

Building Adaptive Education in the Era of Change

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Abstract. *This study aims to explore the concept, implementation, and benefits of adaptive education in the digital era. It also seeks to identify key challenges and propose strategic solutions to ensure inclusive, equitable, and future-oriented learning. This study uses literature study and comparative analysis methods to examine the concepts, benefits, challenges, and strategies for the implementation of adaptive education in Indonesia. The results of the study show that adaptive education is effective in improving the quality and inclusiveness of learning, but still faces challenges in the form of infrastructure inequality, teacher readiness, and data privacy issues. Collaboration between governments, educators, and technology developers, as well as policies that support teacher training and equitable access to technology, is needed so that adaptive education can be the foundation of a relevant and quality future education system in the digital era.*

Keywords: *Adaptive education, artificial intelligence, digital technology*

Introduction

The digital revolution has redefined education beyond knowledge delivery. It now fosters adaptability, critical thinking, and creativity in learners to meet modern challenges. “Digital natives” exhibit unique learning preferences shaped by constant exposure to digital technology (Alruthaya et al., 2021). Educators must therefore design curricula that align with these traits to optimize engagement and outcomes. This shift is essential to prepare students for a competitive, technology-driven world. According to Prensky, these learners are deeply immersed in technology and accustomed to the rapid flow of information, which challenges the relevance and effectiveness of conventional, one-size-fits-all educational models. Consequently, traditional methods that prioritize uniformity and the collective mastery of content fall short in addressing the personalized and dynamic learning needs of students today. To remain effective, educational institutions must reimagine their strategies and methodologies to align with the evolving characteristics of the digital age (Prensky, 2001)

Adaptive education has emerged as a transformative paradigm in response to the growing need for more personalized learning experiences in diverse educational settings. It addresses this challenge by tailoring the teaching and learning process according to each student's needs, abilities, and learning styles, thereby enhancing the effectiveness of instruction (Johnson et al., 2016). This approach increases student engagement by giving them more control over learning. It empowers learners to absorb material at their own pace. It aligns content delivery with individual preferences. It fosters deeper motivation and active participation. Overall, it enhances both enjoyment and learning effectiveness (Bulger, 2021). Through the integration of advanced technologies such as artificial intelligence (AI), big data, and learning analytics, adaptive education systems can provide real-time customization and feedback to optimize learning outcomes. Research conducted by Baso Intang Sappaile et al. (2024) demonstrates that AI-based adaptive learning can significantly boost academic performance by 20–40%, largely due to its capacity to continuously adjust content and instructional methods in alignment with student needs. Therefore, adaptive education is not merely a trend, but a crucial innovation for fostering inclusive, equitable, and high-quality education in the digital era (Sappaile et al., 2024).

Remote regions in Indonesia face stark disparities in technology access. This imbalance hampers adaptive education implementation. A study by (Harahap et al., 2025) found that insufficient internet and device availability in rural areas significantly restricts online learning effectiveness. Schools in many regions struggle to create effective technology-based learning environments due to inadequate infrastructure. A recent review highlighted that limited access to computers, unreliable internet, and poor ICT facilities remain primary barriers to integrating digital tools in education especially in developing countries (Lomos et al., 2023). Teachers often lack sufficient training to implement adaptive and educational technologies, undermining their readiness to adopt adaptive learning methods. A 2022 scoping review found that without targeted professional development and technical support, teachers’ self-efficacy in using adaptive learning tools remains low, limiting effective integration into their teaching practice (Simon & Zheng, 2024). This lack of digital literacy among teachers significantly reduces the potential benefits of adaptive learning systems. As noted by Er-Rafy, these barriers must be addressed to ensure that adaptive education can be implemented effectively and equitably across the country (Er-Rafy et al., 2024).

Adaptive education implementation is often hampered by misaligned and fragmented education policies that do not support system-wide coherence (Mirata et al., 2020). Current educational frameworks often suffer from rigidity and a lack of inclusivity, which limits their ability to meet diverse learner needs and adapt to rapidly evolving educational contexts. Integrating Universal Design for Learning (UDL) principles such as multiple means of representation, engagement, and expression enhances both flexibility and inclusivity, ensuring curricula can accommodate a wider range of learners effectively (Pannullo et al., 2024). To address this issue, the government must formulate responsive

policies that support the development and sustainability of adaptive education practices. This includes comprehensive training programs for teachers to enhance their pedagogical adaptability and technological competencies. Additionally, the provision of adequate infrastructure, such as digital learning tools and accessible classroom environments, plays a crucial role in supporting adaptive learning. Without these foundational supports, efforts to implement adaptive education will likely remain fragmented and ineffective.

Given these circumstances, an in-depth exploration of adaptive education becomes not only relevant but also necessary. Understanding its underlying concepts, potential benefits, practical implementations, as well as the challenges faced, provides a strategic basis for reimagining the future of education. Adaptive education holds the promise of creating a more inclusive, equitable, and personalized learning experience for all students. However, its success depends on a systemic commitment from stakeholders across all levels, including policy makers, educators, and institutions. Identifying and analyzing viable solutions to common barriers in adaptive education can guide more effective planning and policy development. Thus, this study is crucial in contributing to the discourse on how to construct a quality, inclusive, and future-oriented educational landscape.

Methods

This study employs a literature study method combined with comparative analysis using a descriptive-analytical approach. The use of this method is considered appropriate because it enables researchers to systematically collect, interpret, and evaluate relevant literature to gain a comprehensive understanding of the phenomenon of adaptive education. Through this approach, the study examines various scholarly sources that discuss how education systems respond to dynamic societal and technological changes. Adaptive education, as explored in multiple studies, highlights the need for curricula, teaching methods, and policies that adjust to learners' needs and evolving environments (OECD, 2021); (Darling-Hammond et al., 2020). Comparative analysis further strengthens this method by enabling cross-contextual insights that reveal patterns, gaps, and innovations in adaptive educational practices across different regions or countries. Therefore, this combined methodology is essential for producing a well-rounded analysis that informs both theoretical understanding and practical implications in the field of adaptive education.

The literature study acts as a foundational step in research, establishing the necessary theoretical framework before data collection and analysis. This approach aligns with methodology best practices that emphasise grounding empirical work within existing scholarly evidence (Bolanos et al., 2024). Data was gathered from a wide range of credible sources, such as scientific journals, scholarly articles, research reports, and other academic references. These sources specifically address themes related to adaptive education, the integration of digital technology, the role of artificial intelligence (AI), and the broader transformation of education in the digital era. Particular emphasis is placed on literature that focuses on the context of Indonesia, highlighting national trends and educational shifts. By synthesizing findings from these materials, the study identifies current challenges and opportunities in implementing adaptive and technology-based education. This methodological approach ensures a well-informed analysis grounded in existing academic discourse.

The implementation of adaptive education varies across countries, requiring a comparative analysis to understand its diverse applications and implications. By collecting and analyzing data from different educational systems, researchers can identify patterns, similarities, and differences in adaptive strategies and their outcomes. This approach is crucial for uncovering best practices and transferable models that may inform the Indonesian context. Furthermore, the analysis highlights specific challenges unique to Indonesia, such as technological disparities, teacher preparedness, and curriculum rigidity (Sari & Wibowo, 2022) (. Through this comparative lens, policymakers and educators can tailor adaptive

education reforms that address local constraints while leveraging international insights. Ultimately, such analysis serves as a foundation for more equitable, personalized, and effective learning environments across diverse educational settings.

The study employs a descriptive-analytical approach to offer a comprehensive understanding of the implementation of adaptive education and the various challenges it faces in practice. This methodological framework enables researchers to examine phenomena in a systematic, structured, and objective manner, allowing for a nuanced interpretation of educational dynamics. By utilizing this approach, the research aims to generate in-depth insights into how adaptive education contributes to educational transformation in the digital era. Furthermore, the study highlights key issues surrounding the integration of digital technology and personalized learning strategies in Indonesian education. It is anticipated that the findings will inform the formulation of more effective and responsive education policies tailored to local contexts. Ultimately, this approach reinforces the importance of evidence-based strategies in shaping the future direction of national education reforms.

Results and Discussion

Adaptive Education as a Response to the Era of Change

In the midst of accelerating social and technological changes, the education sector faces increasing pressure to move away from traditional, one-size-fits-all models toward more personalized and adaptive systems. Adaptive education, which leverages artificial intelligence (AI) and data analytics, provides a transformative approach by adjusting the learning process according to each student's individual needs. This shift in paradigm enhances the interactivity, dynamism, and effectiveness of education, making learning more meaningful and student-centered (Krechetov & Romanenko, 2020). Through such tailored instruction, learners are more engaged and can progress at a pace that suits their abilities and preferred learning styles. As a result, adaptive education maximizes students' potential while minimizing common frustrations associated with mismatched content difficulty. These innovations suggest that education must evolve in tandem with the digital era to remain relevant and impactful.

Moreover, adaptive education aligns with the growing necessity to equip learners with 21st-century competencies, notably the 4C skills: critical thinking, collaboration, creativity, and communication. These competencies are crucial for navigating an increasingly complex and uncertain global landscape. A personalized learning experience fosters the development of these essential skills by providing relevant content and real-world contexts, which in turn promote deeper understanding and practical application. Additionally, the integration of digital tools enhances students' digital literacy, a fundamental requirement in today's workforce. The benefits of adaptive education extend beyond academic achievement, positioning it as a strategic response to broader societal needs. Ultimately, this educational model represents a holistic approach to learning, one that prepares students not only for academic success but also for lifelong adaptability in a rapidly changing world (Krechetov & Romanenko, 2020).

Positive Impact of Adaptive Education

Adaptive education has emerged as a transformative approach to teaching and learning in the digital age. It utilizes technological innovations to tailor learning experiences according to the individual needs, abilities, and progress of each student. Unlike conventional methods, which often apply uniform instruction, adaptive education provides personalized pathways that optimize student engagement. Studies have shown that this personalization leads to greater motivation and autonomy in learning, especially as students receive real-time feedback that aligns with their comprehension levels (Johnson et al., 2022). As a result, learners become more active participants in their educational journey. This

shift from passive to active learning is key to fostering deeper understanding and academic growth.

Moreover, adaptive education contributes significantly to improving academic achievement across diverse student populations. Empirical evidence indicates that students involved in adaptive learning environments tend to perform better on assessments and achieve higher overall academic outcomes than those taught using traditional approaches (Smith & Lee, 2023). The use of data-driven instruction ensures that materials are neither too easy nor too difficult, promoting a zone of proximal development for each learner. This ensures that students are continually challenged without being overwhelmed. Additionally, adaptive systems can adjust to different learning speeds, allowing high-achieving students to progress while supporting those who need more time. This flexibility accommodates a wide range of learners, enhancing overall academic equity.

Beyond academic performance, adaptive education fosters social justice by addressing the disparities in learning opportunities among students from various socioeconomic backgrounds. With the integration of timely interventions, struggling students can receive immediate support, preventing them from falling behind (Garcia & Thompson, 2022). This approach helps to close achievement gaps that are often exacerbated by rigid educational systems. Personalized learning plans take into account individual student circumstances, promoting inclusivity and fairness. As a result, adaptive education has the potential to democratize learning by ensuring that every student has the opportunity to succeed regardless of their background. Therefore, adaptive education is not only a pedagogical innovation but also a tool for promoting educational equity and social inclusion.

Implementation of Adaptive Education in Indonesia

The implementation of adaptive education in Indonesia presents significant challenges, primarily stemming from disparities in technological infrastructure between urban and rural areas, along with teachers' varying levels of readiness to integrate digital tools into the classroom. One of the most pressing issues is the unequal access to technology, which hinders the equitable application of adaptive learning solutions across different regions. Additionally, concerns regarding the protection of student data and the ethical use of artificial intelligence (AI) in education remain unresolved. Despite these barriers, efforts to modernize Indonesia's education system have begun to emerge through the integration of AI-powered learning platforms and Learning Management Systems (LMS). Notable examples include Ruangguru and Zenius, which have introduced personalized learning content that adapts to each student's individual progress and learning needs. These innovations signal a promising step toward a more inclusive and data-driven education system in the country (Christanti et al., 2024).

The successful implementation of adaptive education in Indonesia largely depends on the preparedness and competence of teachers to integrate adaptive technology into classroom learning. As emphasized by Rahman (2023), continuous professional development and consistent support from educational institutions are essential to enhance teachers' abilities in utilizing educational technology effectively. Similarly, Er-Rafyg et al. (2024) highlight the need for structured and sustainable training programs that empower educators to adapt to evolving digital tools in pedagogy. In addition to teacher readiness, government intervention plays a crucial role by ensuring equitable access to technological infrastructure across diverse regions. Regulatory frameworks are also needed to guarantee the protection and ethical use of students' personal data. Therefore, the synergy between teacher capacity building and robust policy support forms the foundation of successful adaptive education implementation in Indonesia (Er-Rafyg et al., 2024).

Challenges and Overcoming Strategies

The main challenges of adaptive education include:

1. Teacher Readiness:

The implementation of adaptive education faces significant challenges, particularly regarding teacher readiness. A substantial number of educators lack sufficient technological competence and the pedagogical adaptability needed to support personalized learning environments. This shortfall is often exacerbated by inadequate professional training programs that fail to equip teachers with the necessary digital and instructional skills. Consequently, these limitations hinder the effective integration of adaptive education in classroom settings.

2. Technological Infrastructure:

One of the major challenges in implementing adaptive education is the disparity in technological infrastructure across regions. Students in remote and rural areas often face limited access to stable internet connections and digital learning devices, which hinders their participation in adaptive learning environments. This inequality creates a significant gap in educational opportunities compared to students in urban areas, where access to technology is more readily available. Addressing this issue requires collaborative efforts from governments, private sectors, and educational institutions to improve digital infrastructure and ensure equitable access for all learners (Christanti et al., 2024).

3. Data Privacy and Security:

One of the main challenges in implementing adaptive education is ensuring data privacy and security, as educational technologies often collect and process students' personal information. The risk of data misuse or unauthorized access can undermine trust and hinder the adoption of such technologies. Therefore, it is crucial to establish clear and transparent policies that govern the protection and ethical use of student data. These policies serve not only to safeguard privacy but also to build stakeholder confidence in digital learning environments (Er-Rafy et al., 2024).

Strategic solutions that can be implemented include:

1. Strategic solutions to address challenges in adaptive education include organizing continuous training and mentoring programs for teachers to enhance their skills in using adaptive technologies and implementing innovative pedagogical approaches. These initiatives aim to improve teacher competence, enabling them to effectively integrate technology into the learning process. Strengthening teacher capacity in this way is essential to creating a more dynamic and responsive educational environment. Ultimately, such efforts contribute to the successful implementation of adaptive education in various learning contexts.
2. Strategic solutions to address the challenges in adaptive education must include increasing investment in educational technology infrastructure across all regions, particularly in remote and underserved areas. This effort requires strong collaboration between governments and the private sector to ensure equitable access to quality digital learning tools. By bridging the digital divide, students from all backgrounds can benefit from inclusive and effective learning experiences. Consequently, such strategic investments not only support current educational needs but also build long-term resilience in education systems.
3. Strategic solutions that can be implemented in adaptive education include the development and enforcement of data protection policies and ethical standards in the use of digital learning

technologies. These policies are essential to safeguard students' personal data and ensure compliance with ethical norms in educational settings. By prioritizing data security and ethical usage, educational institutions can build trust among students, parents, and educators. Furthermore, such measures promote responsible innovation and sustainability in the digital transformation of education systems.

4. Strategic solutions to support adaptive education include encouraging collaboration among teachers, technology developers, and policymakers. Such partnerships are essential to building a sustainable ecosystem that supports long-term educational transformation. Through collaboration, stakeholders can co-develop innovative tools and pedagogical strategies tailored to diverse student needs. This synergy enhances the effectiveness of solutions in addressing the complex challenges of modern education systems.

Future Perspectives

The rapid advancement of educational technology continues to transform the learning landscape, with emerging trends in 2025 and beyond highlighting the growing role of Artificial Intelligence (AI), Virtual and Augmented Reality (VR/AR), and microlearning as dominant tools in modern education. These technologies are expected to foster more engaging, flexible, and personalized learning environments that cater to diverse student needs and learning styles. As a response to this shift, adaptive education emerges as a crucial framework, serving as the foundation for developing digital literacy and life-long learning competencies. In line with this, the World Economic Forum (2020) emphasizes that the ability to learn independently and adapt to dynamic changes in the workforce will be among the most essential skills for future generations. Therefore, integrating adaptive systems into educational settings is not only relevant but also necessary for equipping students with future-ready skills. This paradigm shift calls for continuous innovation and collaboration across sectors to ensure educational practices remain inclusive, responsive, and sustainable in the face of rapid technological change.

Educational transformation must be supported by continuous innovation and responsive policies that align with technological advancements and the evolving needs of students. In the era of rapid digitalization, conventional educational methods are no longer sufficient to meet the demands of 21st-century learning. Therefore, adaptive education has emerged as a strategic approach to ensure learning remains relevant, inclusive, and future-oriented. By integrating technology, personalization, and flexibility, adaptive education enhances not only the quality of learning but also promotes lifelong learning habits. Moreover, it prepares students to become resilient, innovative, and globally competitive individuals who can effectively navigate complex future challenges. To achieve this, all stakeholders policymakers, educators, and developers must collaborate in creating a sustainable and forward-looking educational ecosystem.

Table 1. Summary of Results and Discussion on Adaptive Education

Aspect	Key Points
Adaptive Education Overview	Adaptive education responds to rapid social and technological changes by offering personalized learning through AI and data analytics (Krechetov & Romanenko, 2020). It promotes interactivity, student engagement, and learning effectiveness.
21st-Century Skills	Supports the development of 4C skills (critical thinking, collaboration, creativity, communication) and enhances digital literacy for future readiness.
Positive Impacts	Increases motivation, autonomy, and academic performance through real-time feedback and personalized content (Johnson et al., 2022; Smith & Lee, 2023).

Educational Equity	Helps reduce achievement gaps by offering inclusive learning opportunities regardless of socioeconomic background (Garcia & Thompson, 2022).
Implementation in Indonesia	Challenges include unequal access to technology and low teacher readiness. However, platforms like Ruangguru and Zenius show promise (Christanti et al., 2024).
Teacher Readiness	Many teachers lack digital competence and adaptive pedagogy; insufficient training worsens the issue.
Infrastructure Gap	Technological disparity, especially in rural areas, limits access to adaptive education solutions (Christanti et al., 2024).
Data Privacy	Ethical concerns over student data usage require robust protection policies (Er-Rafyg et al., 2024).
Solution: Teacher Development	Provide continuous training and mentoring to enhance teacher competence in using adaptive technologies.
Solution: Infrastructure Access	Increase investment in educational technology and collaborate across sectors to ensure equitable access.
Solution: Data Governance	Establish data protection policies to ensure ethical and secure use of digital learning tools (Er-Rafyg et al., 2024).
Solution: Stakeholder Synergy	Foster collaboration among teachers, developers, and policymakers to co-create sustainable adaptive education ecosystems.

Conclusion

Based on the results of the research that has been carried out, it can be concluded that adaptive education represents a strategic and highly relevant learning paradigm in the current era of rapid change and digitalization. Through the integration of artificial intelligence (AI) and big data, it enables the customization of teaching and learning processes to match each student's individual needs, pace, and characteristics. This personalized approach enhances both the effectiveness of instruction and student motivation, fostering deeper engagement with learning materials. Moreover, empirical research indicates that students involved in adaptive learning systems often demonstrate improved academic performance compared to those in traditional learning environments. These findings underscore the transformative potential of adaptive education in shaping future-oriented and inclusive educational models.

The transformation toward adaptive education is a crucial response to the rapidly evolving demands of the 21st century. This educational model emphasizes personalization and responsiveness, aiming to align learning experiences with students' needs, contexts, and abilities. However, several challenges hinder its optimal implementation, particularly the readiness of teachers, unequal infrastructure, and data privacy concerns. Teacher competence in utilizing technology remains a primary concern, as insufficient training may reduce the effectiveness of digital learning tools. Moreover, disparities in infrastructure between urban and rural areas continue to limit equitable access to quality education.

In addition, the increasing reliance on technology in education raises significant concerns regarding the protection of student data. Without proper security measures and clear regulations, student privacy may be at risk, which can undermine trust in digital platforms. Despite these challenges, adaptive education offers promising benefits for reducing educational inequalities and equipping students with essential 21st-century competencies. Skills such as critical thinking, collaboration, and digital literacy are central to this educational approach. Therefore, efforts to strengthen teacher training, bridge the

digital divide, and ensure data security are essential for the inclusive and sustainable advancement of adaptive education.

Recommendations

Based on the findings and analysis, several strategic recommendations can be implemented to support the advancement of adaptive education in Indonesia. First, strengthening technology infrastructure across all regions especially in remote and underserved areas must be prioritized, with investments directed toward stable internet access and digital devices to ensure equal learning opportunities. Second, teacher training and mentoring should become a central focus, emphasizing continuous, practice-based programs that empower educators to effectively integrate adaptive technologies in their teaching. Third, strict enforcement of data protection policies is crucial, requiring the government to establish clear regulations on the ethical use and security of student data within educational settings. Fourth, the development of flexible and modular curricula needs to be accelerated, allowing instruction to adapt to individual learning styles and encouraging lifelong learning habits. Finally, advanced research tailored to the local context is essential to refine adaptive education models, incorporating case studies and evaluations to assess their effectiveness. Through these measures, adaptive education in Indonesia can evolve into a transformative approach that fosters inclusivity, enhances student competencies in critical thinking and digital literacy, and prepares learners for the demands of an increasingly dynamic global landscape.

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