A Comprehensive Systematic Literature Review on Opportunities, Challenges, and Implementation Strategies of Artificial Intelligences for Indonesian Primary Schools

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Abstract. This study, employing a systematic literature review (SLR) of nine carefully selected studies from an initial pool of 180 on Google Scholar, investigates the benefits and challenges of using Artificial Intelligence (AI) in primary education, particularly for making recommendation for the Indonesian context. Utilizing the PRISMA 2020 framework for selection, the research highlights AI's potential to revolutionize education by personalizing learning experiences, enhancing pedagogical methods, and improving assessment and administrative efficiencies. However, it also identifies significant challenges, including concerns about academic integrity, ethical and privacy issues, and the digital divide. Crucially, the study offers targeted recommendations for the effective implementation of AI in Indonesian primary schools, emphasizing the need for equitable technology access and comprehensive teacher training. These recommendations aim to mitigate the challenges while maximizing the benefits, thereby facilitating a more adaptive, inclusive, and forward-looking educational environment. This study provides valuable insights for policymakers and educators, underlining the importance of a strategic approach in integrating AI into primary education systems.

Keywords: Perceived Benefits, Challenges, Artificial Intelligence (AI), Primary Education

INTRODUCTION

The integration of Artificial Intelligence (AI) within the educational sector represents a transformative shift with the potential to redefine traditional teaching methodologies and learning outcomes (Chen, Chen, and Lin 2020). Globally, the infusion of AI in various levels of education has garnered significant interest, evident from the plethora of studies examining its implications across different teaching and administrative domains. However, elementary education—a critical stage in the academic and cognitive development of individuals—has witnessed a comparatively slow and less documented incorporation of AI technologies (Zawacki-Richter et al. 2019).

The state of the art in AI application across sectors such as healthcare (Hee Lee and Yoon 2021), business (Akter et al. 2020), and governance (Zuiderwijk, Chen, and Salem 2021) has shown promising results, underscoring the transformative capabilities of AI in enhancing performance and efficiency. For instance, AI's role in diagnosing diseases from medical imaging or streamlining complex legal document analysis has been well-documented in the last decade (Zhong et al. 2020). Yet, literature focusing on the integration of AI within elementary education, especially within the Indonesian context, remains scant.

This gap in research is particularly conspicuous when considering the unique benefits that AI could potentially offer to primary education, such as personalized learning pathways and improved educational accessibility (UNESCO 2019). Conversely, challenges such as ethical considerations, infrastructural readiness, and teacher training present a complex set of issues that require thorough investigation within the specific milieu of Indonesian elementary education (UNESCO 2019).

e-ISSN: 2808-8263
p-ISSN: 2829-0976

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The present study aims to fill this gap by conducting a systematic literature review to evaluate the perceived benefits and challenges of AI integration in elementary education. By doing so, it seeks to carve out a novel niche that distinctively differs from previous studies which have predominantly concentrated on other sectors or on higher levels of education (Zawacki-Richter et al. 2019). The research pivots on a comparative analysis, juxtaposing global trends with the Indonesian scenario, to shed light on the multifaceted implications of AI in an educational setting that has not been the focal point of substantial AI research.

This review will adopt a methodological approach, systematically sifting through existing literature to identify, evaluate, and synthesize findings related to the application of AI in primary education (Page et al. 2021). By distilling insights from global practices and contrasting them with the Indonesian educational context, this study will highlight the nuances and idiosyncrasies of AI implementation at the elementary level.

The expected outcome of this research is to provide a comprehensive overview that elucidates the current landscape, identifies the perceived benefits and challenges of AI in education, and proposes a strategic direction for the use of artificial intelligence in Indonesia primary schools context. The objective is not only to augment the academic discourse on AI in education but also to offer a pragmatic framework for stakeholders in the Indonesian education system to understand and leverage AI for enhancing elementary education.

METHOD

The methodology of this study follows a systematic and structured approach to ensure the thoroughness and relevance of the literature review concerning the integration of Artificial Intelligence (AI) in elementary education. The selection criteria stipulate that the literature search is limited to research articles published between 2018 and 2023, guaranteeing the data's recency and relevance. Furthermore, the literature must explicitly address the core themes of this research, as outlined by Page et al. (2021).

The literature search was conducted using Google Scholar, utilizing keywords reflective of this study's themes, namely: Artificial Intelligence, education, primary school, benefits, challenges. However, only English-language journals indexed within the Scopus database were deemed suitable to ensure high standards of quality and reliability of the sources selected. Additional selection criteria included full accessibility to the content of the literature, not just abstracts, to allow for a thorough and comprehensive analysis.

The adopted method of analysis follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) pattern (Page et al., 2021). The PRISMA approach was chosen for its capacity to provide a systematic and comprehensive framework for literature review, ensuring that every aspect of the relevant literature is meticulously examined. Moreover, the PRISMA approach distinguishes this study from others by providing a consistent and recognized standard for compiling and reporting findings, ensuring the integrity and reliability of the results of the analysis. Through this approach, the study will involve a quality evaluation of the selected research articles using standard quality assessment criteria for evaluating primary research papers (Kmet et al., 2004). These criteria will aid in assessing the reliability, validity, and integrity of the findings and conclusions drawn from the selected literature.

In terms of the research site and subjects, this review will encompass a global perspective with a specific focus on the Indonesian context. The subjects of this research are the scholarly articles that discuss AI in the field of education, with particular attention to studies that may provide insights into the Indonesian setting. This will involve an examination of the educational environment, the pedagogical framework, infrastructural provisions, and the cultural context within which AI is being integrated into Indonesian primary schools. The detailed, context-specific analysis will ensure that the study's findings are grounded in the actual conditions of the research site and are directly applicable to the subjects under consideration.

RESULTS

In conducting this systematic literature review, the researcher employed a meticulous process to ensure the inclusion of relevant and high-quality studies focusing on the integration of

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Artificial Intelligence (AI) in elementary education (Page et al. 2021). Initially, we identified a pool of 180 records through a database search using Google Scholar. To maintain a high standard of review, we first removed 40 duplicate records. We then screened the remaining 140 records by examining their titles and abstracts, which resulted in the exclusion of 60 records that did not meet our preliminary relevance criteria.

The subsequent phase involved a more in-depth retrieval process, where the researcher sought to obtain 70 full reports for detailed assessment. However, challenges such as access restrictions prevented us from retrieving 20 of these reports. The remaining 50 reports were thoroughly assessed for eligibility, with particular attention to their alignment with this research criteria and objectives. Through this rigorous evaluation, this study identified specific reasons to exclude 31 studies, which have included factors such as non-alignment with the research scope, empirical insufficiency, or subpar study quality.
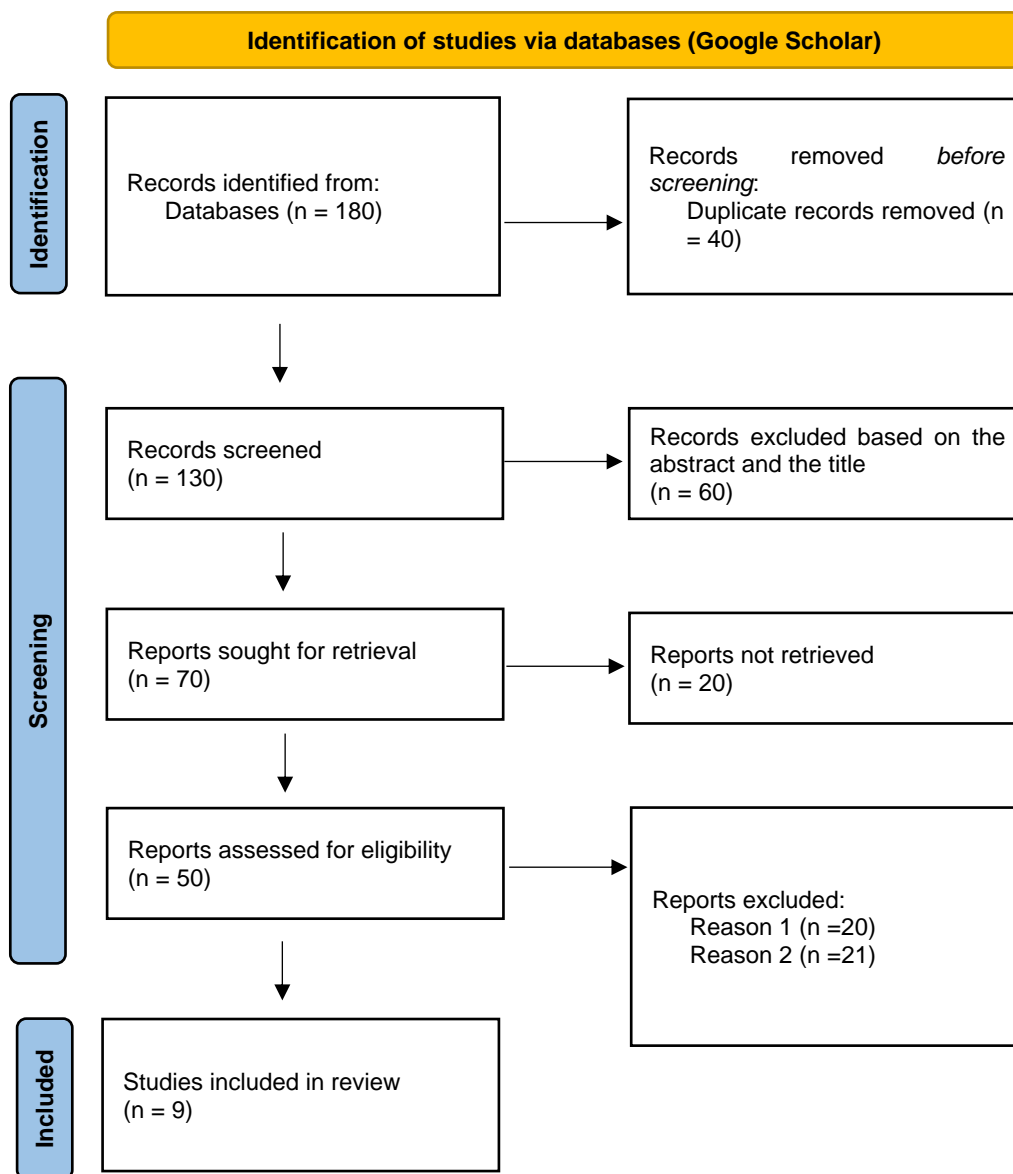

Figure 1 Prisma SLR for Selection (Page et al. 2021)

At the conclusion of this Prisma selection process, the researcher included 9 studies that withstood our strict eligibility criteria. These studies were deemed to provide the most valuable insights into benefits and challenges of AI integration within the context of elementary education. This stringent methodological approach ensures that our systematic literature review is

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e-ISSN: 2808-8263
p-ISSN: 2829-0976

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comprehensive, robust, and reflective of the latest and most pertinent research in the field (Page et al. 2021). Among the nineth studies selected for inclusion in this systematic literature review, this study has categorized them by their study locations, providing a clear geographical context which aligns with the aim of our paper to present a global perspective on the integration of AI in elementary education.

In Asia, the selected studies span a wide range of educational environments, reflecting diverse approaches to AI implementation. The countries represented in the review include Singapore (Rudolph, Tan, and Tan 2023), China (2) (Chen, Chen, and Lin 2020; Lin et al. 2021), Turkey (Akçapınar, Altun, and Aşkar 2019), Taiwan (Hwang et al. 2020), and Hong Kong (T. Wang and Cheng 2021). Each of these nations contributes unique insights into the regional trends and cultural implications of AI in educational settings. In Europe, the selected studies have a study from Germany, specifically in Berlin (Renz and Hilbig 2020), which offers a perspective from a developed European country known for its strong educational framework and technological advancements. Additionally, this study has included studies that fall under broader, more inclusive categories. One such study encompasses an international scope, incorporating data and insights from 38 countries, providing a comprehensive view of AI in education across multiple regions (Zawacki-Richter et al. 2019). Another study is stating that the contexts is a global study, featuring diverse countries such as the United Arab Emirates, Kenya, Bhutan, Kyrgyzstan, Chile, China, Uruguay, Brazil, South Africa, and Kenya (Chen, Chen, and Lin 2020). This study provides a cross-continental analysis, offering a rich comparative understanding of how AI is integrated into elementary education across various educational and cultural landscapes. Those categories allow for a nuanced understanding of the global trends in AI education, highlighting regional specificities while also offering a synthesized view of the international application of AI technologies in the primary education sector. The inclusion of both specific countries and broader international categories ensures that our review captures the varied and multifaceted nature of AI integration in elementary education around the world. Meanwhile, to explore the trends of AI Education, the researcher will show the graph as below.
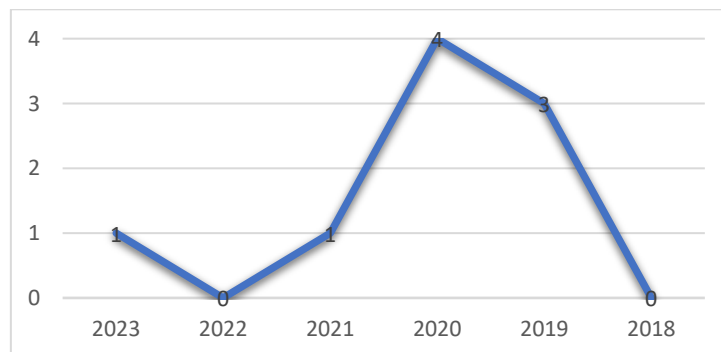

Figure 2 Trends of AI in Observed This Study

The line graph in figure 2 presents a visual narrative on the trend of AI research in education over a period from 2018 to 2023. The graph begins in 2018 with no studies, suggesting that at this point, AI research in education had not yet gained significant academic traction or possibly that relevant studies from that year are not captured in the dataset (Bajaj and Sharma 2018). In 2019, there is a notable surge to three studies, indicating a burgeoning interest in the intersection of AI and education (Akçapınar, Altun, and Aşkar 2019). This leap may reflect an increased acknowledgment of AI's potential in enhancing educational strategies and outcomes. The upward trend continues into 2020, the most prolific year, with four studies. This peak is likely reflective of a confluence of factors, including the accelerated interest in digital educational tools and platforms in response to the COVID-19 pandemic, which prompted a worldwide pivot to remote learning. However, in 2021, there is a sharp decline to just one publication, which could be attributable to a variety of factors such as a market correction after the previous year's surge, a saturation of immediate research questions, or perhaps a shift in focus towards the

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e-ISSN: 2808-8263
p-ISSN: 2829-0976

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implementation and evaluation of AI tools introduced during the pandemic. The year 2022 shows a complete absence of studies, suggesting a possible hiatus in research output which could be due to a myriad of factors such as changes in research funding priorities, the academic publishing cycle, or external global factors influencing research directions. In 2023, the trend line ascends again with one study, indicating a renewal of interest in AI research in education (Rudolph, Tan, and Tan 2023). This rekindled interest could be attributed to the ongoing developments in AI technology and its applications in educational settings, or it may reflect an adaptation phase where new AI-related educational research is beginning to emerge after the previous years' hiatus. Overall, the graph suggests that AI research in education is subject to fluctuations, with periods of intense activity followed by lulls, potentially reflecting the field's responsiveness to technological advancements, global events, and academic cycles.

However, this study does not mean making conclusion on AI trends in education. It is only making insight based on the selected studies used in this paper. One of the limitations of this systematic literature review arises from the stringent study selection criteria that were applied, which, while ensuring the relevance and quality of the included studies, also resulted in the exclusion of a considerable number of publications (Page et al. 2021). This rigorous selection process, aimed at honing in on the most pertinent and high-quality research, inevitably led to a smaller pool of studies for review. By setting specific inclusion criteria, this study prioritized the alignment and direct applicability of the studies to our research question. This approach may have overlooked research that, while not fitting the criteria perfectly, could offer valuable insights or indirect evidence pertinent to the integration of AI in elementary education. For instance, studies with a broader educational focus, those examining AI in a non-school or higher education context, or research published in languages other than English, were likely excluded. Additionally, limiting the search to articles indexed in Scopus and published within a certain timeframe could have omitted relevant studies that are either too recent to be indexed, published in less widely recognized journals, or conducted in years preceding our review window. This could exclude seminal works that laid the foundation for subsequent research or innovative studies that have yet to gain recognition. The exclusion of such studies due to stringent criteria might result in a form of selection bias, potentially affecting the comprehensiveness of the review. It is also important to acknowledge that the landscape of AI in education is rapidly evolving, and the research output can be influenced by various factors including funding availability, publication cycles, and shifts in research focus which might not be entirely captured within the scope of our review criteria.

In this systematic literature review examining the best practices of artificial intelligences in education, the selected papers have adopted a diverse array of research methodologies to investigate the intricacies of AI's educational applications (Page et al. 2021; Chen, Chen, and Lin 2020). Starting with practical applications, one study ventured into the experimental domain with ChatGPT, an AI conversational model, to directly assess its utility in a classroom setting. This investigation likely yielded firsthand observations on the model's interaction with students and teachers, providing valuable insights into the user experience, the practical benefits, and the hurdles faced during its deployment in primary education. Complementing the empirical approach, traditional literature reviews within the selected papers provided a broad sweep of the existing academic discourse on AI in education (Chen, Chen, and Lin 2020). These reviews synthesized findings from a variety of sources, offering a narrative that maps the landscape of AI's educational benefits and challenges, setting the stage for a comprehensive understanding of the field's current state (Hwang et al. 2020).

A subset of this research corpus employed the systematic literature review method, adhering to stringent protocols to ensure the inclusion of relevant and high-quality studies (Randolph 2009). This methodological rigor allows for a more focused discussion on the effectiveness of AI in primary education, drawing from a wide array of studies to pinpoint the most significant outcomes and concerns. Adding depth to the review, qualitative research featured prominently in our selection. Studies using this method unraveled the qualitative nuances of AI integration, capturing the voices and experiences of educators and learners through interviews and classroom observations. These narratives are critical, as they often reveal the subtle and

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complex ways in which AI impacts the educational process beyond what quantitative data can convey. Furthermore, our selection included a study that adopted a technical stance, evaluating different AI classification algorithms and data pre-processing techniques. This research likely provided a comparative analysis of various AI tools to determine their suitability and efficacy in educational settings, crucial for understanding how technical aspects of AI can influence educational outcomes. Lastly, the collection featured studies employing quantitative surveys, which offered a statistical perspective on the prevalence and perception of AI use in primary education. This approach is vital for quantifying the extent of AI's integration into educational systems and understanding the collective attitudes towards its use. Together, these methodologies paint a detailed portrait of AI's role in primary education. By embracing both qualitative and quantitative approaches, the selected papers contribute to a nuanced understanding of how AI technologies are being integrated into educational practices and the effects of these integrations on the educational landscape.

Perceived Benefits of AI in Education

As the study explores into the expansive domain of Artificial Intelligence (AI) in education, especially in primary education, the systematic literature review has unearthed a spectrum of benefits that AI technology brings to this foundational level of learning. The selected studies, each a beacon of scholarly inquiry, provide a multifaceted view of how AI applications are reshaping the educational experience for students, teachers, and administrators alike (Chen, Chen, and Lin 2020; Hwang et al. 2020; Fullan et al. 2023; Lin et al. 2021).

In what follows (table 1), this study presents a synthesis of these benefits, classified into coherent themes that emerged consistently across our research corpus. These findings, drawn from an array of studies conducted over recent years, underscore the transformative potential of AI in the educational landscape. They not only highlight the diverse ways in which AI can support and enhance the educational journey but also offer a glimpse into the future of learning that is being molded by the hands of technology. The results are organized in a manner that provides a clear reference to the underlying studies, allowing for a deeper understanding of the context and the scope of the reported benefits. As we navigate through this compilation, it becomes evident that AI's role in education is not a mere augmentation but a paradigm shift towards a more personalized, efficient, and engaging learning environment (Ouyang and Jiao 2021).

Tabel 1 Benefits of AI in Education

No	Theme	Benefits	References
1	Student Support and Personalization	Improving Students Support Systems, Intelligent tutoring System, Profiling and Prediction, Adaptive Systems and Personalization, Early Warning Systems, Indicators of Student Success, Support Personalized Learning	(Rudolph, Tan, and Tan 2023; Akçapınar, Altun, and Aşkar 2019; Lin et al. 2021)
2	Pedagogical Enhancement	Facilitating Innovative Teaching and Learning, Advanced Technologies for Experiential Learning	(Rudolph, Tan, and Tan 2023)
3	Teacher Support and Professional Development	Teacher-Facing AI Application, Assist Teachers	(Rudolph, Tan, and Tan 2023; Hwang et al. 2020)
4	Assessment and Evaluation	AI-Powered Assessment Applications, Assessment and Evaluation	(Rudolph, Tan, and Tan 2023)

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e-ISSN: 2808-8263
p-ISSN: 2829-0976

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No	Theme	Benefits	References
5	Administrative Efficiency	Improved Administrative Efficiency, Accessibility of Learning Materials Globally, Better Data Analytics in Education Management Systems	(Chen, Chen, and Lin 2020), (Chen, Chen, and Lin 2020)
6	Learning Analytics and Data-Driven Insights	Learning Analytics as a Prerequisite for AI in Further Education	(Renz and Hilbig 2020)
7	Educational Equity and Quality	Enhancing Educational Equity and Quality, Growing Social Importance and Pedagogical Value of AIED	(Chen, Chen, and Lin 2020; T. Wang and Cheng 2021)
8	Motivation and Engagement	Increasing Intrinsic Motivation, Sustaining Attention to AI, Promoting Confidence in Learning AI, Enhanced Career Motivation	(Lin et al. 2021)
9	Implementation and Infrastructure	Identification of Drivers and Barriers for AI in Education	(Renz and Hilbig 2020)
10	Curriculum and Learning Outcomes	Improving Learning Outcomes, Building Adaptive Systems	(Hwang et al. 2020)

In the vanguard of educational transformation, Artificial Intelligence (AI) stands as a pivotal catalyst, reshaping the dynamics of primary education through an array of innovative applications and systems (Ouyang and Jiao 2021). This systematic literature review has meticulously mapped these advancements across a constellation of studies, revealing a rich tapestry of benefits that AI confers upon the educational domain (Page et al. 2021). At the heart of AI's contribution is the Student Support and Personalization category, a realm where AI's impact is both profound and multifaceted. Intelligent tutoring systems stand out as a cornerstone, providing students with a personalized learning journey tailored to their unique needs and pace, as evidenced by studies such as ChatGPT: Bullshit spewer or the end of traditional assessments in higher education? (Rudolph, Tan, and Tan 2023) and Using learning analytics to develop an early warning system for at-risk students (Akçapınar, Altun, and Aşkar 2019). These systems, coupled with AI's capability for profiling and prediction, unlock new avenues for understanding and fostering student success, a narrative further explored in Modelling the structural relationship among primary students' motivation to learn artificial intelligence (Lin et al. 2021). The theme of Pedagogical Enhancement showcases AI's role in redefining teaching methodologies.

As illustrated by the referenced studies, AI facilitates a leap into the future of teaching, bringing with it a suite of advanced tools for experiential learning, from 3-D models to virtual reality environments. The impact of such technologies on educational experiences is vast, expanding the horizons of what can be achieved within the classroom walls. Teacher Support and Professional Development is another critical arena where AI's influence is distinctly beneficial. AI applications designed for educators, as discussed in the referenced works, offer significant assistance in lesson planning and delivery. They serve as a digital ally to teachers, augmenting their capabilities and enriching the educational process. In the domain of Assessment and Evaluation, AI-powered applications stand at the forefront, revolutionizing the way assessments are conducted and evaluated. The studies referenced here underscore AI's ability to streamline the evaluation process, offering timely and precise feedback, thus enhancing the quality and efficiency of educational assessments. AI's role in Administrative Efficiency cannot be overstated, with studies highlighting its capacity to improve administrative processes and global accessibility of learning materials.

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AI's analytical prowess is leveraged to refine education management systems, making them more robust and responsive to the needs of a diverse student body. The influence of Learning Analytics and Data-Driven Insights is pivotal, as AI becomes a prerequisite for extracting meaningful insights from educational data. The study Prerequisites for artificial intelligence in further education (Renz and Hilbig 2020) emphasizes the importance of learning analytics in paving the way for more informed educational strategies and decisions. Educational Equity and Quality emerge as a social imperative, with AI recognized for its potential to democratize education and enhance its quality. The studies highlight AI's role in leveling the educational playing field, offering high-quality learning experiences to all students, regardless of their background. Motivation and Engagement are critical components of effective learning, and AI has shown potential in enhancing these aspects. The ability to increase students' intrinsic motivation and sustain their attention, as shown in Modelling the structural relationship among primary students' motivation to learn artificial intelligence (Lin et al. 2021), is vital in fostering an engaging and supportive learning environment.

The Implementation and Infrastructure category addresses the foundational elements necessary for AI's integration into education. The research underscores the need to understand the drivers and barriers to AI adoption, ensuring that educational institutions are poised to harness the benefits of AI effectively. Lastly, the Curriculum and Learning Outcomes category reflects AI's transformative capacity to improve learning outcomes and develop adaptive systems. The referenced studies discuss how AI can tailor the educational content to the needs of students, leading to a more dynamic and effective curriculum. Each category, enriched by the studies cited, presents a compelling case for the integration of AI in primary education. Together, the selected studies illustrate a landscape where AI is not just an auxiliary tool but a transformative force, driving a paradigm shift in how education is delivered, experienced, and valued (Ouyang and Jiao 2021).

Challenges of AI in Education

The advent of Artificial Intelligence (AI) in primary education heralds a transformative epoch, yet it is accompanied by a complex array of challenges that must be navigated with care and foresight. As this study stands on the cusp of this technological renaissance within the classroom, our systematic literature review has meticulously collated a compendium of studies, each shedding light on various obstacles that educators, policymakers, and technologists' encounter (Ouyang and Jiao 2021). These challenges, thematically rich and varied, range from ethical quandaries and privacy concerns to practical issues of implementation and the necessity of curriculum evolution (Lin et al. 2021).

Before we delve into the detailed exposition of these hurdles, it is paramount to acknowledge the overarching context that gives rise to them. AI, in its promise to enhance educational delivery and outcomes, inherently poses questions about the integrity of academic work, the readiness of our teachers, and the preparedness of our infrastructures. It challenges traditional pedagogies and invites us to rethink the role of technology in learning. The ensuing discussion of challenges is not merely an inventory of problems but a tapestry of the current state of AI in primary education—a snapshot of the growing pains of a rapidly advancing technological frontier.

Tabel 2 Challenges of AI in Education

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e-ISSN: 2808-8263
p-ISSN: 2829-0976

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No	Theme	Challenges	References
1	Academic Integrity	- Academic Integrity and Cheating - Overreliance on AI, Need for Digital Literacy, Education - Updating Academic Integrity Policies - Ensuring Quality and Relevance of Curriculum	(Rudolph, Tan, and Tan 2023)
2	Ethical and Privacy Concerns	- Ethical implications and risks, such as privacy and data protection concerns - Potential replacement of human roles by AI solutions	(Zawacki-Richter et al. 2019)
3	Systematic Approaches and Evidence	- Lack of evidence and systematic approaches in LA and AI - High barriers in using data-based EdTech solutions meaningfully	(Renz and Hilbig 2020)
4	Transferability and Generalizability	- Challenges in the transferability and generalizability of prediction models to different courses - Developing and validating prediction models for different courses	(Akçapınar, Altun, and Aşkar 2019)
5	Policy and Teacher Preparedness	- Developing comprehensive public policies for AI in sustainable development - Ensuring inclusion and equity in AI in education - Preparing teachers for AI-powered education - Developing quality and inclusive data systems - Making research on AI in education significant - Addressing ethical concerns in data collection, use, and dissemination	(Chen, Chen, and Lin 2020)
6	Digital Divide and Power Dynamics	- Ethical issues - Digital hegemony - Power relationships among learners, teachers, and AI systems - Digital divide	(Hwang et al. 2020)
7	Implementation Barriers	- Lack of clear pathways for AI incorporation - Limited guiding values in current literature - Struggles with deploying AI systems in educational settings	(T. Wang and Cheng 2021)
8	Curriculum Design and Impact Evaluation	- Need for further research on when and how to educate young students about AI - Designing curricula that accommodate AI education - Evaluating the effects of AI education decisions	(Lin et al. 2021)

The results of this systematic literature review, distilled into a coherent table, reveal the intricate tapestry of challenges that educators, policymakers, and technologists face in the realm of Artificial Intelligence (AI) in primary education (Lin et al. 2021; Hwang et al. 2020). These challenges, categorized under various themes, are reflective of the multifaceted nature of AI implementation and the complexities that accompany its integration into educational ecosystems. Under the theme of Academic Integrity, the study ChatGPT: Bullshit spewer or the end of traditional assessments in higher education? (Rudolph, Tan, and Tan 2023) brings to light the precarious balance between leveraging AI for educational advancement and safeguarding against its potential misuse. The challenge here extends beyond the mere act of cheating; it encompasses

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the broader implications of overreliance on AI, the pressing need for digital literacy, and the urgency to revise academic integrity policies.

There is an imperative call for a curriculum that maintains relevance and quality in an era where AI's capabilities are rapidly evolving. The second theme, Ethical and Privacy Concerns, encapsulated by a systematic review, delves into the ethical conundrums and privacy quandaries posed by AI's data-centric nature. The concerns are twofold: the protection of personal data within expansive digital networks and the looming question of whether AI could supplant roles traditionally held by humans. These issues are not just operational but deeply philosophical, challenging educators to consider the ethical fabric of AI-infused pedagogy. In the realm of Systematic Approaches and Evidence, the absence of structured methodologies in learning analytics (LA) and AI surfaces as a formidable barrier. The lack of evidence-based frameworks for the deployment of educational technology solutions points to a gap between AI's theoretical potential and its practical application. This gap signals a high threshold for meaningful integration, underscoring the necessity for robust, evidence-driven approaches to AI in education.

Next, the issue of transferability and generalizability is keenly felt in the challenge of adapting AI prediction models to diverse educational contexts (Chen, Chen, and Lin 2020). The study on learning analytics for at-risk students spotlights the difficulty of creating AI systems that perform consistently across different courses and instructional conditions. This challenge underscores the need for AI systems that are not only advanced but also adaptable and sensitive to the varied landscapes of learning. The fifth theme, policy and teacher preparedness, acknowledges the intricate challenge of formulating comprehensive public policies that encapsulate AI's role in sustainable development (Y. Wang 2021). The threads of this challenge weave through the necessity for inclusive AI education, the preparedness of teachers to embrace AI, the development of data systems that are both inclusive and high-quality, and the importance of conducting significant research to guide AI's trajectory in education. Ethical considerations in data collection, usage, and dissemination emerge as critical factors in this discourse (Kasmiran 2019).

Addressing the digital divide and power dynamics, studies highlight the ethical dilemmas, the potential for digital hegemony, and the complex power relationships that AI systems may engender among learners, teachers, and the technology itself (Ouyang and Jiao 2021). The digital divide looms as a persistent challenge, raising questions about equitable access to AI resources and the potential for AI to exacerbate or ameliorate existing educational disparities. The Implementation and Infrastructure theme confronts the practical barriers in embedding AI into the fabric of education. The challenges of establishing clear pathways for AI incorporation, the limited guiding values in current literature, and the logistical difficulties of deploying AI systems in educational settings are brought into sharp focus.

Lastly, under the curriculum and learning outcome's theme, the challenge presented is twofold: determining the appropriate juncture and methodology for introducing young students to AI and the consequential task of designing and evaluating curricula that effectively integrate AI education (T. Wang and Cheng 2021). This dual challenge underscores the need for a pedagogical paradigm that is both forward-thinking and critically reflective (Chen, Chen, and Lin 2020). Collectively, these themes and the challenges they encompass provide a comprehensive view of the hurdles that stand in the way of realizing AI's full potential in primary education (Kasmiran 2019). They underscore a need for a strategic, thoughtful approach to AI integration—one that is cognizant of the ethical, practical, and policy-related complexities that AI brings to the forefront of education.

DISCUSSION

The integration of Artificial Intelligence (AI) in primary education is a burgeoning field that promises to fundamentally reshape the learning experience (Lin et al. 2021). Through the systematic analysis of various scholarly articles, our literature review has identified a spectrum of benefits that AI brings to this vital educational stage. AI's influence extends to improving student support systems, where it customizes learning paths via intelligent tutoring systems, and enables the accurate profiling and prediction of student performance, thereby personalizing the

e-ISSN: 2808-8263
p-ISSN: 2829-0976

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education experience to an unprecedented degree. It enhances pedagogical methods, introducing innovative teaching and learning capabilities through advanced technologies like virtual reality, which fosters an immersive learning environment (Chen, Chen, and Lin 2020).

AI also serves as an invaluable resource for teachers, providing AI-driven applications that assist in curricular planning and delivery, thus augmenting the educators' role and enriching the teaching process. In the realm of assessment and evaluation, AI-powered applications have been shown to revolutionize traditional methods, offering more efficient and precise evaluations (Ouyang and Jiao 2021). On the administrative front, AI contributes significantly by streamlining operational efficiencies and making educational materials globally accessible, overcoming traditional barriers of distance and language. Furthermore, AI facilitates a more equitable educational landscape, promoting inclusivity and quality, and supporting the development of learning analytics that provide educators and policymakers with deep, data-driven insights. The motivational aspect of AI cannot be overlooked, as it fosters an engaging learning environment that sustains student attention and builds confidence in their abilities. Lastly, the potential of AI to inform curriculum design and improve learning outcomes points to its transformative capacity within the educational sector. These manifold benefits underscore the profound impact AI is poised to have on primary education, heralding a shift towards a more adaptive, efficient, and student-centered approach to learning (Ouyang and Jiao 2021).

The integration of artificial intelligence (AI) in primary education, while promising, presents a complex array of challenges as highlighted in a systematic literature review (Chen, Chen, and Lin 2020). These challenges are multi-faceted, encompassing academic integrity, ethical and privacy concerns, systematic approaches, transferability, policy, teacher preparedness, digital divide, and curriculum design (Ouyang and Jiao 2021). Academic integrity issues like cheating, overreliance on AI, and the need for digital literacy and updated policies are critical (Hwang et al. 2020). Ethical and privacy concerns revolve around data protection and the potential replacement of human roles (Adams and Almahmoud 2023).

The lack of evidence-based frameworks for AI in education and the high barriers to using data-driven EdTech solutions meaningfully are also significant obstacles. Challenges in the transferability and generalizability of AI models across different educational contexts and courses arise. There is a need for developing comprehensive policies for AI in sustainable development, ensuring inclusion and equity in AI education, preparing teachers, developing quality data systems, and addressing ethical concerns in data usage (Ouyang and Jiao 2021). The digital divide, digital hegemony, power dynamics, and equitable access to AI resources are key considerations. Practical barriers include the lack of clear pathways for AI incorporation, limited guidance in current literature, and struggles with deploying AI systems in educational settings (UNESCO 2019). Lastly, there's a need for research on when and how to educate young students about AI, designing curricula accommodating AI education, and evaluating the effects of these decisions. These challenges call for a strategic and thoughtful approach to AI integration, cognizant of the ethical, practical, and policy complexities involved.

The integration of artificial intelligence (AI) in primary education, as explored through various scholarly analyses, represents a significant paradigm shift in educational practices (UNESCO 2019). This transformation extends beyond the incorporation of new technologies; it redefines the very essence of teaching and learning processes. AI's potential to personalize education through intelligent tutoring systems and precise student performance prediction challenges the traditional, homogeneous approach to education. It promises a future where learning is deeply individualized, catering to each student's unique needs and pace. Simultaneously, AI's role in enhancing pedagogical methods, such as through the use of virtual reality, marks a departure from conventional classroom environments. It introduces an immersive and interactive dimension to learning, which can significantly boost student engagement and motivation.

The potential of AI to revolutionize assessment and evaluation techniques also underscores a fundamental change. By offering more efficient and accurate evaluations, AI challenges the traditional paradigms of testing and grading, shifting towards a more holistic and continuous assessment of student learning (Ouyang and Jiao 2021; T. Wang and Cheng 2021). Furthermore,

The 6th International Conference on Elementary Education Volume 6 (1)
Elementary Education Study Program, School of Postgraduate Studies, Universitas Pendidikan Indonesia

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e-ISSN: 2808-8263
p-ISSN: 2829-0976

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the integration of AI in primary education is not limited to student-facing applications but extends to teacher support and administrative efficiency. AI-driven applications that assist in curriculum planning and operational tasks represent a substantial shift in the educator's role. This shift sees teachers transitioning from content deliverers to facilitators of learning, where they leverage AI tools to enhance their teaching strategies and classroom management (Chen, Chen, and Lin 2020).

However, this transformative potential of AI in education comes with its own set of challenges, which are critical to address in this paradigm shift (Ouyang and Jiao 2021). Issues of academic integrity, ethical and privacy concerns, and the digital divide present significant hurdles (UNESCO 2019). The overreliance on AI and the necessity to update policies and curricula to incorporate digital literacy and AI education highlight the need for a comprehensive and multi-faceted approach to AI integration. These challenges underscore the complexity of implementing AI in a way that is equitable, ethical, and effective. Moreover, the requirement for teacher preparedness and policy development in the face of AI integration indicates a need for systemic changes in educational frameworks. Teachers must be equipped not only with the tools but also with the knowledge and skills to effectively integrate AI into their teaching practices. Policymakers must create frameworks that address the ethical implications of AI, ensuring that its integration into the educational system is beneficial and equitable (UNESCO 2019).

One critical assumption in the discussion about implementing AI in primary schools in Indonesia is that there will be equitable access to the necessary technology and infrastructure across all regions. This includes not only access to AI tools and platforms but also to reliable internet connectivity and digital devices. The assumption is that these foundational elements will be uniformly available to students and teachers in both urban and rural areas, enabling the effective integration of AI in the educational process (UNESCO 2019).

Given this assumption, a key recommendation for the successful implementation of AI in Indonesian primary schools would be the development and execution of a comprehensive national digital infrastructure program (UNESCO 2019). This program should focus on ensuring that all schools, regardless of their geographic location or socio-economic status, have access to high-speed internet, modern digital devices, and AI educational tools (Chen, Chen, and Lin 2020). Additionally, this program should include initiatives for training teachers in AI literacy and digital pedagogy, ensuring that they are well-equipped to integrate AI into their teaching methods effectively. This approach will not only address the digital divide but also ensure that the benefits of AI in education are accessible to all students in Indonesia, fostering an inclusive and equitable educational environment (Ouyang and Jiao 2021).

CONCLUSION

The integration of Artificial Intelligence (AI) in primary education in Indonesia represents a significant and transformative step forward in the realm of educational technology. This study has highlighted the numerous benefits that AI can bring to the educational sector, including personalized learning paths, enhanced pedagogical methods, improved assessment and evaluation techniques, and increased administrative efficiency. These advancements promise to make learning more adaptive, engaging, and student-centered. However, the study also acknowledges the myriad challenges that accompany the integration of AI in education. These include concerns about academic integrity, ethical and privacy issues, the digital divide, and the need for comprehensive policy development and teacher training.

The effective implementation of AI in education hinges on addressing these challenges through a strategic and multifaceted approach. The assumption of equitable access to technology and infrastructure underpins the potential success of AI in Indonesian primary education. Based on this, the study recommends a national initiative to enhance digital infrastructure, ensuring uniform access to AI tools and internet connectivity across Indonesia's diverse regions. It also emphasizes the importance of teacher training in AI and digital pedagogy. While the path to integrating AI in Indonesian primary education is dealing with challenges, the potential rewards are substantial. With careful planning, investment in infrastructure, and commitment to overcoming the hurdles, AI can significantly enhance the educational experience for Indonesian students, preparing them for a future in an increasingly digital world.

The 6th International Conference on Elementary Education Volume 6 (1)
Elementary Education Study Program, School of Postgraduate Studies, Universitas Pendidikan Indonesia

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e-ISSN: 2808-8263

p-ISSN: 2829-0976

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