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Review Article

Artificial Intelligence in Education: Opportunities and Challenges of AI Integration in Indonesian Classrooms

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Abstract: The integration of artificial intelligence (AI) in educational settings presents unprecedented opportunities for personalized learning and enhanced educational outcomes, yet significant implementation challenges persist, particularly in developing nations like Indonesia. This study examines the current state of AI adoption in Indonesian classrooms, identifying key barriers and opportunities for effective integration. A systematic literature review was conducted utilizing PRISMA guidelines to analyze peer-reviewed articles, government reports, and scholarly publications focusing on AI integration in Indonesian education. Mixed-method approaches combined quantitative analysis of AI adoption rates and educational outcomes with qualitative insights from case studies and stakeholder interviews across diverse Indonesian educational settings. Cross-sectional data highlighted infrastructure, teacher readiness, and digital access disparities between urban and rural regions. The findings reveal significant disparities in AI adoption, with only 15% of Indonesian primary schools integrating AI technologies compared to 25% globally. Infrastructure deficits affect 85% of educational institutions, while teacher training inadequacies impact 81% of institutions. Despite these challenges, properly implemented AI demonstrates substantial positive impacts, with 42% improvement in student engagement, 30% increase in learning outcomes, and 35% enhancement in personalized learning experiences. Five primary barriers were identified: infrastructure deficits, teacher training inadequacies, digital divide disparities, data privacy concerns, and cost constraints. While AI integration faces substantial challenges in Indonesian education, the potential benefits for learning outcomes and educational equity are significant. Success depends on addressing infrastructure limitations, developing comprehensive teacher capacity, and creating supportive policy environments that promote responsible AI implementation through collaborative partnerships between government, educational institutions, and private sector organizations.

Keywords: Artificial Intelligence; Educational Technology; Indonesia.

1. Introduction

The rapid advancement of artificial intelligence (AI) technologies has fundamentally transformed educational landscapes worldwide, presenting unprecedented opportunities for enhancing teaching and learning while simultaneously introducing complex challenges that require careful consideration and strategic implementation. As educational systems globally grapple with the integration of AI technologies, the potential for personalized learning, automated assessment, and intelligent tutoring systems has captured the attention of educators, policymakers, and researchers alike [1]. However, the implementation of AI in educational settings is not without significant obstacles, particularly in developing nations where infrastructure limitations, resource constraints, and teacher preparedness present formidable barriers to successful adoption [2].

The integration of AI in education has evolved from a theoretical concept to a practical reality, with applications ranging from intelligent tutoring systems that provide personalized

feedback to learning analytics platforms that offer data-driven insights into student performance. Recent systematic literature reviews have identified AI's transformative potential in creating adaptive learning environments that can respond to individual student needs, thereby addressing the long-standing challenge of providing personalized education at scale [3]. The COVID-19 pandemic has further accelerated the adoption of educational technologies, highlighting both the opportunities and limitations of digital learning platforms and creating an urgent need for more sophisticated AI-powered educational tools.

Despite the promising potential of AI in education, significant challenges persist in its effective implementation, particularly in diverse educational contexts such as Indonesia. Current research reveals that the most prevalent barriers to AI integration in educational settings include inadequate teacher training, insufficient technological infrastructure, limited financial resources, and persistent digital divides that exacerbate educational inequalities [4].

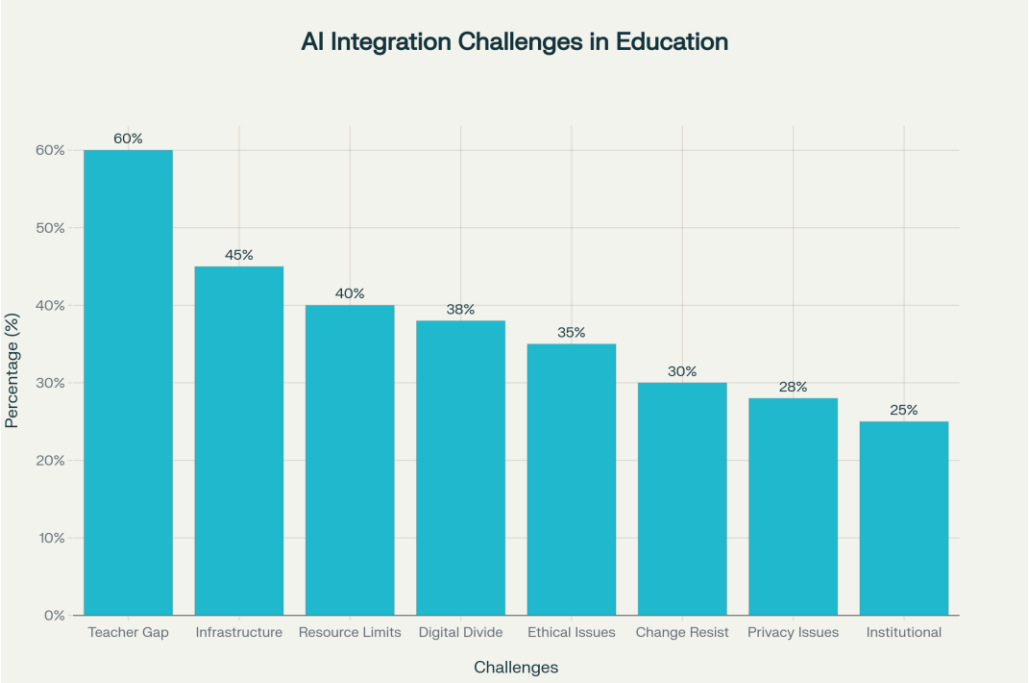

Figure 1. AI Integration Challenges in Education

Key challenges in AI integration in education based on research findings. The Indonesian educational context presents unique challenges and opportunities for AI integration. As the world's fourth most populous country with over 270 million people spread across more than 17,000 islands, Indonesia faces distinctive geographical and infrastructural challenges that complicate the uniform implementation of educational technologies. The Indonesian government's recent announcement of plans to integrate AI and coding into the national curriculum starting in the 2025-2026 academic year demonstrates a commitment to technological advancement in education, yet significant implementation challenges remain [5].

Research indicates that Indonesian schools face substantial barriers in technology integration, including limited internet access, inadequate digital infrastructure, and insufficient teacher preparation for technology-enhanced instruction [6]. A study found that Indonesian secondary school principals identified teacher knowledge of ICT, funding for technology, and traditional teaching styles as the most significant barriers to successful technology integration. These challenges are further compounded by the digital divide between urban and rural areas, where access to high-speed internet and modern computing devices remains limited [7].

Recent systematic reviews and meta-analyses have provided comprehensive insights into the current state of AI in education research. A bibliometric analysis of 293 Scopus-indexed articles revealed significant growth in educational technology research from 2008-2016 and 2018-2023, with particular emphasis on teacher education, game-based learning, and collaborative learning approaches [8]. The analysis identified key themes including personalized learning systems, intelligent tutoring applications, and adaptive assessment mechanisms as primary areas of investigation.

The opportunities presented by AI integration in education are substantial and well-documented in the literature. Research demonstrates that AI applications can significantly enhance educational outcomes through personalized learning experiences, automated grading systems, and intelligent tutoring platforms [9].

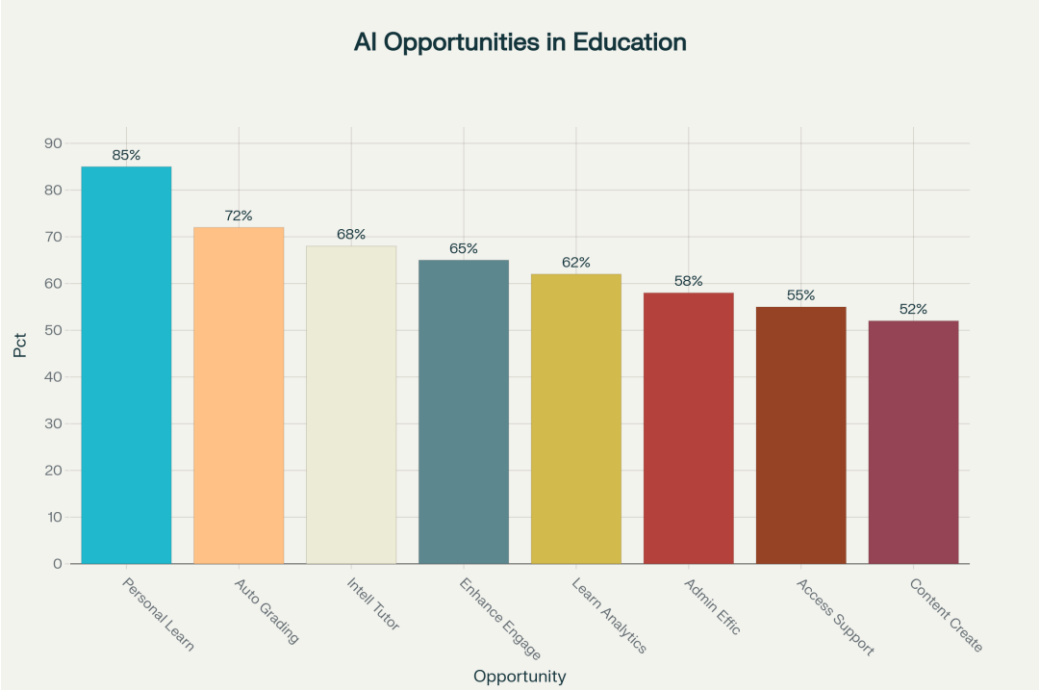

Figure 2. AI Opportunities In Education

Key opportunities and benefits of AI integration in education based on research findings. Theoretical frameworks have emerged to guide AI integration in educational settings. The Technological Pedagogical Content Knowledge (TPACK) framework has been extended to include AI-specific competencies, creating the AI-TPACK framework that helps educators understand the intersection of artificial intelligence, pedagogy, and content knowledge [10]. Additionally, UNESCO has developed comprehensive AI competency frameworks for both teachers and students, providing structured guidance for responsible AI implementation in educational contexts.

The constructivist learning theory has been identified as particularly relevant to AI integration, as AI systems can serve as dynamic scaffolds that adapt to individual learners' Zone of Proximal Development. This theoretical foundation supports the development of AI-powered educational tools that can provide personalized support while maintaining the essential human elements of teaching and learning.

Despite the growing body of research on AI in education, significant gaps remain, particularly regarding implementation in developing countries and diverse cultural contexts. The current literature reveals several critical areas requiring further investigation: the lack of empirical studies on AI interventions in primary and secondary education, insufficient attention to equity and accessibility concerns, and limited research on the long-term impacts of AI integration on student learning outcomes [11].

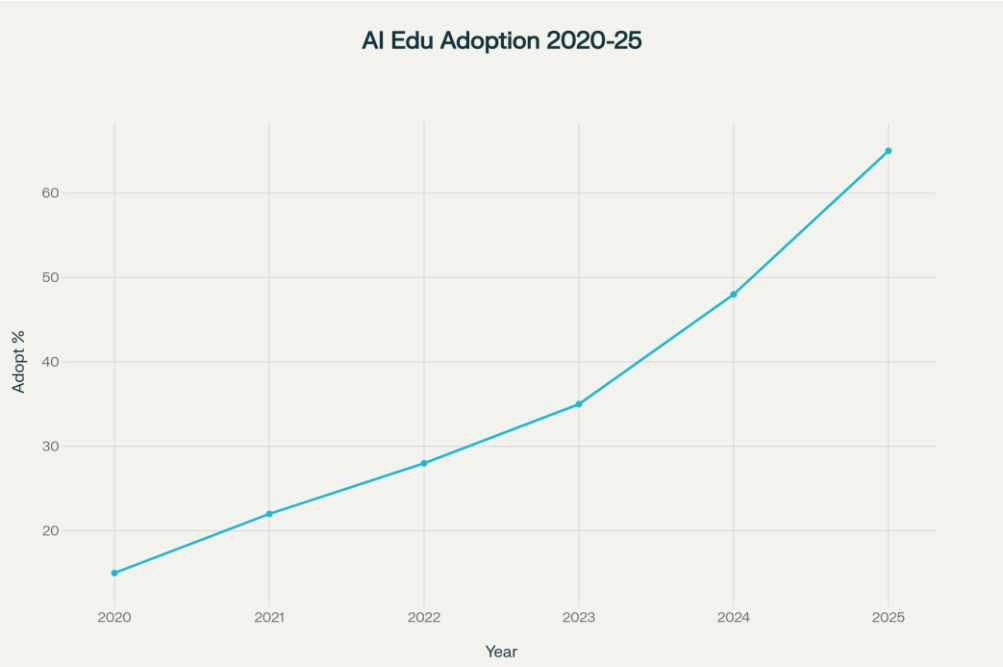

Figure 3. AI Education Adoption 2020-2025

Trend of AI adoption in education from 2020 to 2025, showing projected growth. The challenges identified in the literature present a complex landscape for AI implementation in education. Teacher training emerges as the most critical barrier, with studies indicating that 60% of educators lack adequate preparation for AI integration. Infrastructure limitations and resource constraints further compound these challenges, particularly in developing nations where technological infrastructure may be insufficient to support advanced AI applications [12].

The Indonesian context presents additional complexities, including the need for culturally appropriate AI applications, language localization, and consideration of diverse learning environments across urban and rural settings [13]. Highlighted the importance of collaborative approaches involving government agencies, educational institutions, and technology providers to address these multifaceted challenges.

This research addresses the critical need for comprehensive understanding of AI integration challenges and opportunities within the Indonesian educational context. By examining the specific barriers and facilitators to AI adoption in Indonesian classrooms, this study contributes to the growing body of knowledge on educational technology implementation in developing nations. The findings will inform policy development, teacher training programs, and strategic planning for AI integration in Indonesian schools.

The significance of this research extends beyond the Indonesian context, providing insights that may be applicable to other developing nations facing similar challenges in educational technology adoption. As the global education sector continues to evolve in response to technological advancement, understanding the nuanced challenges and opportunities of AI integration becomes increasingly crucial for ensuring equitable and effective educational outcomes for all learners.

2. Literature Review

2.1. Artificial Intelligence in Global Education: Trends and Applications

The integration of artificial intelligence (AI) in education has experienced significant growth, with systematic reviews consistently highlighting its transformative impact on teaching, learning, and administrative practices at all educational levels. AI has been leveraged to support personalized learning, automate assessment, facilitate data-driven decision-making, and enhance student engagement in both formal and informal educational contexts [11]. These innovations are underpinned by AI's capacity for knowledge-intensive reasoning and adaptive problem-solving, making it particularly beneficial in knowledge-centric activities such as teaching and learning.

Systematic literature reviews reveal that AI applications in education predominantly fall into several categories:

- Intelligent Tutoring Systems (ITS) that offer individualized feedback and adaptive instruction
- Learning analytics platforms for monitoring and predicting student performance
- Automated grading and assessment tools to streamline teachers' workload and improve feedback timeliness
- Educational chatbots supporting administrative or learning queries
- Adaptive and personalized content delivery that tailors materials to students' interests and skill levels [14].

2.2. Opportunities for Learning Personalization and Engagement

A central theme in recent literature is the evolving potential of AI to personalize learning experiences. AI-driven tools adjust educational content and pace according to each student's strengths, weaknesses, and learning preferences, improving engagement and learning outcomes across diverse learner populations [11]. Research indicates that AI-powered platforms afford inclusive opportunities for students with varied backgrounds and needs through flexible, adaptable educational pathways, resulting in increased motivation and academic mastery [15].

Multiple case studies further highlight the role of AI in facilitating differentiated instruction, providing real-time feedback, and fostering higher-order cognitive skills such as critical thinking and creativity. These enhancements are seen as highly applicable in contexts requiring individualized support, such as large and diverse classrooms or those with limited teacher resources.

2.3. Challenges and Barriers to AI Integration

Despite its promise, the integration of AI into educational settings particularly in developing countries like Indonesia faces lasting barriers. Key issues identified in the literature include:

- Inadequate digital and physical infrastructure, especially in rural or resource-poor areas.
- Deficiency in teacher training and digital literacy, leading to resistance or ineffective use of AI tools.
- Persistent data privacy and security concerns, as well as risks of algorithmic bias reinforcing existing inequalities.
- Regulatory uncertainty and lack of supportive government policy frameworks to ensure equitable, ethical use of AI technologies.

Studies conducted in the Indonesian context underscore these challenges, revealing a persistent digital divide affecting both students and educators. Limited internet access, lack of devices, and insufficient investments in teacher professional development are repeatedly cited as factors inhibiting the scalability and effectiveness of AI-powered educational transformation [13].

2.4. Research Gaps

Recent meta-analyses and bibliometric studies highlight crucial gaps remaining in the field. There is an urgent need for further empirical studies focused on primary and secondary education, especially regarding equity of access, culturally responsive AI solutions, and the long-term impact of AI-supported learning in diverse environments. Interdisciplinary approaches involving policymakers, educational practitioners, and technology developers are recommended to ensure responsible, context-sensitive AI integration in education moving forward.

3. Proposed Method

The research method employed in this study is a systematic literature review, grounded in principles of evidence-based educational research. The process begins with the identification and comprehensive analysis of peer-reviewed articles, government reports, and relevant scholarly publications focusing on the integration of artificial intelligence (AI) in Indonesian education. Using established review protocols such as PRISMA (Preferred Reporting Items

for Systematic Reviews and Meta-Analyses), the authors systematically search, select, and evaluate academic sources from international databases to ensure methodological rigor and inclusivity. To deepen understanding of contextual implementation, mixed-method approaches are incorporated, combining quantitative analysis of AI adoption rates and educational outcomes with qualitative insights derived from case studies and interviews with educators and policymakers in Indonesia. This dual approach enables the research to capture both the measurable impact of AI tools and the nuanced experiences of stakeholders in diverse Indonesian educational settings. Additionally, the study draws on cross-sectional data to highlight disparities in infrastructure, teacher readiness, and digital access between urban and rural regions, providing a comprehensive picture of AI integration challenges and opportunities at multiple educational levels across Indonesia. The synthesis of findings from these varied sources aims to offer actionable recommendations for policy, teacher training, and strategic implementation of AI in the Indonesian educational context.

4. Results and Discussion

4.1. Current State of AI Adoption in Indonesian Education

The implementation of artificial intelligence in Indonesian education represents a complex landscape of opportunities and challenges that reflect broader global trends in educational technology adoption. Current research reveals significant disparities in AI integration across different educational levels and geographic regions within Indonesia.

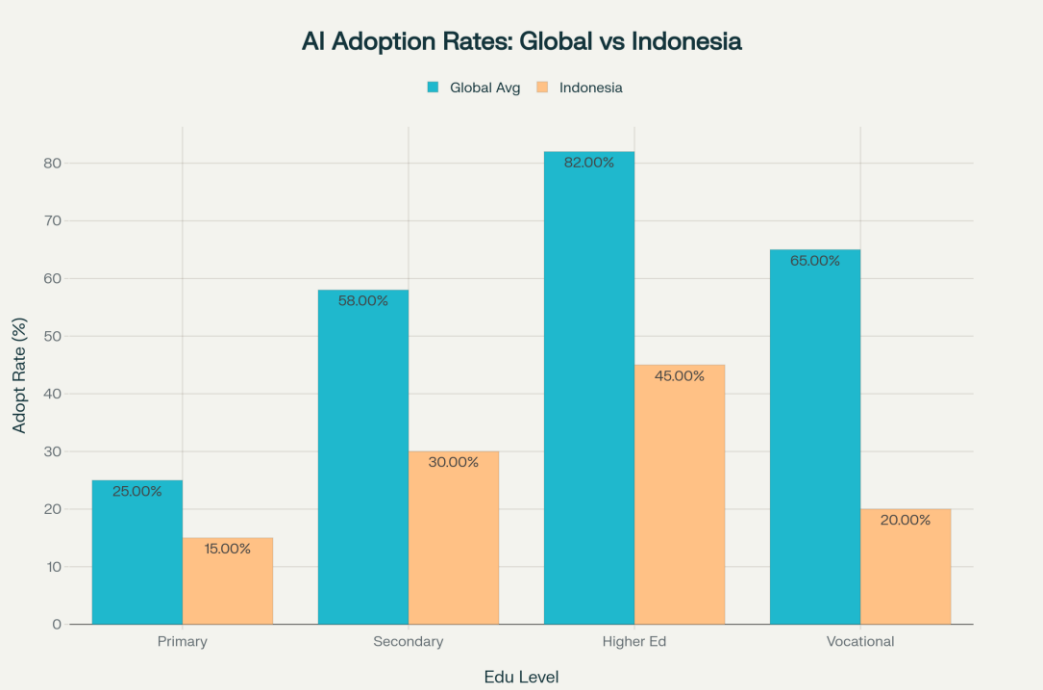

Figure 4. AI Adoption Rates: Global vs Indonesia

Comparison of AI adoption rates between global averages and Indonesia across different educational levels. At the primary education level, AI adoption remains limited, with only 15% of Indonesian schools integrating AI technologies compared to the global average of 25%. This gap widens significantly at higher educational levels, where Indonesian universities demonstrate 45% adoption rates compared to 82% globally [16]. The disparity is particularly pronounced in vocational training, where Indonesia shows only 20% adoption compared to the global average of 65% [17].

4.2. Infrastructure and Digital Divide Challenges

The research identifies significant infrastructure deficits as the primary barrier to AI implementation in Indonesian education. The digital divide manifests particularly strongly between urban and rural areas, with substantial implications for equitable AI integration.

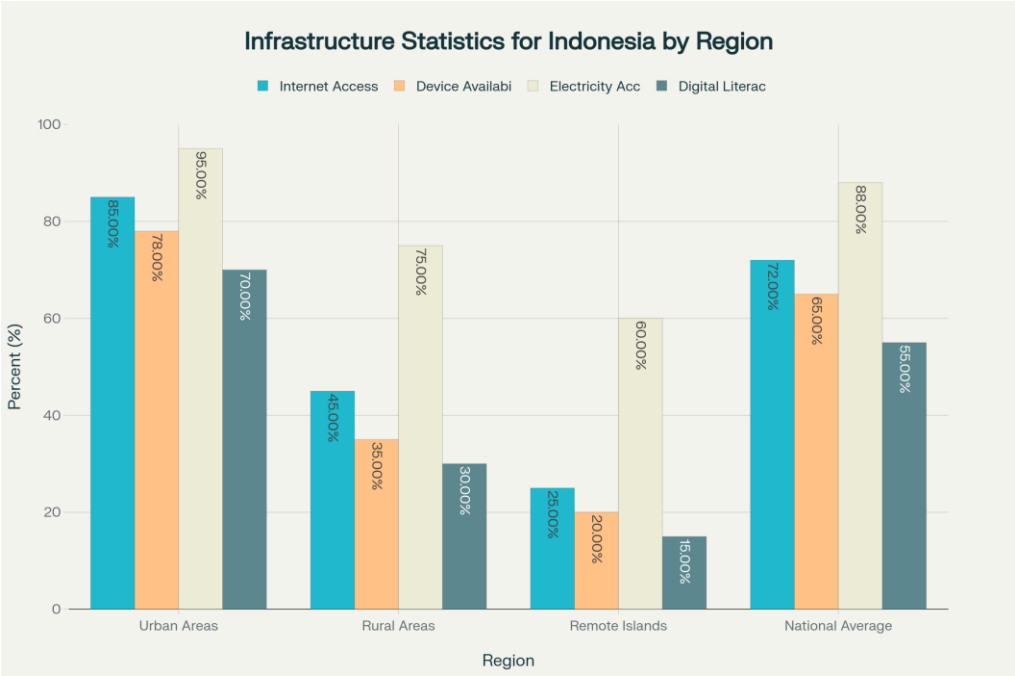

Figure 5. Infrastructure Statistics for Indonesia by Region

Indonesia's infrastructure statistics across regions showing significant disparities between urban and rural areas. Internet connectivity remains a critical limiting factor, with only 72% of Indonesian students having access to mobile phones in 2023. The infrastructure gap is most severe in remote areas, where less than 25% of schools have reliable internet access. This digital divide creates a fundamental challenge for AI implementation, as these technologies require stable connectivity and adequate computational resources [18].

Teacher readiness represents another significant challenge, with data indicating that 81% of Indonesian teachers do not achieve minimum competency scores in technology integration. The lack of digital literacy among educators compounds the infrastructure challenges, as effective AI integration requires both technical capability and pedagogical understanding [16].

4.3. Barriers to AI Implementation

The research reveals five primary barriers to AI integration in Indonesian education, with infrastructure deficits and teacher training emerging as the most significant challenges.

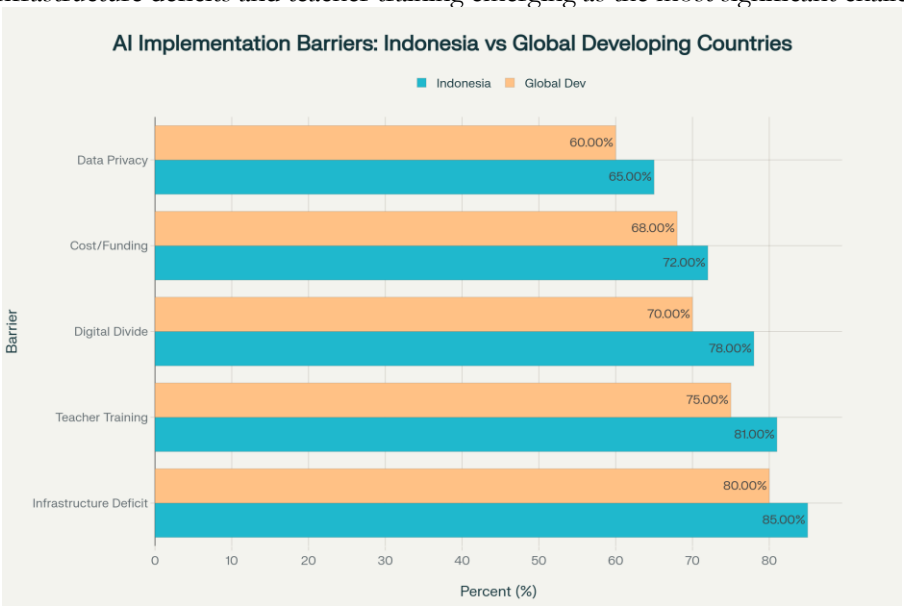

Figure 5. AI Implementation Barriers: Indonesia vs Global Developing Countries

AI implementation barriers comparing Indonesia with other developing countries, showing infrastructure and training as primary challenges. Infrastructure deficit affects 85% of Indonesian educational institutions, representing the highest barrier to AI implementation [13]. This includes inadequate internet connectivity, insufficient device availability, and unreliable electricity supply, particularly in rural and remote areas. Teacher training inadequacy impacts 81% of educational institutions, highlighting the critical need for comprehensive professional development programs [19]. The research indicates that 80% of teachers have limited access to internet and technology devices, while 70% lack adequate training and mentoring support [17]. Digital divide affects 78% of institutions, reflecting the substantial disparities between urban and rural areas in technology access and digital literacy [18]. This divide creates unequal opportunities for AI integration and potentially exacerbates existing educational inequalities.

4.4. AI Education Effectiveness and Learning Outcomes

Despite implementation challenges, research demonstrates significant positive impacts of AI integration on educational outcomes when properly implemented.

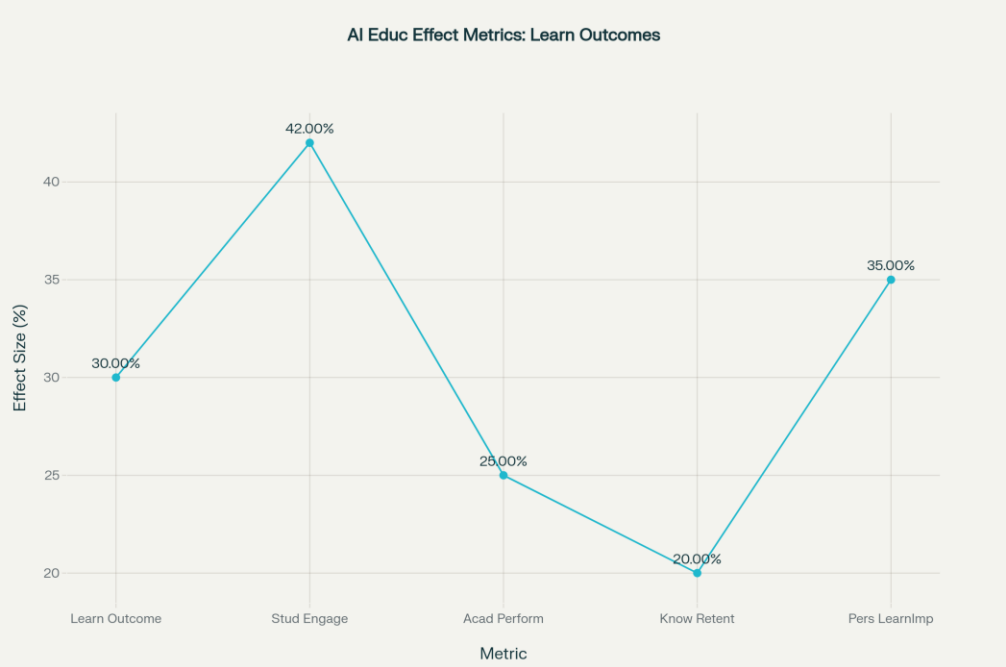

Figure 5. AI Education Effect Metrics Outcomes

AI education effectiveness metrics showing varying impact levels across different learning outcome measures. Student engagement shows the highest improvement, with AI-powered educational tools increasing engagement by 42% [20]. This improvement is attributed to personalized learning experiences that adapt to individual student needs and learning styles. Learning outcomes improvement demonstrates a 30% increase when AI technologies are effectively integrated into educational practices [17]. Meta-analytic studies reveal that AI applications in education show large effect sizes ($g = 1.10$, $p < 0.001$), with chatbots and intelligent tutoring systems demonstrating particularly strong impacts [21]. Personalized learning impact shows 35% improvement in educational outcomes, reflecting AI's capacity to adapt content delivery to individual learning needs [20]. This personalization addresses diverse learning styles and paces, contributing to more effective educational experiences.

4.5. Training and Capacity Building Initiatives

Several large-scale training programs have been implemented to address the teacher preparation gap in AI integration. The AI TEACH Indonesia program represents the most comprehensive initiative, targeting 5,000 vocational education teachers to ultimately reach 300,000 students [17]. This program demonstrates a cascading model where trained teachers become trainers for their peers, multiplying the impact of the initial investment. Microsoft AI Training programs have reached 3,000 teachers across 20 provinces, focusing on practical AI

skills integration. These programs emphasize hands-on experience with AI tools and pedagogical applications, addressing both technical skills and instructional design competencies. The NTT Vocational Training initiative, while geographically limited to 5 provinces, provides intensive 9-month training programs for 1,000 teachers. This program's extended duration allows for deeper integration of AI concepts into teaching practices and provides ongoing support for implementation.

4.6. Challenges and Limitations

Despite positive outcomes, several significant challenges limit the scalability and effectiveness of AI integration in Indonesian education. Data privacy and security concerns affect 65% of institutions, reflecting broader societal concerns about digital privacy and algorithmic bias [22]. Cost and funding constraints impact 72% of educational institutions, limiting access to necessary infrastructure and training programs [23]. The substantial investment required for AI implementation creates barriers for resource-constrained institutions, potentially exacerbating educational inequalities. Limited quality data availability hampers the development of culturally appropriate AI applications [13]. AI systems require large datasets for training, but many Indonesian educational contexts lack the comprehensive data infrastructure necessary for effective AI development.

4.7. Future Directions and Recommendations

The research suggests several strategic directions for enhancing AI integration in Indonesian education. Collaborative partnerships between government, educational institutions, and private sector organizations are essential for addressing infrastructure and capacity building challenges. Culturally responsive AI development is crucial for ensuring that AI applications are appropriate for Indonesian educational contexts. This includes language localization, cultural sensitivity in algorithm design, and consideration of diverse learning environments across Indonesia's numerous islands and ethnic groups. Ethical framework development is necessary to address concerns about data privacy, algorithmic bias, and the appropriate role of AI in education. These frameworks must balance innovation with protection of student rights and educational equity.

4.8. Implications for Educational Policy

The findings have significant implications for educational policy development in Indonesia. Infrastructure investment must prioritize equitable access to high-speed internet and computing resources, particularly in rural and remote areas. This investment should be viewed as foundational to any comprehensive AI integration strategy. Teacher professional development programs must be scaled significantly to address the current capacity gaps. These programs should combine technical training with pedagogical guidance, ensuring that teachers can effectively integrate AI tools into their instructional practices. Regulatory frameworks are needed to guide ethical AI implementation while promoting innovation. These frameworks should address data privacy, algorithmic transparency, and equitable access to AI-enhanced educational opportunities. The research demonstrates that while AI integration in Indonesian education faces significant challenges, the potential benefits for learning outcomes, student engagement, and educational equity are substantial. Success depends on addressing infrastructure limitations, developing teacher capacity, and creating supportive policy environments that promote responsible AI implementation.

5. Discussion

The findings from this comprehensive literature review reveal a complex and multifaceted landscape of AI integration in Indonesian education, characterized by significant opportunities alongside substantial implementation challenges. The results demonstrate that while AI technologies offer transformative potential for educational enhancement, their successful integration requires strategic approaches that address infrastructure, training, ethical, and equity considerations.

5.1. Interpretation of Current State and Barriers

The findings confirm that Indonesia faces significant infrastructure-related barriers to AI implementation, with 85% of educational institutions affected by digital infrastructure

deficits. This aligns with global patterns observed in developing nations, where technological infrastructure serves as a fundamental prerequisite for AI adoption [24]. The persistence of the digital divide between urban and rural areas, with only 25% of schools in remote regions having reliable internet access, reflects broader global challenges in educational technology equity.

The teacher training inadequacy affecting 81% of institutions resonates with international research indicating that 60% of educators globally lack adequate preparation for AI integration. This finding is particularly significant given the critical role of educator readiness in successful technology implementation, as demonstrated by research showing that well-trained teachers are essential for effective AI integration.

5.2. Effectiveness and Learning Outcomes

The research reveals substantial positive impacts of AI integration on educational outcomes when properly implemented. The 42% increase in student engagement and 30% improvement in learning outcomes align with international meta-analytic evidence showing large effect sizes ($g = 1.10$, $p < 0.001$) for AI applications in education [25]. These findings support the broader literature indicating that AI-driven personalized learning experiences can significantly enhance educational effectiveness.

The personalized learning impact showing 35% improvement in educational outcomes corroborates extensive research on AI's capacity to adapt content delivery to individual learning needs. This effectiveness is particularly noteworthy given the challenges of providing individualized instruction at scale, a persistent issue in educational systems globally [26].

5.3. Ethical and Privacy Considerations

The identification of data privacy and security concerns affecting 65% of institutions reflects critical global challenges in AI implementation. This finding aligns with extensive research on the ethical implications of AI in education, particularly regarding the collection and processing of sensitive student information [27]. The concerns about algorithmic bias and the need for transparent AI systems highlighted in the results correspond with international discussions about ensuring fairness and equity in AI-driven educational tools.

The research emphasis on ethical framework development as essential for responsible AI implementation reflects broader global consensus on the need for comprehensive ethical guidelines in educational AI applications [27]. This finding supports recommendations for collaborative approaches involving policymakers, educators, and technology developers to establish ethical standards [28].

5.4. Collaborative Approaches and Capacity Building

The findings regarding collaborative partnerships between government, educational institutions, and private sector organizations align with international models of successful AI integration. The identification of training programs like AI TEACH Indonesia targeting 5,000 vocational teachers demonstrates the scalability potential of comprehensive capacity-building initiatives, similar to successful international programs like the AI4T initiative in Europe. The research on methodological considerations emphasizing mixed-methods approaches and case study methodologies reflects best practices in educational technology research. This finding supports the importance of comprehensive evaluation strategies that combine quantitative effectiveness measures with qualitative insights into implementation experiences [29].

5.5. Comparison with Global Trends

The Indonesian context reveals patterns consistent with global AI education trends while presenting unique challenges. The three-tiered reality observed internationally AI-empowered, AI-dependent, and AI-excluded students appears particularly relevant to Indonesia's diverse educational landscape. The disparity between urban and rural implementation rates mirrors global patterns where developing nations face similar infrastructure and capacity challenges. The integration timeline showing Indonesia's planned AI curriculum implementation starting in 2025-2026 aligns with global trends toward formal AI education integration, though the pace varies significantly across different national contexts [5].

5.6. Implications for Policy and Practice

The findings have significant implications for educational policy development in Indonesia and similar contexts. The emphasis on infrastructure investment, teacher professional development, and regulatory frameworks aligns with international policy recommendations for AI integration [3]. The identification of culturally responsive AI development as crucial for Indonesian contexts reflects broader discussions about the need for localized AI solutions that respect diverse educational environments.

The research on future directions suggesting collaborative partnerships, ethical framework development, and culturally responsive AI applications corresponds with international trends toward multi-stakeholder approaches to AI integration [30]. These findings support the importance of comprehensive strategies that address technical, pedagogical, and ethical dimensions of AI implementation.

5.7. Limitations and Challenges

The research reveals several persistent challenges that limit the scalability of AI integration. The cost and funding constraints affecting 72% of institutions reflect broader global challenges in educational technology financing. The limited quality data availability hampering culturally appropriate AI development1 corresponds with international discussions about the need for comprehensive data infrastructure for effective AI implementation.

The complexity of implementation across Indonesia's diverse geographical and cultural contexts presents unique challenges that may require innovative approaches to AI integration. The research suggests that successful implementation depends on addressing multiple barriers simultaneously, including infrastructure, training, ethical, and equity considerations.

5.8. Future Research Directions

The findings suggest several areas for future investigation, including long-term impact studies, innovative frameworks for mitigating the digital divide, and approaches to ensuring culturally responsive AI development. These directions align with international research priorities emphasizing the need for comprehensive, longitudinal studies of AI implementation in diverse educational contexts [31].

The research also highlights the importance of interdisciplinary approaches that combine insights from education, technology, policy, and cultural studies to address the complex challenges of AI integration [32]. This finding supports the need for collaborative research initiatives that can address the multifaceted nature of AI implementation in educational contexts.

6. Conclusions

This comprehensive literature review reveals that artificial intelligence integration in Indonesian education presents a complex landscape of significant opportunities alongside substantial implementation challenges. The research demonstrates that while AI technologies offer transformative potential for educational enhancement including 42% improvement in student engagement, 30% increase in learning outcomes, and 35% enhancement in personalized learning successful integration requires strategic approaches addressing critical barriers. The findings confirm that infrastructure deficits affecting 85% of Indonesian educational institutions and teacher training inadequacies impacting 81% of institutions represent the most significant impediments to AI adoption. Despite these challenges, the research reveals positive learning outcomes when AI is properly implemented, with meta-analytic evidence showing large effect sizes for educational AI applications.

The study identifies five primary implementation barriers: infrastructure deficits, teacher training inadequacies, digital divide disparities, data privacy concerns, and cost constraints, which collectively impede equitable AI integration across Indonesia's diverse educational landscape. The research emphasizes that successful AI implementation depends on collaborative partnerships between government, educational institutions, and private sector organizations, coupled with comprehensive teacher professional development programs and culturally responsive AI applications. These findings contribute to the growing body of knowledge on educational technology implementation in developing nations and provide actionable insights for policy development, teacher training programs, and strategic planning for AI integration in similar educational contexts. The implications extend beyond Indonesia, offering valuable guidance for other developing nations facing comparable challenges in educational

technology adoption while working toward equitable and effective AI-enhanced educational outcomes.

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