higher Secondary Education in the Future | Google Scholar | AIED, ALEAI, TRAIL, EAIED | QL |
| (Alnasib, 2023) | A Study Conducted in the Context of Higher Education in Saudi Arabia Examined the Factors Influencing Faculty Members' Readiness to Incorporate Artificial Intelligence into Their Teaching Practices. | Scopus | AIED, ALEAI, TRAIL | QN |
| (Tapalova & Zhiyenbayeva, 2022) | Artificial intelligence in the classroom: AIEd for customized learning paths | Google Scholar | AIED, ALEAI, TRAIL, EAIED | QL |
| (Cowin et al., 2024) | From the perspective of space merchants, artificial intelligence and the future of marketing education | Google Scholar | AIED, ALEAI, TRAIL, EAIED | QL |
| (Chen et al., 2020) | A Review of Artificial Intelligence in Education | IEEE | AIED, ALEAI, TRAIL | QL |
| (Lee et al., 2021) | A Scoping Review of Artificial Intelligence in Undergraduate Medical Education | Web of Science | AIED, ALEAI, TRAIL, EAIED | QL |
| (Akhmadieva et | A Bibliometric Analysis of | Scopus | AIED, ALEAI, | QL |

| Author | Title | Index | Main Topic | Method |
|---|---|---|---|---|
| al., 2023) | Artificial Intelligence in Scientific Education | | TRAIL | |
| (Zhai et al., 2021) | An Analysis of 2010–2020 Artificial Intelligence (AI) in Education | Scopus | AIED, ALEAI, TRAIL, EAIED | QL |
| (Körkkö et al., 2022) | Creating a Professional Development Plan for Teacher in-service Training: Illustrating the Procedure | Scopus | AIED, TRAIL | QL |
| (Yu & Guo, 2023) | Educational Reform Is Empowered by Generative AI: Present State, Challenges, And Opportunities | Scopus | AIED, ALEAI, TRAIL, EAIED | CL |
| (Cirlos et al., 2023) | ChatGPT: prospects and hazards in the domains of healthcare, education, and research | DOAJ | AIED, TRAIL | CL |
| (Gupta & Bhaskar, 2020) | Factors That Encourage and Restrict Teachers' Adoption of AI-Based Teaching and Learning Solutions: Setting Priorities Through the Analytic Hierarchy Process | Scopus | AIED, ALEAI, TRAIL | QN |
| (Luo, 2024) | Novel studies on AI-supported instructional strategies for collegiate English speaking and listening classes | Google Scholar | AIED, ALEAI, TRAIL, EAIED | QL |
| (Liu, 2023) | Examining Artificial Intelligence's Use in Teaching Foreign Languages: Obstacles and Prospects | DOAJ | AIED, ALEAI, TRAIL | CL |
| (Hwang & Tu, 2021) | Artificial Intelligence's Functions and Research Trends in Mathematics Education: A Systematic Review and Bibliometric Mapping Analysis Gwo-Jen | Scopus | AIED, ALEAI, TRAIL | QL |
| (Grunhut et al., 2022) | Applications, Difficulties, and Needs of Artificial Intelligence in Medical Education Programs | Scopus | AIED, ALEAI, TRAIL | CL |
| (Ma, 2021) | An Immersion Contextual Approach to College English Instruction Using Virtual Reality Technology with Artificial Intelligence and Machine Learning | Scopus | AIED, ALEAI, TRAIL | QN |
| (Nurjanah et al., 2024) | A Review of the Use of Artificial Intelligence (AI) in the Teaching and Learning Process of Today | EBSCO | AIED, ALEAI, TRAIL | QL |
| (Ozigagun et al., 2024) | AI-Powered Education Revolution: An Extensive Analysis of Improving Educational Experiences | Google Scholar | AIED, ALEAI, TRAIL, EAIED | CL |

| Author | Title | Index | Main Topic | Method |
|---|---|---|---|---|
| (Kong et al., 2023) | Artificial Intelligence Research Facilitates Superior Vocational Education Development | Scopus | AIED, ALEAI, TRAIL | QN |
| (Kim et al., 2022) | Leading educators' opinions on AI in education: designing lessons to facilitate student-AI collaboration | Scopus | AIED, ALEAI, TRAIL, EAIED | QL |
| (Yau et al., 2023) | Teachers' perceptions of teaching artificial intelligence (AI) in K–12 classrooms: a phenomenographic approach | Scopus | AIED, ALEAI, TRAIL | QL |
| (Seo et al., 2021) | Artificial intelligence's effects on online learning interactions between students and teachers | Scopus | AIED, ALEAI, TRAIL, EAIED | QL |
| (McCoy et al., 2020) | What knowledge of artificial intelligence is truly necessary for medical students? | Scopus | AIED, ALEAI, TRAIL, EAIED | CL |
| (Chaudhry & Kazim, 2022) | An Elite Academic and Industrial Remark on Artificial Intelligence in Education (AIED) from 2021 | EBSCO | AIED, ALEAI, TRAIL, EAIED | CL |
| (Zhao et al., 2021) | Examining the Professional Growth and Essential Skills of Primary School Music Teachers in the Age of Artificial Intelligence | Scopus | AIED, ALEAI, TRAIL, EAIED | QN |
| (Soelistiono & Wahidin, 2023) | AI-Integrated Learning System Design in AILS-Based Education: An Innovative Approach to Educational Technology | Copernicus | AIED, ALEAI, TRAIL | QL |
| (Paek & Kim, 2021) | An examination of global research patterns about the effects of AI in education | Scopus | AIED, TRAIL | QL |
| (Quy et al., 2023) | AI and Digital Transformation in Higher Education: The Goals and Methods of a Particular Vietnamese University | Scopus | AIED | CL |
| (Liu & Ren, 2022) | The Impact of Artificial Intelligence Technology on Instruction at the "internet+" Threshold: The Example of an English Education Platform Application | Scopus | AIED, ALEAI, TRAIL | QN |
| (Adeleye et al., 2024) | A Review of Inclusive Educational Approaches in the Age of Artificial Intelligence: Innovative Teaching Methodologies | Google Scholar | AIED, ALEAI, TRAIL, EAIED | CL |
| (Wood et al., 2021) | Students and Faculty Survey: Are We Prepared to Include Artificial Intelligence Literacy in the Medical School Curriculum? | DOAJ | AIED, ALEAI | QN |

| Author | Title | Index | Main Topic | Method |
|---|---|---|---|---|
| (Akavova et al., 2023) | Survey of Students and Faculty: Is the Medical School Curriculum Ready to Incorporate Artificial Intelligence Literacy? | Google Scholar | AIED, ALEAI, TRAIL, EAIED | QL |
| (Dogan et al., 2023) | A Comprehensive Analysis of Empirical Research on the Application of Artificial Intelligence (AI) in Distance Education and Online Learning Processes | Scopus | AIED, ALEAI, TRAIL, EAIED | QL |
| (Semeniuk et al., 2024) | Novel Techniques and Strategies for Artificial Intelligence Instruction in Ukrainian Higher Education | Copernicus | AIED, ALEAI, TRAIL | QL |

Source: Processed by Researcher

AIED: AI in Education; ALEAI: Adaptive Learning with AI; TRAIL: Teacher Role in AI-Assisted-Learning; EAIED: Ethical Challenges in AI Education; QN: Quantitative; QL: Qualitative; CL: Conceptual.

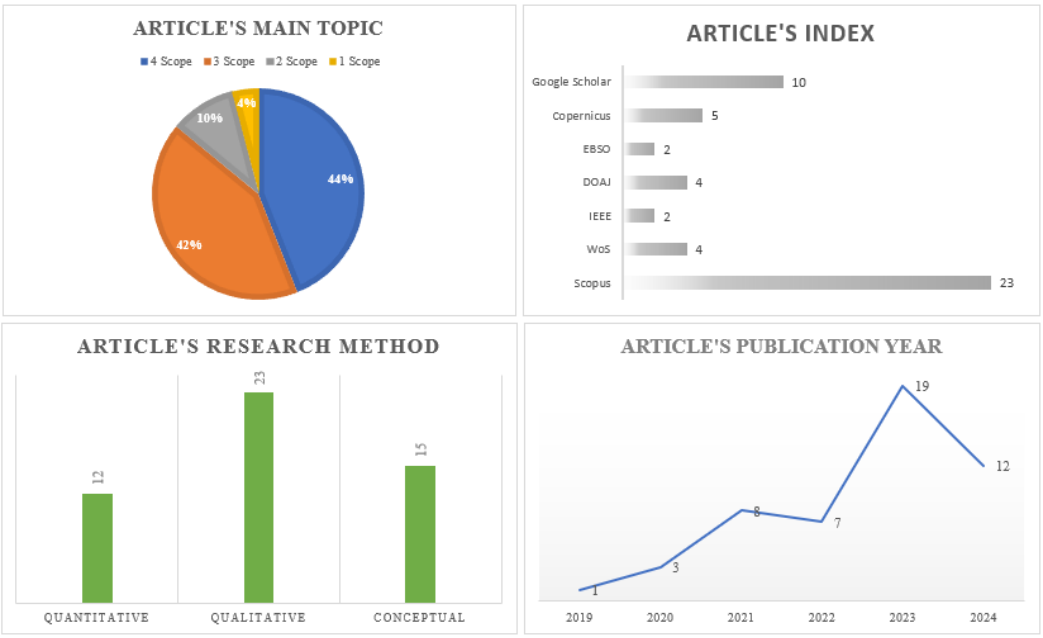


**Figure 2.** Visualization of Research Results from 50 Articles
Source: Processed by Researcher

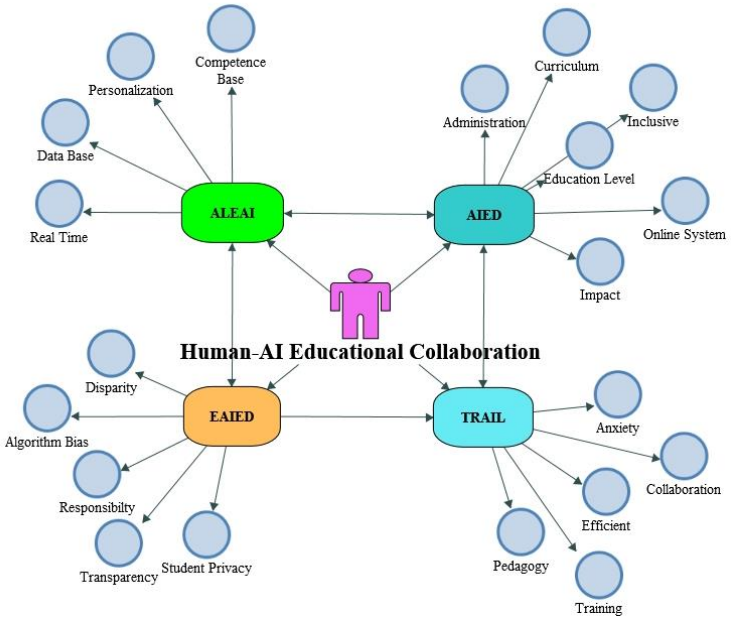


**Figure 3.** Thematic Analysis of 50 Articles using NVivo 12
Source: Processed by Researcher

**Artificial Intelligence in Education (AIED)**

A total of 45 out of 50 articles emphasize that AI has high capabilities in creating adaptive and personalized learning environments. AI enables learning systems to adjust the content, pace, and learning style of students based on real-time data analysis, either through e-learning platforms or AI-based learning applications (Ma et al., 2021; Zhai et al., 2021). In this context, Intelligent Tutoring Systems (ITS) and Learning Analytics systems enable teachers to monitor students' overall progress, identify learning difficulties early, and provide timely interventions (Liu, 2023; Dogan et al., 2023).

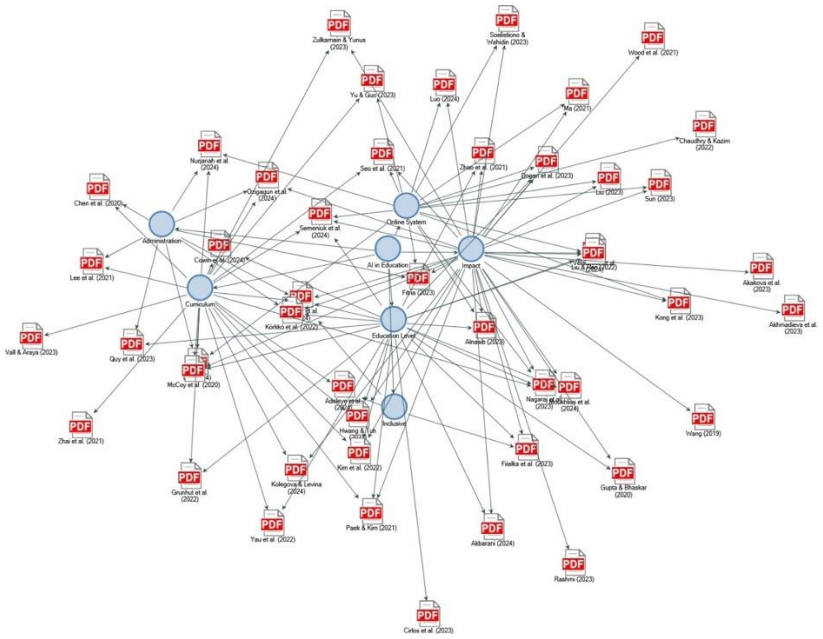

**Figure 4.** Thematic Analysis of Artificial Intelligence in Education (AIED)
Source: Processed by Researcher

- Administration
  AI simplifies school administration by automating administrative tasks, such as student data management, enrollment, and student progress tracking. This frees up time for teachers and administrators to focus more on student learning and guidance.
- Curriculum Design
  AI helps in designing curriculum that is more adaptive and relevant to the needs of students in the digital age. AI-powered curricula can be automatically updated based on changing industry trends, skill needs, and technological advancements. With AI in place, subject matter can be customized more dynamically, allowing students to learn relevant and up-to-date content.
- Inclusive Learning
  AI can improve inclusivity in education by providing tools for students with special needs. AI-based technologies, such as voice-based devices, visual aids, and language recognition systems, enable students with disabilities to learn more effectively. In addition, AI also enables learning flexibility for students at different levels of education and socio-economic backgrounds.
- Online Learning Systems
  In the context of the pandemic and technological development, AI plays an important role in supporting online learning systems. AI supports more interactive and personalized interactions in online learning environments, where students can learn anywhere and anytime with customized support.

AIED shows how AI can improve access to education, speed up administration, and ensure a more adaptive and inclusive education for all students.

**Adaptive Learning with Artificial Intelligence (ALEAI)**

A total of 43 out of 50 articles emphasized that AI has high capabilities in creating adaptive and personalized learning environments. AI enables learning systems to adjust the content, pace, and learning style of students based on real-time data analysis, either through e-learning platforms or AI-based learning applications (Ma et al., 2021; Zhai et al., 2021). In this context, Intelligent Tutoring Systems (ITS) and Learning Analytics systems enable teachers to monitor students' overall progress, identify learning difficulties early, and provide timely interventions (Liu, 2023; Dogan et al., 2023).

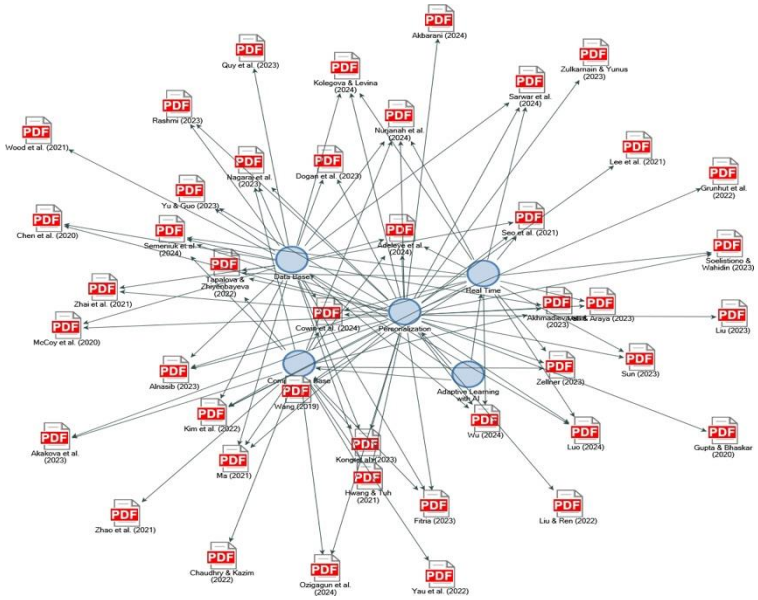


**Figure 5.** Thematic Analysis of Adaptive Learning with Artificial Intelligence (ALEAI)
Source: Processed by Researcher

- Personalization
  AI allows learning materials to be customized according to a student's pace and ability. Each student receives personalized content, which is different from the traditional uniform curriculum. AI analyzes student data to identify their strengths and weaknesses, then devises learning strategies tailored to individual learning styles. This increases student engagement and ensures they learn in the most effective way.
- Real-Time Feedback
  AI-based learning provides real-time feedback, which helps correct mistakes and reinforce student understanding can see programs in real time, allowing teachers and students to adjust their teaching approaches as needed.
- Competence-Based Learning
  AI also supports competency-based learning, where students can progress according to their progress in mastering certain skills will not proceed to the next material until they have fully understanding the previous concepts, allowing for deeper and more meaningful learning.
- Data-Driven Learning
  By collecting and analyzing data, AI provides deep insights into student progress, learning preferences, and challenges faced. This not only supports individualized learning, but also provides teachers with data to evaluate the overall effectiveness of their teaching methods.

Overall, ALEAI has proven to be highly effective in improving learning outcomes by supporting personalization and competency-based learning, allowing students to learn more efficiently and focus on their specific needs.

**Teacher Roles in AI-Assisted Learning (TRAIL)**

The theme of TRAIL appears explicitly in 49 out of 50 articles, which emphasize that AI does not replace teachers, but rather reconstructs their role. Teachers are positioned as mediators, moral guides, and managers of the social context of learning that AI cannot automate (Fitria, 2023; Zulkarnain & Yunus, 2023). On the one hand, AI can reduce teachers' administrative burden through automation of tasks such as formative assessment, but on the other hand it requires teachers to have new competencies in AI literacy.

- Teacher Anxiety
  Many teachers feel anxious that AI could replace their role in education. However, research shows that AI is more effective when used as a support tool, rather than replacement. Teachers remain key in providing context, motivation, and personalized guidance that AI cannot.
- Collaboration Between Teachers and AI
  AI and teachers can collaborate to create more effective learning. AI helps with administrative tasks and provides relevant data on students, while teachers use the information to provide more in-depth and personalized guidance.
- Pedagogical Transformation
  AI is bringing about major changes in pedagogy. Teachers now need to adapt their teaching methods to work with AI, creating approaches that are more interactive, data-driven, and responsive to student needs. This includes the ability to use data provided by AI to adjust learning strategies in real-time.
- Training and Professional Development
  To maximize the potential of AI in education, teachers need adequate training. This training should include how to use AI technology in daily teaching, how to analyze student data, as well as how to integrate technology into lesson plans.
- Efficient Teaching
  AI helps improve efficiency in teaching, reduces teachers' workload, and allows them to focus

more on developing students' more complex skills, such as critical thinking, collaboration, and creativity.

Through TRAIL, the role of the teacher evolves to work with AI, creating a learning environment that is more dynamic and responsive to the needs of students in the digital age.

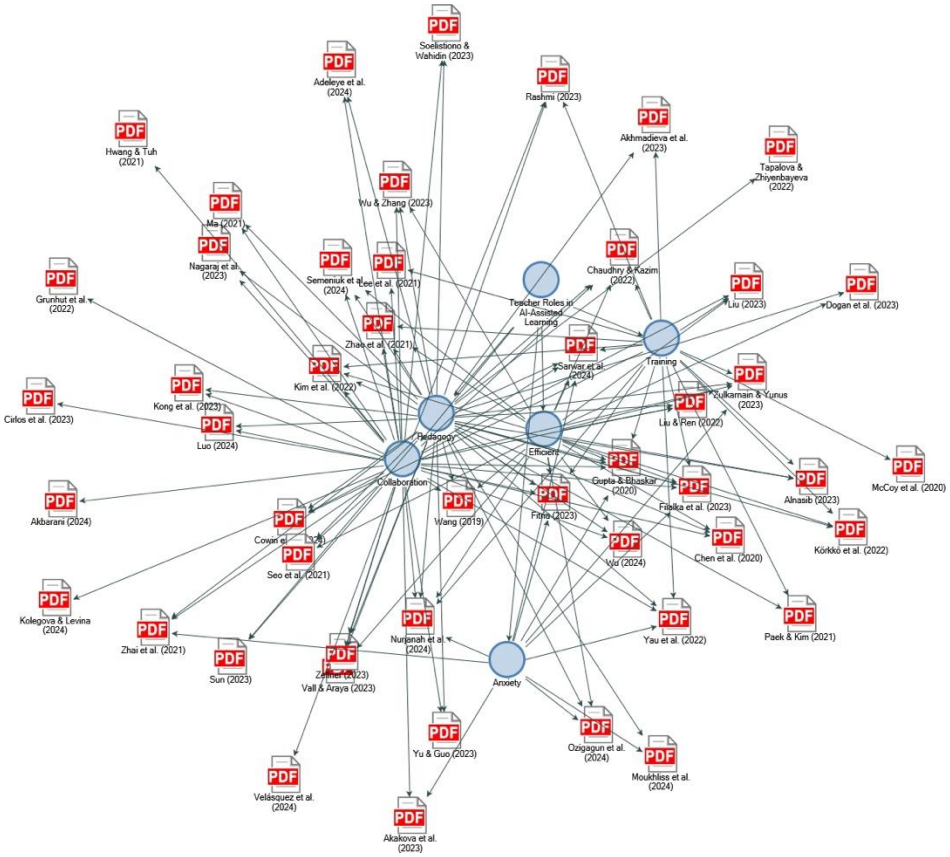


**Figure 6**. Thematic Analysis of Teacher Roles in AI-Assisted Learning (TRAIL)
Source: Processed by Researcher

**Ethical Challenges in AI Education (EAIED)**

A total of 23 out of 50 articles specifically raised ethical issues in the application of AI in education. Dominant issues include concerns over the privacy and security of student data, potential algorithm bias, and the lack of transparency of AI systems in making decisions (Sarwar, 2024; Vall & Araya, 2023). Algorithm bias, for example, can reinforce discrimination against certain groups if the training data used is not inclusive. This is especially challenging in automated scoring systems that do not involve human verification.

- Algorithm Bias

  One of the main challenges in using AI is the risk of algorithm bias. AI trained with unrepresentative data may exacerbate inequities in education. For example, students from certain socioeconomic backgrounds may be overlooked or treated unfairly by AI systems. Therefore, it is important for developers and educators to ensure that the algorithms used are inclusive and free from bias.

- Student Privacy

  The use of student data to support AI systems raises concerns about data privacy and security. Students often do not have full control over the data they generate during the learning process. Discussions on student privacy emphasize the need for strong policies to protect

student data from misuse or unauthorized access.

- Transparency

  Transparency in the use of AI is essential to ensure that students, parents, and educators understand how data is used and how AI makes decisions regarding learning. Transparency is also needed so that stakeholders can provide feedback on the development and use of AI.

- Disparity

  Inequality in access to AI technologies remains a major challenge, especially in remote areas or schools with limited resources. Unequal access to AI can exacerbate educational inequality, where students in urban or more advantaged areas have more opportunities to utilize AI technologies than students in rural areas.

By addressing these ethical challenges, EAED seeks to ensure that AI is used in an ethical and inclusive manner in educational contexts, protecting student rights and ensuring equitable access to technology.

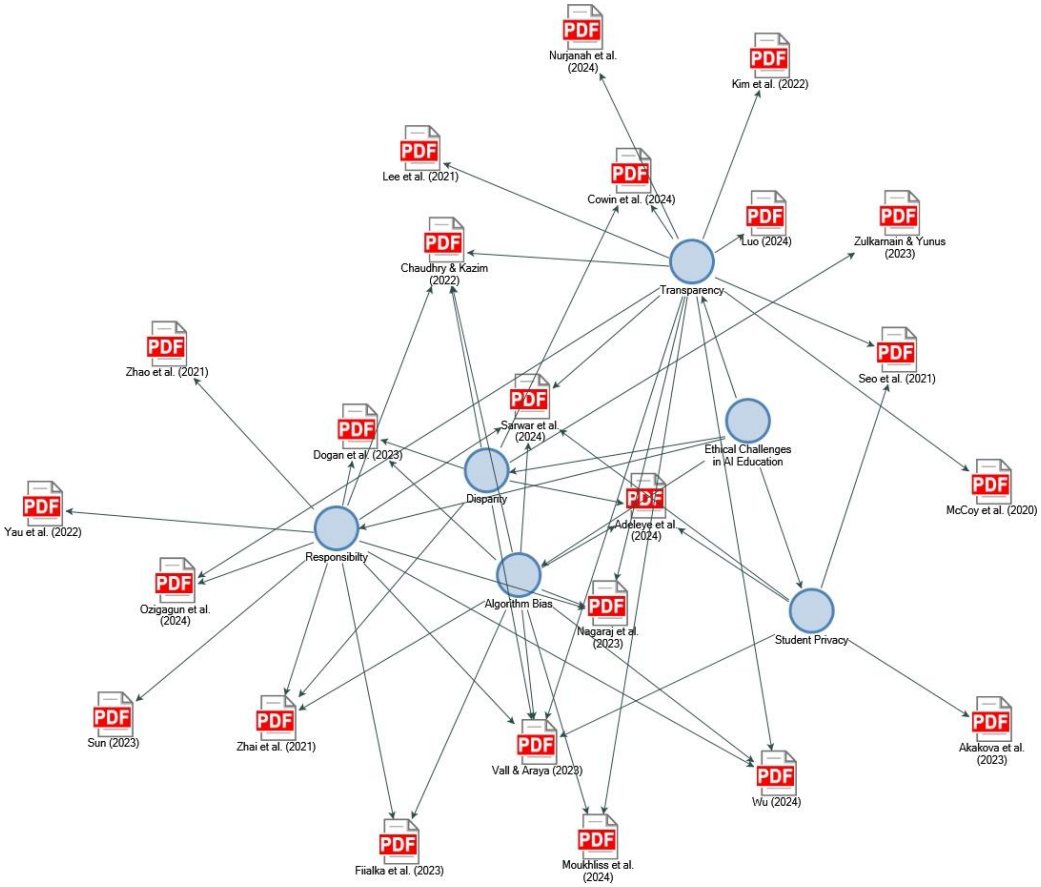


Figure 7. Thematic analysis of Ethical Challenges in AI Education (EAIED)
Source: Processed by Researcher

**Policy Implications for AI Implementation in Education**

The application of artificial intelligence (AI) in education has a significant impact on the learning process, school management, and educational outcomes of students. However, to ensure that AI is used in a responsible and fair manner, it is important for governments, educational institutions, and other stakeholders to design policies that support AI implementation. Good policies should not only support the efficient use of AI, but also address the ethical, legal, and social challenges that arise. Here are some policy implications to consider to ensure effective and inclusive AI implementation in education.

1. Data Protection and Privacy Frameworks

AI implementation in education requires robust data protection based on established frameworks, such as GDPR Article 22, which Estonia's e-School system successfully adapts for algorithmic transparency in student assessment (Kelli et al., 2020). Singapore's Personal Data Protection Act (PDPA) demonstrates practical implementation by requiring explicit consent for AI processing and mandatory impact assessments for high-risk educational AI applications (Tan & Lim, 2021). However, developing countries face resource constraints and limited regulatory infrastructure (OECD, 2019). A tiered approach proves effective: urban schools implement full GDPR-equivalent protections while rural schools begin with basic data minimization, as demonstrated by Indonesia's phased Personal Data Protection Law implementation over three years with government-funded training programs (Sari & Putri, 2023).

2. Algorithmic Bias Prevention and Auditing

Systematic bias prevention requires embedded auditing mechanisms, such as the Netherlands' Algorithm Register, which mandates quarterly bias assessments using demographic parity metrics for all educational AI systems (Almada, 2019). New York City's Automated Decision Systems Task Force requires annual algorithmic impact assessments for AI systems that affect over 500 students, with a focus on addressing racial and socioeconomic disparities (Richardson et al., 2019). Technical challenges include shortage of qualified audit personnel and statistical complexity (Barocas et al., 2019). Finland's National AI Programme addresses this through regional consortiums sharing audit costs and providing standardized bias detection tools, funded by €100 million over five years to support all educational institutions (Finnish Ministry of Education, 2022).

3. Teacher Professional Development and AI Literacy

Effective AI integration requires comprehensive teacher training beyond technical skills. Finland's AI Education Programme mandates 60 hours of AI literacy training covering technical understanding, pedagogical integration, and ethical considerations (Vahtivuori-Hänninen et al., 2021). Singapore's National Institute of Education offers a 120-hour certification showing 78% improvement in teacher confidence and 45% increase in effective classroom AI integration (Chai & Lin, 2022). The main challenge is scale and teacher resistance to change (König et al., 2020). Estonia's e-School demonstrates successful cascade training models using "AI champion" teachers to support colleagues, reaching 95% of teachers within three years through peer mentoring and standardized competency assessments (Laanpere et al., 2021).

4. Equity and Access Considerations

Equitable AI access requires targeted infrastructure investment, particularly in underserved communities. Rwanda's One Laptop per Child initiative combined with AI tutoring demonstrates comprehensive implementation, offering devices, connectivity, training, and support as an integrated package (Nsengimana et al., 2020). Brazil's ProInfo program combines federal funding with state flexibility, allocating resources based on socioeconomic indicators to achieve 25 Mbps connectivity in 95% of schools (Brazilian Ministry of Education, 2022). Infrastructure limitations in rural areas require offline-capable AI systems and solar-powered devices (World Bank, 2021). India's Digital India initiative shows how public-private partnerships accelerate development through tax incentives for telecoms and educational discounts for device manufacturers (Sharma & Kumar, 2023).

5. Regulatory Frameworks and Governance Structures

Effective AI governance requires multi-level frameworks balancing innovation with risk mitigation. The EU's AI Act classifies educational AI as "high-risk" requiring conformity assessments and human oversight (European Commission, 2021). Canada's Directive on Automated Decision-Making requires Algorithmic Impact Assessments with public consultations for high-impact educational applications (Treasury Board of Canada, 2019). Schools need AI ethics committees with enforcement authority, modeled on the University of Montreal's DIRO Ethics Committee conducting monthly reviews (Baum et al., 2020). Implementation challenges include technical complexity and innovation stifling (Winfield & Jirotka, 2018). The UK's Centre for Data Ethics demonstrates proportionate risk-based regulation: minimal burden for low-risk applications (scheduling) and extensive oversight for high-stakes systems (admissions) (McDonald & Milne, 2021).

6. Local Context-Based Policy Adaptation

Local cultural, economic, and infrastructural conditions significantly influence the implementation of AI policy. Cultural factors influence acceptance: Hierarchical educational cultures (East Asia) prefer AI-supporting teacher authority, while egalitarian traditions (Scandinavia) emphasise collaborative learning and student agency (Hofstede & Hofstede, 2020; Zhang et al., 2021). Economic conditions determine the implementation pace: high-income countries, such as Singapore, afford comprehensive rollouts with sophisticated systems, while middle-income countries, like Indonesia, require gradual approaches that prioritise cost-effective solutions. In contrast, low-income contexts begin with offline-capable systems, building toward connectivity infrastructure (UNESCO, 2021).

Infrastructural realities create additional constraints: countries with robust internet connections (such as South Korea) can implement cloud-based, real-time AI systems, while those with limited connectivity (such as Sub-Saharan Africa) require edge computing and offline-capable solutions (ITU, 2022). Geographic factors matter: Archipelagic nations (such as Indonesia and the Philippines) require distributed implementation across their remote islands, whereas continental countries often leverage centralised data centres (Asian Development Bank, 2021). Linguistic diversity in multilingual societies (India, Nigeria) requires AI systems operating across multiple languages with policies ensuring equal access for linguistic minorities, necessitating investment in local language processing and culturally appropriate content development (Bender et al., 2021).

Successful policy frameworks maintain core protective principles while allowing local adaptation flexibility, establishing minimum international standards for data protection and bias prevention while permitting variation in implementation methods, funding mechanisms, and technological approaches based on local conditions and capabilities (OECD, 2023).

The four themes found are interrelated and form an educational ecosystem based on human-AI collaboration. Adaptive learning (ALEAI) and systemic efficiency (AIED) will be difficult to realize without active teacher engagement (TRAIL) and without strong ethical governance (EAIED). Therefore, collaboration between humans and AI in education should be seen not as a replacement for the role of humans, but as a more strategic and reflective expansion of that role. This article recommends the need for a multidisciplinary, integrative, and local context-based policy approach to address the challenges and maximize the opportunities of human-AI collaboration in education.

**CONCLUSIONS**

This research demonstrates that the integration of artificial intelligence (AI) in education not only brings technological innovation but also triggers fundamental shifts in the roles of teachers, pedagogical approaches, and ethical principles of learning. Through thematic analysis of 50 scholarly articles, four main components in the academic discourse related to human-AI collaboration in education were found, namely: Adaptive Learning with Artificial Intelligence (ALEAI), Artificial Intelligence in Education (AIED), Ethical Challenges in AI Education (EAIED), and Teacher Roles in AI-Assisted Learning (TRAIL). These four themes represent the complexity of digital education systems that demand a balance between technological efficiency and humanistic values.

AI has been proven to improve learning personalisation, administrative efficiency, and the expansion of educational access. However, this potential can only be achieved if accompanied by system readiness, technological literacy, and pedagogical leadership from teachers. AI does not replace teachers; instead, their role shifts to reflective facilitators who are responsible for ensuring the moral and social validity of the learning process. In an AI-based learning ecosystem, teachers function as value keepers, mediators of meaning, and connectors between algorithms and humanity. Therefore, strengthening teacher capacity and in-depth policy support are key requirements for the successful integration of AI in education.

These findings have significant implications for the development of AI-based education policies in Indonesia and other developing countries. Policies are needed to ensure the protection of student data, prevent algorithmic bias, equitably expand access to digital infrastructure, and support teacher training based on values, not just technical skills. Furthermore, additional research is needed to assess the long-term effects of AI use on classroom social dynamics, educational leadership, and the preservation of ethical values in the learning process. With an inclusive, ethical, and collaboration-based approach, AI can be a true partner in shaping future education that is adaptive, meaningful, and equitable.

## LIMITATION & FURTHER RESEARCH

This study has several limitations that should be considered as part of its methodological reflection. First, although the literature sources used were drawn from reputable international journals indexed in databases such as Scopus, SpringerLink, and Google Scholar, most of the analyzed articles were written in English and originated from developed countries. This introduces a perspective bias, as the findings tend to reflect educational contexts and approaches in environments with relatively advanced digital infrastructure and well-established technology policies. As a result, the dynamics of AI–teacher collaboration in developing countries, such as Indonesia, may not be proportionally represented in this analysis.

Second, the qualitative approach employed through thematic analysis using NVivo offers strengths in exploring meaning and conceptual patterns, but it inherently carries a high degree of subjectivity. The coding process and theme development heavily rely on the researcher's interpretation despite the implementation of validation procedures and an audit trail. Third, this study does not directly examine the implementation of AI in classrooms or empirically assess teacher and student perceptions of it. Therefore, the findings remain conceptual and synthetic rather than field-based.

For future research, it is recommended to focus on empirical studies within local contexts in Indonesia or other developing countries to explore teachers' perceptions of AI, infrastructure challenges, and pedagogical readiness in adopting the technology. Field studies, focus group discussions (FGDs), and in-depth interviews can complement this literature review with more concrete contextual insights. Moreover, bibliometric approaches or scientific network analyses may be employed to map the broader evolution of AI research in education. Future studies should also

support the development of fair and ethical local policy frameworks, ensuring that the integration of AI into classrooms does not overlook humanistic and inclusive pedagogical values.

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