www.americanosp.com/index.php/AJBSP ISSN online: 3064-7568

American Journal of Business Science Philosophy

Roles of Artificial Intelligence in Promoting Education for Sustainable Development in Lower-Middle-Income ASEAN Economies

Masatoshi Hara

Business Breakthrough University, Tokyo, Japan.
Swiss School of Business and Management, Geneva, Switzerland.
ORCID: 0000-0002-5975-454X. Email: masaharatoshi@gmail.com

Paper type: Article

Received: 28 September 2024
Revised: 21 October 2024
Accepted: 13 December 2024
Published: 30 December 2024

Citation: Hara, M. (2024). Roles of Artificial Intelligence in Promoting Education for Sustainable Development in Lower-Middle-Income ASEAN Economies. *American Journal of Business Science Philosophy*, 1(2), 86-103. https://doi.org/10.70122/ajbsp.v1i2.15

Abstract

This study examines the role of artificial intelligence (AI) in promoting Education for Sustainable Development (ESD) in lower-middle-income ASEAN economies, focusing on two critical areas: the challenges to AI adoption and strategies to optimize AI alignment with sustainable development goals. The research identifies key barriers to AI integration, including technological readiness, financial constraints, policy gaps, and socio-cultural factors, through document analysis and case studies. It highlights region-specific challenges, such as inadequate digital infrastructure and limited teacher training, that hinder AI adoption in education. Additionally, the study explores how AI can be optimized to support Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 9 (Innovation and Infrastructure), by enhancing educational access, promoting gender equality, and enabling personalized learning. Using the Grounded Theory model, the findings suggest that AI can reduce inequalities and empower underserved communities by improving educational outcomes. However, successful AI integration requires a balanced approach that prioritizes ethical considerations and inclusivity. The study advocates for collaborative efforts between governments, educational institutions, and technology providers to establish an ecosystem that supports responsible AI deployment. By addressing these challenges and leveraging AI's potential, stakeholders can unlock new opportunities to foster sustainable development and improve educational outcomes in ASEAN lower-middle-income economies.

Keywords: artificial intelligence; education; sustainable development; ASEAN

1. Introduction

Since the early 2020s, Education for Sustainable Development (ESD) has gained widespread recognition as a vital approach to tackling global challenges (UNESCO, 2023a), particularly in lower-middle-income economies (LMIEs) within the Association of Southeast Asian Nations (ASEAN). These LMIEs face the challenge of implementing ESD in environments characterized by limited resources, financial constraints, and inadequate educational infrastructure, which significantly hinder efforts to achieve sustainable and inclusive growth (Hara, 2023). ESD aims to equip learners with the knowledge, skills, and values necessary for promoting sustainability, emphasizing key issues such as climate change, biodiversity, energy efficiency, and sustainable livelihoods (Tilbury, 2011). However, the lack of adequate resources has constrained the scalability and effectiveness of sustainable educational models, underscoring the urgent need for innovative solutions to address these gaps and enhance the accessibility and impact of ESD (Jabareen, 2012; Mair & Druckman, 2023). In light of these challenges, the integration of Artificial Intelligence (AI) presents a promising avenue for advancing ESD in ways that are both adaptive and resource-efficient (UNESCO, 2021a). By leveraging AI technologies, educational systems in ASEAN LMIEs could potentially overcome traditional barriers to ESD,

including limited access to quality educational resources, insufficient teacher training, and the need for personalized learning and real-time data analysis to inform decision-making (Stefanic, 2022). AI-driven learning platforms, for instance, could provide students in remote or underserved regions with interactive, customized educational content that aligns with local contexts and environmental priorities (Pedro, 2019). Furthermore, AI tools can assist teachers in delivering complex sustainability topics more effectively, while offering precise tracking of learning outcomes and identifying areas for improvement beyond what conventional methods can achieve (EC, 2024; Nyhan, 2024).

Despite these potential benefits, adopting AI within ESD frameworks poses several challenges. LMIEs in ASEAN may face obstacles such as inadequate digital infrastructure, limited technical expertise, high implementation costs, and ethical concerns related to data privacy and digital literacy gaps (Hara and Hashi, 2023). Moreover, aligning AI applications in education with the Sustainable Development Goals (SDGs) require careful consideration of local contexts, including cultural, socio-economic, and policy factors (Ally and Perris, 2022). The success of AI-enhanced ESD initiatives in these economies will depend on strategic planning, supportive policy environments, and strong partnerships among governments, educational institutions, and technology providers (ASEAN Secretariat, 2023).

This study aims to explore the challenges and constraints in adopting AI within ESD frameworks in lower-middle-income ASEAN countries. It will also investigate strategies to optimize AI integration, ensuring alignment with sustainable development goals. The ultimate objective is to provide actionable insights that can drive both educational and environmental progress in these regions. By focusing on AI's potential to enhance ESD, this research seeks to contribute to a deeper understanding of how emerging technologies can support sustainable development in education, particularly within resource-constrained settings.

2. Literature Review

2.1. Education for Sustainable Development

Education for Sustainable Development (ESD) serves as a critical framework for cultivating skills and knowledge that promote sustainability, aligning with global objectives such as those outlined by the United Nations. ESD emphasizes not only academic development but also social and environmental responsibility, which is particularly significant in ASEAN economies where diverse socioeconomic challenges intersect with development goals. This review explores the definitions, frameworks, and objectives of ESD, drawing on key contributions from Kuroda and Yokozeki (2005), Salgür (2013), Patrinos (2016), Pandey (2022), and other relevant sources.

Kuroda and Yokozeki (2005) define ESD as an educational approach that integrates knowledge, skills, and attitudes for sustainable development. They argue that ESD should prioritize critical thinking, problem-solving, and decision-making to prepare learners for active participation in building sustainable societies. This comprehensive definition aligns with the ASEAN context, where such competencies are crucial in rapidly industrializing economies facing growing environmental concerns. Their work underscores the importance of embedding ESD throughout all levels of education, expanding its scope beyond environmental issues to encompass economic and social sustainability.

ESD frameworks provide a structured approach for implementing sustainability goals within educational systems. Salgür (2013) presents a multidimensional framework that includes cognitive, socio-emotional, and behavioral learning objectives, forming a holistic approach to ESD. Salgür highlights the necessity of fostering empathy, ethics, and global awareness alongside technical skills. This perspective is particularly relevant for ASEAN economies, where collective well-being and community values are deeply rooted in cultural norms. Salgür's framework suggests that ESD should encourage learners to think beyond individual achievements and consider the societal and environmental impact of their actions.

The goals of ESD, particularly in the ASEAN region, are further examined by Patrinos (2016), who contends that ESD should aim to reduce inequality and promote economic stability while advancing environmental sustainability. Patrinos emphasizes that ESD is not only about fostering a sustainable future but also about ensuring equitable educational opportunities tailored to the unique challenges of each nation. For ASEAN economies, ESD seeks to develop a resilient workforce capable of adapting to climate and economic shifts. Patrinos (2016) stress that effective ESD initiatives must be context-specific, addressing the distinct developmental needs of each ASEAN member, such as emphasizing agriculture in rural areas or advancing green technologies in urban centers.

Pandey (2022) delves into the regional disparities affecting ESD implementation within ASEAN. In resource-limited countries, ESD faces challenges such as insufficient funding and a lack of trained educators. Pandey highlights the importance of inclusive policies that support marginalized communities, ensuring ESD benefits all socioeconomic groups. For ASEAN nations, this requires aligning ESD goals with sustainable development policies and improving access to quality education, particularly in rural regions.

Additionally, resources like Geeks for Geeks (n.a.) offer practical insights into the digital and technological dimensions of ESD, emphasizing the role of online platforms in enhancing sustainability education. These tools democratize ESD by providing cost-effective methods for integrating sustainability topics into curricula, from interactive climate change modules to virtual collaboration tools that connect students across regions.
Overall, the literature emphasizes ESD's role in advancing sustainable development across ASEAN economies through a combination of cognitive skills, ethical awareness, and technological tools. While ESD frameworks and objectives may differ, they collectively aim to empower learners with the knowledge and values necessary for contributing to a sustainable future. However, achieving these goals requires targeted strategies to address regional disparities and strengthen the capacity for ESD within existing educational systems.

2.2. Artificial Intelligence in Education

Artificial Intelligence (AI) in education has garnered global attention, driven by innovations that enhance learning experiences, optimize educational outcomes, and expand access. Key advancements such as personalized learning systems, virtual classrooms, and data-driven insights have significantly transformed traditional educational models, as highlighted by Korwatanasakul, Nguyen, and Seth (2022) and Pandey (2022).

Personalized learning, a core application of AI, leverages algorithms to customize content and pace according to individual student needs, thereby improving engagement and retention. Korwatanasakul, Nguyen, and Seth (2022) highlight the effectiveness of personalized learning tools in accommodating diverse learning styles, particularly among students with varying cognitive abilities. These tools use machine learning models to continuously refine content based on real-time data about students' progress, preferences, and challenges, addressing gaps in knowledge more efficiently than conventional approaches. This approach also encompasses intelligent tutoring systems, which have demonstrated considerable success in improving students' understanding of complex topics by providing real-time feedback and adaptable lesson plans.

In the domain of virtual classrooms, AI-powered platforms have been pivotal in enhancing remote learning, particularly during global crises like the COVID-19 pandemic. Korwatanasakul, Nguyen, and Seth (2022) explore how AI-supported virtual classrooms offer interactive and immersive experiences through technologies like natural language processing (NLP) and virtual reality (VR). These platforms simulate physical classroom interactions, facilitating real-time discussions, digital whiteboards, and group activities, enabling active participation from geographically dispersed students. Moreover, virtual classrooms generate valuable data on student engagement and interaction, which can be analyzed to improve teaching methods. AI-driven tools within these environments assist educators in identifying engagement patterns, allowing them to adjust their instructional strategies to better support student needs.

Another critical application of AI in education lies in data-driven insights, which empower educators and institutions to make informed decisions based on performance metrics, attendance, and behavioral trends. According to Korwatanasakul, Nguyen, and Seth (2022), AI analytics tools convert raw data into actionable insights, enabling targeted interventions for struggling students, optimizing resource allocation, and refining curricula. Predictive analytics tools, in particular, can identify students at risk of academic decline, facilitating early intervention and support. This proactive strategy is especially beneficial in higher education, where institutions often manage large and diverse student populations.

Pandey (2022) emphasizes AI's role in democratizing education by addressing regional disparities and improving access to quality education in underserved areas. Adaptive assessment tools and AI-driven tutoring systems accessible via mobile devices provide personalized learning opportunities for students who lack traditional educational resources. Pandey notes that AI applications optimized for low-bandwidth environments have enhanced learning in remote and under-resourced communities, supporting Sustainable Development Goals aimed at promoting inclusive and equitable quality education.

Despite these advancements, integrating AI into education presents several challenges. Concerns about data privacy, ethical considerations, and potential biases in AI algorithms are significant issues requiring ongoing attention. Furthermore, the growing reliance on AI raises questions about the evolving role of human educators and the necessity for regulatory frameworks to ensure responsible and effective AI usage.

Overall, the literature indicates that AI-driven innovations, such as personalized learning, virtual classrooms, and data-driven insights, hold substantial potential to transform education globally. However, achieving this potential requires addressing technical, ethical, and policy challenges to ensure these technologies enhance educational systems equitably and sustainably.

2.3. Challenges in Lower-Middle-Income ASEAN Economies

Gill and Kharas (2007) categorized global economies into high, middle, and low-income groups, introducing the Middle-Income Trap (MIT) concept. This framework describes the difficulty countries face in transitioning from low and middle-income stages to higher levels of economic prosperity. Southeast Asian nations such as Vietnam, Indonesia, and the Philippines have struggled to break out of the lower-middle-income category for over two decades. Since 1987, several countries in the region have advanced from low-income to at least lower-middle-income status. Notably, China reached higher-middle-income status by 2010, maintaining growth rates exceeding 10% for 15 consecutive years. Similarly, Malaysia and Thailand achieved higher-middle-income status in 1992 and 2010, respectively. By 2021, significant progress had been made across Southeast Asia, with numerous countries attaining LMIE and HMIE status.

Tran (2016) proposed a developmental framework that divides economies into four income groups: low, lower-middle, higher-middle, and high-income. To break free from the MIT, Tran identified two specific syndromes—the Lower-Middle-Income Trap (LMIT) and the Higher-Middle-Income Trap (HMIT). He recommended strategies such as institutional strengthening and increased capital investment to escape LMIT, while emphasizing the importance of total factor productivity (TFP) growth and human resource development to overcome HMIT (Tran & Karikomi, 2019). The Asian Development Bank (ADB, 2017) highlighted several factors contributing to MIT, including unfavorable demographics, limited economic diversification, inefficient financial markets, inadequate infrastructure, weak innovation, poor institutions, and an underdeveloped labor market. In contrast, the prerequisites for economic advancement include robust infrastructure, industrialization, efficient financial systems, a strong labor market, governance improvements, social welfare programs, and sound political institutions (ADB, 2017; Allen, 2012; Otsuka, 2020). Researchers underscore industrialization's pivotal role in helping Southeast Asian countries overcome MIT.

The implementation of AI in education within Lower-Middle-Income Economies (LMIEs) encounters substantial challenges. A primary barrier is infrastructure inadequacy, where unreliable electricity, limited internet access, and outdated technological equipment hinder the effective deployment of digital tools, which

depend on stable connectivity and modern hardware (ADB, 2017; Allen, 2011; Otsuka, 2020). Another critical issue is teacher readiness. Many educators lack the specialized training needed to incorporate AI into their teaching practices, with resistance to adopting new technologies further slowing progress (UNICEF, 2023). Economic constraints exacerbate these challenges, as limited financial resources hinder government investments in AI tools, infrastructure, and teacher training. Competing priorities, such as improving basic literacy and numeracy, often take precedence (Hara, 2023). Additionally, LMIEs face innovation constraints, relying heavily on imported technologies instead of developing AI solutions tailored to their specific educational needs. A shortage of skilled professionals in AI development and limited funding for research further impedes progress (UNICEF, 2023). Addressing these issues will require significant investments in infrastructure, teacher training, and local innovation, alongside broader economic reforms, to enable AI to improve educational outcomes in LMIEs.

2.4. AI and Education for Sustainable Development

The convergence of Artificial Intelligence (AI) and Sustainable Development Goals (SDGs) is garnering increased attention as countries leverage technology to address multifaceted global challenges. Among the 17 SDGs, AI demonstrates significant transformative potential in advancing SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure). These goals align with AI's capacity to expand educational access and drive innovation in industrial and infrastructural sectors.

AI has the potential to revolutionize educational delivery, particularly in developing regions where conventional resources are scarce. Research shows that AI-driven tools, such as personalized learning platforms, intelligent tutoring systems, and automated grading technologies, enhance learning outcomes by adapting educational content to the individual needs and pace of students (Zawacki-Richter et al., 2019). These tools provide adaptive learning experiences that are otherwise unattainable, especially for underserved communities. Additionally, AI supports inclusive education by offering accessible learning models tailored to students with disabilities, a critical component of SDG 4, which advocates for equitable access to quality education for all (UNESCO, 2021a).

Beyond individual learning enhancements, AI contributes to resource optimization within educational institutions. Data-driven insights into student performance allow educators to pinpoint areas requiring intervention, facilitating targeted improvements in educational quality. Furthermore, AI enables remote learning, reducing geographical and economic barriers to education, particularly in low-income countries with underdeveloped infrastructure (UNESCO, 2023b). However, despite these advantages, significant challenges persist, including concerns over data privacy, algorithmic bias, and reliance on digital infrastructure in resource-constrained environments. Effectively addressing these challenges requires the ethical and sustainable integration of AI in educational systems.

Overall, literature underscores AI's considerable potential to advance SDGs 4 and 9 by improving educational access, fostering industrial innovation, and strengthening infrastructure resilience. However, realizing this potential hinge on overcoming barriers related to data security, digital infrastructure, and equitable access. Bridging these gaps will require collaborative efforts among governments, educational institutions, and industries to ensure that AI technologies advance SDGs in an inclusive and ethical manner. Further research should focus on the impact of AI adoption in lower-income regions, aiming to develop strategies that address these barriers and promote sustainable development through technological innovation.

2.5. Research Gap and Questions

Firstly, while there are studies on AI applications in education globally, there is a gap in comprehensive research specifically addressing the challenges and limitations unique to lower-middle-income ASEAN economies. Issues such as infrastructure deficits, technological readiness, policy gaps, and socio-economic factors in these economies require more focused investigation. This study aims to fill this gap by providing region-specific insights. Secondly, while AI's potential to enhance educational outcomes is well-documented,

there is insufficient research on how AI can be tailored and optimized to meet the sustainable development goals (particularly SDG 4 and SDG 9) in resource-constrained environments. This study seeks to address this gap by exploring practical strategies for aligning AI technologies with the specific educational and sustainability needs of ASEAN LMIEs. The study aims to investigate the challenges and limitations in the adoption of AI for ESD in lower-middle-income ASEAN economies and explore how AI technologies can be optimized to better align with sustainable development goals in education. The study research questions as follows. *RQ1: What challenges and limitations exist in the adoption of AI technologies for ESD in lower-middle-income ASEAN economies?* and *RQ2: How can AI be optimized to better align with sustainable development goals in education?*

3. Frameworks

3.1. Challenges and Limitations in AI Adoption for Education for Sustainable Development (ESD)

This framework addresses RQ1: What challenges and limitations exist in the adoption of AI technologies for ESD in lower-middle-income ASEAN economies? The adoption of AI for Education for Sustainable Development (ESD) in lower-middle-income ASEAN economies (LMIEs) is hindered by significant socio-economic and technological barriers, impacting its effectiveness in promoting sustainable educational goals. Here can be the challenges and barriers in adapting the AI technologies for ESD in the ASEAN LIMEs, referring to some literature items. Figure 1 below is a graphical framework based on the five most significant components that I conceptually designed above.

Figure 1. Challenges and limitations in AI adoption for education for ESD in ASEAN LMIEs.

Firstly, inadequate technological infrastructure and accessibility challenges, particularly in rural regions, contribute to a digital divide that hinders AI adoption. As UNESCO (2021b) notes, limited access to the internet, digital devices, and technical resources restricts the benefits of AI to urban centers, thereby exacerbating educational disparities (Arntz et al., 2021). Secondly, financial constraints present another significant obstacle, as implementing AI requires considerable investment in technology and training. FAO (1990) points out that developing countries often face severe budget limitations and rely heavily on short-term foreign aid. To address this, sustainable funding models, such as public-private partnerships, are necessary to support the long-term deployment of AI initiatives (ADB, 2023). Thirdly, the establishment of a supportive and comprehensive policy framework is crucial. Roger (2023) underscores that the ASEAN Qualifications

Reference Framework is undergoing revisions to incorporate digital transformation elements, including MOOCs, micro-credentials, AI policies, and streamlined approval processes. These updates aim to align ASEAN's framework with other regional systems like the EU's, fostering policy harmonization and building trust among stakeholders, which is vital for widespread AI adoption.

Fourthly, socio-cultural factors also influence AI uptake, as educators may resist change or lack familiarity with digital tools (Tilbury, 2011). Localizing AI applications by adapting them to native languages and cultural contexts can enhance acceptance, as noted by Richter (2024). Finally, limited digital literacy among both educators and students impedes the effective utilization of AI. UNESCO (2018), Korwatanasakul, Nguyen, and Seth (2022), and Pandey (2022) emphasize the importance of capacity-building programs to equip teachers with the skills needed to integrate AI effectively. Such initiatives can amplify the impact of AI and improve educational outcomes. Addressing these challenges through infrastructure development, sustainable funding, regulatory harmonization, cultural adaptation, and capacity-building is essential for maximizing AI's potential in advancing ESD within ASEAN LMIEs.

3.2. Optimizing AI for Sustainable Development Goals in Education

This framework addresses RQ2: How can AI be optimized to better align with sustainable development goals in education? The primary objective of the framework is to explore how AI can be effectively leveraged to advance educational outcomes that align with SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure). Then, with the following five components that can be indispensable for realizing the ESD, Figure 2 below is a graphical framework based on several critical elements that I depicted below.

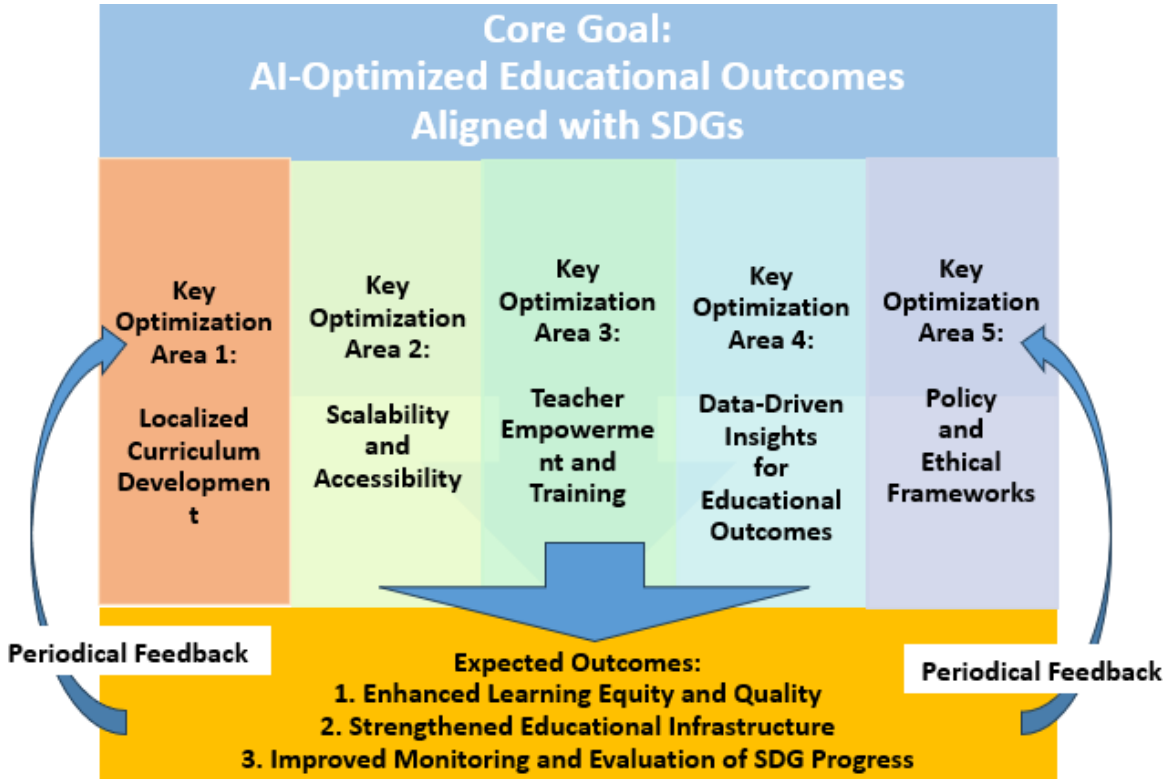

Figure 2. Optimizing AI for sustainable development goals in education.

Firstly, optimizing AI to align with Sustainable Development Goals in education, particularly in lower-middle-income ASEAN economies, requires tailoring AI-driven tools to local contexts to foster inclusive educational experiences. UNESCO (2021a) emphasizes that inclusive systems must accommodate cultural diversity, addressing the needs of students from various backgrounds. By customizing AI tools to reflect linguistic and cultural nuances, accessibility improves, particularly in ASEAN countries characterized by significant diversity. This approach prioritizes educational equity, creating more effective learning environments.

Similarly, Sharma (2024) argues that localized AI technologies enable teachers to better meet students' individual needs, promoting inclusivity in education.

Secondly, ensuring widespread accessibility and scalability of AI applications in education necessitates robust digital infrastructure and affordable access to technology. Bera et al. (2023) highlight that while scalable AI solutions have transformative potential, infrastructure gaps in ASEAN limit their impact. Expanding access to affordable digital technologies in underserved regions is crucial to bridging this divide. UNICEF (2023) notes that scalable AI tools can particularly benefit marginalized communities, advancing SDG targets for equitable and inclusive education outcomes.

Thirdly, empowering teachers as key facilitators of AI in classrooms is essential through skill development and ongoing training. Fitria (2021) underscores that AI supports teachers by enabling personalized instruction and improving resource management, thereby enhancing educational quality. Moreover, teacher training in AI is vital to ensure educators can effectively utilize these tools, directly contributing to sustainable education goals and enriching learning environments, as emphasized by EC (2024) and Nyhan (2024).

Fourthly, AI's data-processing capabilities offer valuable, data-driven insights that help educators and policymakers refine their strategies. Stefanic (n.a.) asserts that AI can revolutionize educational impact assessments by providing real-time, actionable insights for continuous improvement. Similarly, Nedungadi, Tang, and Raman (2024) explain that data collected through AI reveals trends and progress, enabling educational initiatives to remain aligned with SDG 4's objectives for quality and equitable education.

Finally, implementing comprehensive policy and ethical frameworks is critical for ensuring the responsible use of AI in education. The ASEAN Secretariat (2023) provides policy recommendations that prioritize privacy, equitable access, and ethical standards for AI deployment across ASEAN countries. Tilbury (2011) adds that sustainable educational practices depend on clear ethical guidelines, including policies addressing data security, fairness, and accessibility. Such frameworks are essential to leveraging AI in ways that support both SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure).

4. Methodology

4.1. Methodology for Research Question 1

4.1.1. Research Design

For research question (RQ1), a qualitative research design was adopted, focusing on case study analysis and document analysis. This approach aligns with the research objective of understanding how AI technologies can be optimized to support Sustainable Development Goals (SDGs) in education, particularly SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure). The case study method allows for an in-depth exploration of AI applications in educational settings, while document analysis provides critical insights into policy, strategies, and existing frameworks. This combination enhances the contextual understanding of the challenges and opportunities faced by ASEAN LMIEs in applying AI for sustainable education development.

4.1.2. Data Collection

Document Analysis: In line with the methodologies proposed by Bowen (2009), Hussain, Bhuiyan, and Baker (2014), and Dalglish, Khalid, and McMahon (2020), document analysis was conducted to review official reports, policy documents, and research articles. These documents, produced by ASEAN governments and educational institutions, provide valuable insights into the local context, government priorities, and barriers faced in AI integration for Education for Sustainable Development (ESD). Specific attention was given to reports from ministries of education and technology, highlighting issues such as infrastructure deficiencies, policy misalignment, and skill gaps in countries such as Cambodia, Myanmar, Vietnam, the Philippines, and

Lao PDR. The documents chosen were published within the last five years to ensure relevancy and reflect recent developments.

Secondary Data: Data was also sourced from international organizations such as UNESCO, the World Bank, and the ASEAN Secretariat. These documents offered a comparative perspective on AI adoption challenges in education within lower-middle-income economies, with a focus on financial limitations, regulatory challenges, and regional trends. Additionally, quantitative data from reputable sources such as the World Bank's Education Statistics and UNESCO's Institute for Statistics were used to triangulate the qualitative findings, providing a comprehensive view of the barriers to AI integration.

4.1.3. Sampling

Purposive sampling was employed to target ASEAN countries classified as lower-middle-income economies by the World Bank, specifically Cambodia, Vietnam, Myanmar, the Philippines, and Lao PDR. These countries were selected due to their diversity in economic development, infrastructure, and AI readiness, making them ideal candidates for studying AI adoption in education. The sampling was also designed to ensure that documents from a variety of educational levels, policy types, and regions within each country were included. The sample size aimed for theoretical saturation, with a minimum of 12 cases considered, as suggested by Boddy (2016). The final sample included more than 12 cases to ensure data variation in geographical context and AI application focus.

4.1.4. Data-Analysis

Data analysis followed the Grounded Theory (GT) methodology, which is suited for exploring social phenomena and theory generation directly from empirical data. GT's inductive approach, where data collection and analysis occur in an iterative cycle, was critical in identifying patterns of challenges and strategies in AI adoption. The analysis began with initial coding, followed by the development of thematic categories. The major themes anticipated include: Adoption Challenges, such as inadequate infrastructure and resistance to technology. Limitations in Utilization, focusing on budget constraints and policy gaps. The use of ATLAS.ti (Version 24) facilitated the process of coding and categorizing data, enabling a systematic approach to data reduction and theme refinement. These themes helped build a comprehensive framework outlining the barriers to AI adoption for ESD in ASEAN LMIEs.

4.2. Methodology for Research Question 2

4.2.1. Research Design

For research question (RQ2), a similar qualitative research design was adopted, again utilizing case study analysis and document analysis to explore AI optimization for SDGs in education. Case studies of AI-driven educational projects will offer detailed insights into the strategies employed, the barriers faced, and the outcomes achieved. Document analysis will provide the necessary background context, strategic approaches, and best practices for AI integration in education to achieve SDGs, especially SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure).

4.2.2. Data Collection

Case Studies: Five to six case studies were selected to represent a range of AI-driven educational projects from ASEAN LMIEs and other comparable regions. These cases were chosen based on their relevance to SDG goals, innovation in AI applications, and measurable outcomes in enhancing educational quality and accessibility. Examples include AI solutions in rural schools, vocational training programs in Indonesia, and AI-driven sustainable curriculum models in other developing regions. Each case study is based on comprehensive data from project reports, academic literature, and evaluation studies, focusing on the alignment of the projects with sustainability goals and their measurable impact.

Document Analysis: In addition to case studies, document analysis was conducted on policy papers, research articles, and project reports from international organizations (e.g., UNESCO, UNICEF, World Bank) and local policy documents from ASEAN countries. The aim was to review strategies, frameworks, and lessons learned from AI applications that contribute to sustainable education development. This analysis provides an empirical foundation for understanding the best practices and challenges of AI adoption in the education sector across various contexts.

4.2.3. Sampling

A purposive sampling strategy was employed to select case studies from diverse AI applications in education, both from ASEAN LMIEs and comparable global contexts. The sampling aimed for theoretical saturation, ensuring the inclusion of a broad range of case studies that cover different geographical areas, project types, and AI applications. A minimum of 12 cases was considered to ensure a comprehensive analysis, focusing on key factors such as scalability, localized implementation, and partnerships.

4.2.4. Data-Analysis

The analysis used Grounded Theory to identify recurring themes, success factors, and barriers to optimizing AI for sustainable education. Coding focused on themes, including Scalability, Localized Implementation, Partnerships, and Alignment with Sustainability-Oriented Curricula. Comparative analysis was also performed to contrast successful and less effective implementations. By systematically categorizing data and refining themes, this analysis provides actionable insights for optimizing AI in education to support SDGs.

5. Results

5.1. RQ1

I analyzed 14 literature items for document analysis. The review covered the context-specific challenges surrounding AI adoption for Education for Sustainable Development (ESD) in lower-middle-income ASEAN economies, especially of Cambodia, Lao PDR, Myanmar, the Philippines, and Vietnam. Using ATLAS.ti 24, Figure 3 shows the results as follows: The study revealed several challenges and limitations associated with the adoption of AI technologies for Education for Sustainable Development (ESD) in lower-middle-income ASEAN economies, with a total of 14 mentions (Gr=192).

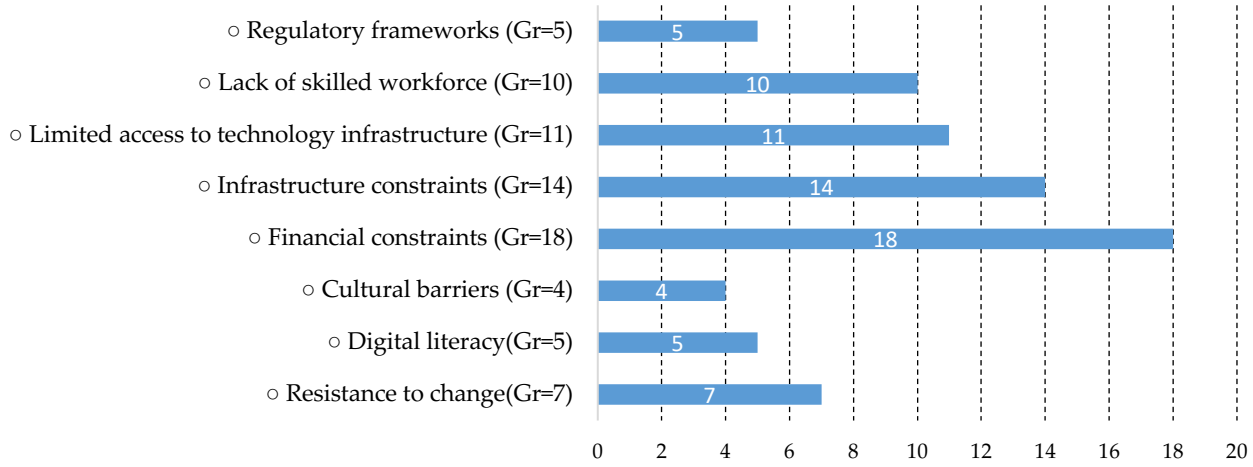

Figure 3. Study results output for RQ1.

Financial barriers (Gr=18) emerged as the most significant challenge, with insufficient budgets limiting the ability of governments and educational institutions to invest in AI technologies. This lack of funding hinders the procurement of essential hardware, software, and infrastructure required for AI integration. Additionally,

it restricts the development and implementation of training programs for educators and administrators, making it difficult to fully leverage the potential of AI in education.

A lack of reliable and adequate infrastructure (Gr=14), such as high-speed internet and modern digital devices, remains a critical hurdle. In rural and remote areas, these challenges are particularly pronounced, leaving many communities unable to access AI-powered educational tools and resources. This infrastructure gap perpetuates inequality and limits the scalability of AI initiatives in education. Unequal access to technology infrastructure (Gr=11) further deepens the digital divide. While urban areas may have better resources, rural communities often struggle with limited or no access to the necessary technological tools. This inequity makes it challenging to implement AI-driven educational solutions that require consistent connectivity and technological support. The shortage of skilled professionals (Gr=10) capable of developing, implementing, and maintaining AI technologies in the education sector poses a significant barrier. Educators, administrators, and technical staff often lack the expertise needed to utilize AI tools effectively, reducing the technology's impact and scalability.

Cultural and institutional resistance to AI adoption (Gr=7) reflects skepticism towards automation and modern assessment tools. Teachers and administrators may perceive AI as a threat to traditional teaching practices, leading to reluctance in embracing these technologies. This resistance is compounded by concerns about the reliability of AI in assessing student performance and delivering equitable outcomes. Weak or underdeveloped regulatory frameworks (Gr=5) create uncertainty about the safe and ethical use of AI in education. Inconsistent policies on data privacy, AI governance, and educational integration make it difficult for institutions to confidently implement AI solutions. These gaps also contribute to public distrust in AI technologies. Low levels of digital literacy (Gr=5) among both educators and students further hinder the adoption of AI. Teachers may struggle to integrate AI tools into their teaching methods, while students, particularly those in underserved areas, may lack the necessary skills to engage with AI-powered learning platforms. Finally, Cultural differences and traditional mindsets (Gr=4) act as barriers to the seamless adoption of AI in education. Language issues, skepticism towards foreign technologies, and concerns over cultural preservation complicate efforts to introduce AI solutions, especially in diverse and traditional societies of those in ASEAN countries.

The adoption of Artificial Intelligence (AI) in education is rapidly expanding, offering opportunities to personalize learning, support students with special needs, prevent dropouts, and improve educational outcomes. AI enhances teacher effectiveness, creates an inclusive learning environment, and provides individualized support. However, challenges such as resistance to AI assessments, technical hurdles, skills gaps, ethical concerns, and unequal access to technology persist. Southeast Asia faces additional issues, including limited policy coherence, inadequate ICT infrastructure, insufficient teacher training, and weak monitoring mechanisms. While countries like the Philippines, Cambodia, Vietnam, and Lao PDR are integrating AI into their education systems—demonstrating benefits like personalized learning, administrative automation, and content creation—they also confront barriers such as financial constraints, underdeveloped regulatory frameworks, and cultural resistance. Addressing these challenges requires holistic approaches, including targeted investments in infrastructure, capacity-building initiatives to upskill educators, and the development of consistent regulatory frameworks to foster trust. Thoughtful engagement with local stakeholders is crucial to overcoming cultural barriers and ensuring AI implementation aligns with societal values and achieves maximum impact.

5.2. RQ2

Similarly, I analyzed 14 more literature items for document analysis. The review covered the primary discussion of how AI technologies can be optimized to support Sustainable Development Goals (SDGs) in education, especially SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure). Using ATLAS.ti 24, Figure 4 shows the results as follows. The results reveal that "Access to Education" emerged as the most significant theme, with a total of 14 mentions (Gr=207). This indicates that AI can play a pivotal role in improving access to education, especially for underserved communities. "Gender Equality" (Gr=10) was

identified as another key area where AI applications can drive equitable educational opportunities by addressing systemic barriers and promoting inclusive policies. "Digital Transformation" (Gr=7) highlights AI's potential to modernize educational systems through advanced tools and technologies that foster interactive and engaging learning experiences. The theme of "Empowerment" (Gr=6) underscores AI's ability to support students and educators by enhancing their skills and capabilities. AI-driven "Personalized Learning" (Gr=5) was also emphasized, showcasing its capacity to adapt content to individual learning styles, thus improving student outcomes. Challenges such as ethical concerns and training needs were prominent, with "Ethical Use" (Gr=3), "Training" (Gr=3), and "Reducing Inequalities" (Gr=3) pointing to the necessity of responsible AI deployment. These results suggest the need for transparency, fairness, and inclusivity in AI integration, as well as targeted capacity-building programs for educators and stakeholders. "Automation" (Gr=2) and "Teacher Training" (Gr=2) were identified as areas where AI can streamline administrative tasks and enhance instructional delivery. Meanwhile, lesser-discussed themes like "Accountable Data Ecosystem" (Gr=1), "Curriculum Development" (Gr=1), and "Policy-Roundtable" (Gr=1) reflect emerging areas of focus that require attention for effective AI adoption in education.

Overall, the findings highlight the transformative potential of AI in advancing sustainable development goals in education. However, these benefits can only be realized through strategic investments in infrastructure, regulatory frameworks, capacity-building initiatives, and collaborative efforts to address challenges related to equity, ethics, and workforce disruptions.

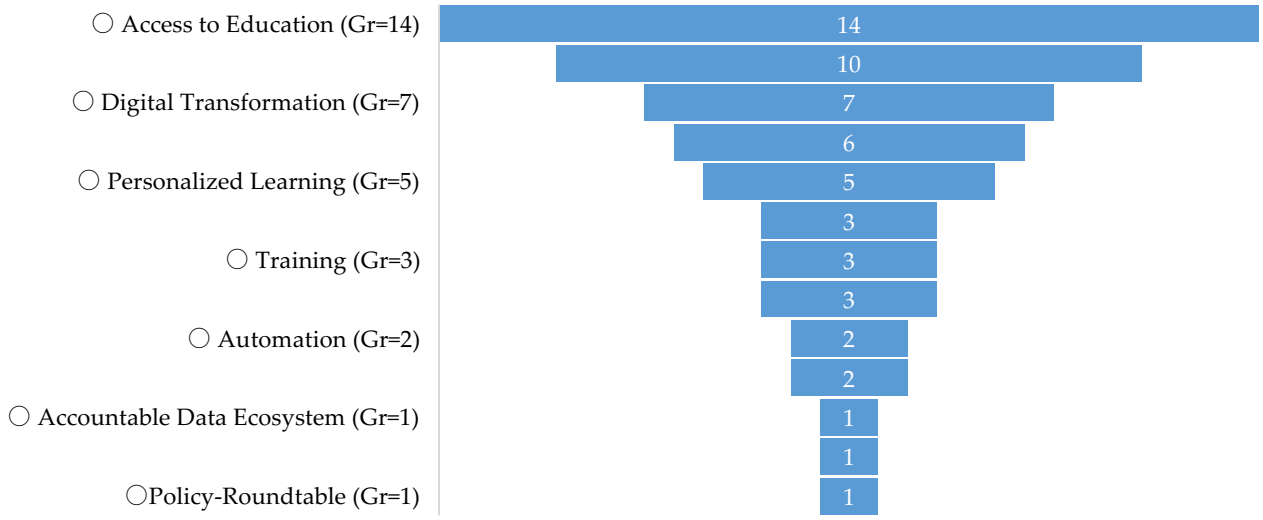

Figure 4. Study results output for RQ2.

6. Discussion

This study contributes to the understanding of AI's role in education and sustainable development in developing countries, particularly within the ASEAN context, offering a detailed analysis of both the barriers and potential strategies for using AI to enhance sustainable education systems, supporting long-term economic and social development. The findings of this study align closely with the proposed conceptual frameworks, demonstrating their applicability in analyzing the dynamics of AI integration in education for sustainable development. Key results highlight the role of AI in enhancing access to education, cited in 14 instances across the reviewed literature, and promoting gender equality, which emerged in 10 sources. These findings validate the theoretical foundations laid out in frameworks such as BOP strategies and Education for Sustainable Development (ESD), providing empirical support for their use in ASEAN middle-income economies. For instance, the ESD framework proved instrumental in exploring the relationship between AI-driven personalized learning, mentioned in five sources, and improved educational outcomes, suggesting that AI technologies can tailor content to individual needs, thereby enhancing learning efficiency. Similarly, AI's role in digital transformation, discussed in seven studies, highlights its potential to streamline administrative processes and make education more accessible, particularly in remote or under-resourced areas. However,

challenges related to ethical use and data privacy, which appeared in three sources each, underscore the need for careful implementation strategies.

This study makes several contributions to the growing body of research on AI's role in advancing sustainable development goals in education. First, it provides empirical evidence of AI's potential to enhance access to education and promote gender equality, particularly in the context of ASEAN middle-income economies. By highlighting the key areas where AI integration has been most effective—such as personalized learning and digital transformation—the study offers actionable insights for policymakers and educators aiming to leverage AI technologies in under-resourced regions. Second, the research emphasizes the importance of addressing ethical concerns, such as data privacy, bias, and fairness, in the deployment of AI systems. These findings reinforce the need for robust governance frameworks to ensure that AI implementations are inclusive and equitable. Furthermore, the study offers practical recommendations for overcoming common barriers, including capacity-building initiatives like teacher training and the development of an accountable data ecosystem.

Despite its contributions, this study has several limitations. The analysis primarily relies on secondary data from literature reviews, which may not fully capture the nuances of AI adoption in specific contexts. Additionally, while the findings are relevant to ASEAN middle-income economies, they may have limited generalizability to other regions with differing socio-economic and technological conditions. Future research could address these limitations by incorporating primary data collection, such as interviews or case studies, to provide deeper insights.

Finally, this study provides valuable insights into the role of AI in advancing Education for Sustainable Development (ESD) within lower-middle-income ASEAN economies. The practical implications of this research are multi-faceted and can guide policymakers, educational institutions, and technology providers in shaping the future of education systems in the region as follows.

1. Policy Development and Strategic Planning
   Governments in ASEAN countries can leverage the findings to design policies that foster the adoption of AI in education. Policymakers should prioritize investments in digital infrastructure, teacher training, and resource allocation to bridge the digital divide. Additionally, regulatory frameworks that ensure ethical AI usage and data privacy are essential for encouraging public trust and adoption.
2. Curriculum and Teacher Training
   Educational institutions should incorporate AI literacy into their curriculum to prepare both students and teachers for the opportunities and challenges presented by AI technologies. Professional development programs for educators, especially in underserved regions, should focus on enhancing digital skills and integrating AI tools to improve teaching practices and outcomes.
3. AI-Powered Learning Solutions
   The research underscores the potential of AI to create personalized learning experiences that cater to diverse student needs. Schools and universities should collaborate with technology providers to implement AI-driven platforms that support adaptive learning, improving both student engagement and performance. These platforms could also assist in overcoming language and resource barriers, particularly in rural or underdeveloped areas.
4. Gender Equality and Inclusivity
   AI technologies have the potential to reduce gender disparities in education by offering flexible and tailored learning experiences for female students in lower-middle-income ASEAN economies. Educational programs should promote the use of AI to ensure equal access to quality education, addressing societal gender biases and providing targeted support for marginalized groups.
5. Collaboration and Ecosystem Development
   Successful AI integration into education requires collaboration between governments, educational institutions, and private sector stakeholders. This study calls for the creation of a robust ecosystem to support AI initiatives, with clear roles for each actor. Partnerships with technology providers can help

ensure that AI tools are developed in a manner that is relevant and beneficial to local contexts, fostering sustainable development through collective effort.

6. Sustainable Development Goals (SDGs) Alignment
   The findings reinforce the alignment of AI with SDGs, particularly SDG 4 (Quality Education) and SDG 9 (Innovation and Infrastructure). By applying AI solutions, ASEAN nations can improve educational outcomes and create scalable models that support sustainable development. The study encourages further research into the broader impact of AI on achieving these global goals, offering opportunities for cross-sector collaboration.
7. Long-term Monitoring and Evaluation
   It is essential to establish systems for monitoring and evaluating the effectiveness of AI interventions in education. This study suggests the development of long-term assessment frameworks to track the impact of AI on student outcomes, educator performance, and overall educational quality. Continuous feedback loops will enable iterative improvements in AI tools and educational practices.

This research highlights the transformative potential of AI in addressing educational challenges and promoting sustainable development in lower-middle-income ASEAN economies. The practical insights provided here can serve as a roadmap for stakeholders aiming to optimize AI integration, ultimately contributing to more inclusive, equitable, and high-quality education systems across the region.

7. Conclusion

This study underscores the transformative potential of AI in advancing sustainable development goals in education. By enhancing access to education, fostering gender equality, and enabling personalized learning, AI technologies can play a pivotal role in reducing inequalities and empowering underserved communities. However, the successful integration of AI requires a balanced approach that prioritizes ethical considerations and promotes inclusive practices. The study calls for collaborative efforts among governments, educational institutions, and technology providers to establish a robust ecosystem that supports responsible AI deployment. By addressing existing challenges and leveraging AI's capabilities, stakeholders can unlock new opportunities to drive sustainable development and improve educational outcomes in ASEAN lower -middle-income economies.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data is available upon request from the authors.

Conflicts of Interest: The author declares no conflicts of interest.

References

Allen, R. C. (2011). *Global economic history: A very short introduction*. Oxford University Press.

Ally, M. and Perris, K. (2022). Artificial intelligence in the fourth industrial revolution to educate for sustainable development. *Canadian Journal of Learning and Technology*, 48(4), 1–20. Retrieved from https://files.eric.ed.gov/fulltext/EJ1374728.pdf

ASEAN Foundation. (2024). ASEAN Foundation and Microsoft launch AI TEACH for ASEAN programme to shape the region's tech future. Retrieved from https://www.aseanfoundation.org/asean_foundation_and_microsoft_launch_ai_teach_for_asean_programme_to_shape_the_region_s_tech_future

AseanWork. (2023). ASEAN's artificial intelligence challenge takes shape amid Southeast Asia's evolving digital landscape. Retrieved from https://www.aseanwonk.com/p/aseans-artificial-intelligence-challenge

Asian Development Bank. (2017). Escaping the middle-income trap: Innovate or perish. *ADBI Working Paper Series*, (685), 1–35. Retrieved from https://www.adb.org/sites/default/files/publication/231951/adbi-wp685.pdf

Baker, R. (2021). Artificial intelligence in education: Bringing it all together. In *OECD Digital Education Outlook 2021: Pushing the frontiers with artificial intelligence, blockchain and robots* (pp. 1–25). OECD Publishing. https://doi.org/10.1787/f54ea644-en

Bera, S., Yao, Y., Palit, A., and Rahut, D. B. (2023). Digital transformation for inclusive and sustainable development in Asia. *Asian Development Bank Institute*. Retrieved from https://www.adb.org/sites/default/files/publication/938186/digital-transformation-inclusive-and-sustainable-development-asia-final-rev2.pdf

Birchwood University. (2024). What are the opportunities and challenges for AI in education? Retrieved from https://www.birchwoodu.org/what-are-the-opportunities-and-challenges-for-ai-in-education/

Birks, M., and Mills, J. (2015). *Grounded theory: A practical guide*. Sage.

Boddy, C. R. (2016). Sample size for qualitative research. *Qualitative Market Research: An International Journal, 19*(4), 426–432. https://doi.org/10.1108/QMR-06-2016-0053

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9*(2), 27–40. https://doi.org/10.3316/QRJ0902027

Bringer, J. D., Johnston, L. H., and Brackenridge, C. H. (2016). Using computer-assisted qualitative data analysis software to develop a grounded theory project. *Field Methods, 18*(3), 245–266. https://doi.org/10.1177/1525822X06287602

Cambodia Investment Review. (2024). Spotlight: Can AI transform Cambodia's education system for a post-LDC era? Retrieved from https://cambodiainvestmentreview.com/2024/04/25/spotlight-can-ai-transform-cambodias-education-system-for-a-post-ldc-era/

Dalglish, S. L., Khalid, H., and McMahon, S. A. (2020). Document analysis in health policy research: The READ approach. *Health Policy and Planning, 35*(10), 1424–1431. https://doi.org/10.1093/heapol/czaa064

Dare, R. (2023). Valuing tradition and transformation: Envisioning a Myanmar approach to educational assessment in the age of AI. *Shan State Buddhist University International Conference for Assessment of Learning*. https://doi.org/10.5281/zenodo.10057158

Dharmaraj, S. (2024). Vietnam's vision for AI development: Policies and partnerships. *OpenGov Asia*. Retrieved from https://opengovasia.com/2024/11/16/vietnams-vision-for-ai-development-policies-and-partnerships/

Distor, C., Ruas, I. C., and Dhaou, S. B. (2024). Responsible artificial intelligence for sustainable development: Evidence from Asia-Pacific cities. *Tech Monitor*. Retrieved from https://apctt.org/sites/default/files/attachment/2024-08/06_Responsible_artificial_intelligence_for_sustainable_development.pdf

EngageMedia. (2021). Governance of artificial intelligence (AI) in Southeast Asia. Retrieved from https://engagemedia.org/wp-content/uploads/2023/06/Engage_Report-Governance-of-Artificial-Intelligence-AI-in-Southeast-Asia_06062023.pdf

Estrellado, C. J. (2023). Artificial intelligence in the Philippine educational context: Circumspection and future. *International Journal of Scientific and Research Publications, 13*(5). https://doi.org/10.29322/IJSRP.13.04.2023.p13704

European Commission. (2024). Preparing teacher education for a future with AI. *European School Education Platform*. Retrieved from https://school-education.ec.europa.eu/en/discover/news/preparing-teacher-education-future-ai

Fitria, T. N. (2021). Artificial intelligence (AI) in education: Using AI tools for teaching and learning process. *Prosiding Seminar Nasional & Call for Paper STIE AAS*, 134–147.

Food and Agriculture Organization of the United Nations. (1990). Constraints, alternatives, and strategies. *Watershed Management Field Manual: Watershed Survey and Planning*. Retrieved from https://www.fao.org/4/t0165e/t0165e10.htm

Francesc, P., Miguel, S., Axel, R., and Paula, V. (2019). Artificial intelligence in education: Challenges and opportunities for sustainable development. *Working Papers on Education Policy, 7*. UNESCO Publishing. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000366994

Geeks for Geeks. (n.d.). Role of education in economic development. Retrieved from https://www.geeksforgeeks.org/role-of-education-in-economic-development/

Gill, I., & Kharas, H. (2007). *An East Asian renaissance: Ideas for economic growth*. The World Bank.

Glaser, B. G. and Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Aldine Publishing.

Global New Light of Myanmar. (2024). AI technology assists Myanmar in various ways. Retrieved from https://www.gnlm.com.mm/ai-technology-assists-myanmar-in-various-ways/

Gosselink, B. H., et al. (2024). AI in action: Accelerating progress towards the sustainable development goals. *Google*. Retrieved from https://static.googleusercontent.com/media/publicpolicy.google/ja//resources/research-brief-ai-and-SDG.pdf

Hara, M. (2022). Educational factors predicting middle-income trap in Southeast Asia. *The Journal of East Asian Educational Research, 13*(5), 44–60. Institute of East Asian Education. Retrieved from https://www.ioeae.com/_files/ugd/7b35bc_d86462961787407ea9466b7846bd9fd6.pdf

Hara, M. (2023). Educational reform for middle-income trap under digitalization: Culprits, challenges, and strategies in the Philippines. *SocioEconomic Challenges, 7*(3), 200–218. https://doi.org/10.61093/sec.7(3).200-218.2023

Hara, M. (2024). Roles of artificial intelligence in education for sustainable development in Asia-Pacific contexts. *Global Journal of Business and Integral Security, 1*(2). Retrieved from https://www.gbis.ch/index.php/gbis/article/view/350

Hara, M. and Hashi, T. (2023). Digitalization for economic development in the ASEAN: Challenges and strategies. *European Economic Letters, 13*(4), 819–833. Retrieved from https://www.eelet.org.uk/index.php/journal/article/view/664

Higuchi, M. (2017). Methodological philosophy of CAQDAS and their functions: Difference between Atlas.ti 7 and Nvivo 11. *Annals of Human Sciences, 38*, 193–210. https://doi.org/10.18910/60474

Hussain, M. D., Bhuiyan, A. B., and Baker, R. (2014). Entrepreneurship development and poverty alleviation: An empirical review. *Journal of Asian Scientific Research*, 4(10), 558-573. Retrieved from https://archive.aessweb.com/index.php/5003/article/view/3681/5838

Jabareen, Y. (2012). Towards a sustainability education framework: Challenges, concepts, and strategies—The contribution from urban planning perspectives. *Sustainability*, 4(9), 2247-2269. https://doi.org/10.3390/su4092247

Korwatanasakul, U., Nguyen, D. D., and Seth, S. (2022). Artificial intelligence to unlock sustainable development potential in Southeast Asia. *Asia Pathways: The Blog of the Asian Development Bank Institute*. Retrieved from https://www.asiapathways-adbi.org/2022/02/artificial-intelligence-to-unlock-sustainable-development-potential-in-southeast-asia/

Kuroda, K. and Yokozeki, Y. (2005). *International education for development: Theory and practice*. Yuhikaku Publishing. (In Japanese)

Mair, S. and Druckman, A. (2023). Assessing the suitability of sustainability frameworks for embedding sustainability in higher education curricula: Pragmatism versus transformation. *International Journal of Sustainability in Higher Education*, 24(9), 318-334. https://doi.org/10.1108/IJSHE-08-2020-0315

Nedungadi, P., Tang, K. -Y., and Raman, R. (2024). The transformative power of generative artificial intelligence for achieving the sustainable development goal of quality education. *Sustainability*, 16(22), 9779. https://doi.org/10.3390/su16229779

Nyhan, M. (2024). The ethical application of generative artificial intelligence in supporting education for sustainable development globally. *Science-Policy Brief for the Multistakeholder Forum on Science, Technology and Innovation for the SDGs*, 1-4. Retrieved from https://sdgs.un.org/sites/default/files/2024-05/Nyhan;%20Marshall_The%20Ethical%20Application%20of%20Generative%20Artificial%20Intelligence%20in%20Supporting%20Education%20for%20Sustainable%20Development%20Globally.pdf

Organisation for Economic Co-operation and Development. (n.d.). *OECD future of education and skills 2030*. Retrieved from https://www.oecd.org/education/2030-project/

Organisation for Economic Co-operation and Development. (2018). *The future of education and skills education 2030* (1-23). Retrieved from https://www.oecd.org/education/2030/E2030%20Position%20Paper%20%2805.04.2018%29.pdf

Organisation for Economic Co-operation and Development. (2020). Trustworthy artificial intelligence (AI) in education: Promises and challenges. *OECD Education Working Paper Series*. Retrieved from https://www.oecd.org/content/dam/oecd/en/publications/reports/2020/04/trustworthy-artificial-intelligence-ai-in-education_f1a7c415/a6c90fa9-en.pdf

Organisation for Economic Co-operation and Development. (2024). The potential impact of artificial intelligence on equity and inclusion in education. *OECD Artificial Intelligence Papers*, No.23. OECD Publishing. Retrieved from https://www.oecd.org/content/dam/oecd/en/publications/reports/2024/08/the-potential-impact-of-artificial-intelligence-on-equity-and-inclusion-in-education_0d7e9e00/15df715b-en.pdf

Otsuka, K. and Kurosaki, T. (2003). *Education and economic development for poverty reduction in developing countries*. The Japan Economic Newspaper. (In Japanese)

Otsuka, K. (2020). Why do impoverished countries never disappear? Thinking about the right choice of development strategies. *The Japanese Economy Newspaper* (2nd ed.). (In Japanese)

Pandey, A. (2022). Education for sustainable development (ESD)—Asia Pacific perspective. *North American Association for Environmental Education*. Retrieved from https://eepro.naaee.org/community/blog/education-sustainable-development-esd-asia-pacific-perspective

Parami University. (2024). The Padauk classroom project: Empowering education in Myanmar through AI. Retrieved from https://www.parami.edu.mm/post/the-padauk-classroom-project-empowering-education-in-myanmar-through-ai

Patrinos, H. A. (2016). Why education matters for economic development. *Education for Global Development*. World Bank Blog. Retrieved from https://blogs.worldbank.org/education/why-education-matters-economic-development

Perkins, D. (2013). *East Asian development: Foundations and strategies*. The Edwin O. Reischauer Lectures.

Putra, B. A. (2024). Governing AI in Southeast Asia: ASEAN's way forward. *Frontiers in Artificial Intelligence*, 7, 1-6. https://doi.org/10.3389/frai.2024.1411838

Richter, F-J. (2024). Achieving the potential of AI across cultures. *Horasis*. Retrieved from https://horasis.org/achieving-the-potential-of-ai-across-cultures/

Roger, Y. C. (n.d.). Transforming the future of education through generative AI. *Digital Education Review*, 1-5. Retrieved from https://der.uni.lu/educational-technology/transforming-the-future-of-education-through-generative-ai

Salgür, S.A. (2013). The importance of education in economic growth. *Euromentor Journal*, 4(4), 50-57. Christian University Dimitrie Cantemir, Department of Education. https://www.proquest.com/docview/1496062418?sourcetype=Scholarly%20Journals

Sharma, S. (2024). Chapter 2: Fostering inclusive education: Harnessing AI in teacher training for digital equality. In *National Educational Policy-2020 for Incredible India* (pp. 20-36). Genic Books Publisher Pvt. Ltd.

Stefanic, D. (n.d.). Revolutionize feedback: AI-powered real-time learning insights. *Hyperspace*. Retrieved from https://hyperspace.mv/revolutionize-feedback-ai-powered-real-time-learning-insights/

Tran, V.T. (2016). *The new horizon of the ASEAN economies and Japan – The new development of each economy and area.* Bunshindo Publishing Corporation. (In Japanese)

Tran, V.T. and Karikomi, S. (2019). *Middle-income trap.* Keiso Shobou. (In Japanese)

United Nations Development Programme. (2024). AI for public good: Charting the path for an inclusive digital future in Viet Nam. Retrieved from https://www.undp.org/vietnam/blog/ai-public-good-charting-path-inclusive-digital-future-viet-nam

United Nations Educational, Scientific, and Cultural Organization. (n.d.). Transforming education and its systems in Asia-Pacific. Retrieved from https://apa.sdg4education2030.org/transforming-education-and-its-systems-asia-pacific

United Nations Educational, Scientific and Cultural Organization. (2019). *Artificial intelligence in education: Challenges and opportunities for sustainable development.* Working Papers on Education Policy 07. Retrieved from https://www.gcedclearinghouse.org/sites/default/files/resources/190175eng.pdf

United Nations Educational, Scientific and Cultural Organization. (2021a). *AI and education: Guidance for policymakers.* UNESCO Education Report. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000376709

United Nations Educational, Scientific and Cultural Organization. (2021b). *Reimagining our futures together: A new social contract for education.* Report from the International Commission on the Futures of Education. https://doi.org/10.54675/ASRB4722

United Nations Educational, Scientific, and Cultural Organization. (2023a). *Greening education for sustainable development in Southeast Asian countries.* Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000388289

United Nations Educational, Scientific, and Cultural Organization. (2023b). Background paper prepared for the 2023 Global Education Monitoring Report: Technology and education, Southeast Asia. https://doi.org/10.54676/LLQV6272

United Nations Educational, Scientific and Cultural Organization. (2023c). *Technology in education: A case study on Cambodia.* Background paper prepared for the 2023 Global Education Monitoring Report: Technology and education, Southeast Asia. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000387739

United Nations Educational, Scientific, and Cultural Organization. (2024). Launch of common framework to guide the digital transformation of education. Retrieved from https://www.unesco.org/en/articles/launch-common-framework-guide-digital-transformation-education

United Nations International Children's Emergency Fund. (2023). *UNICEF Regional Digital Learning and Transformation of Education Strategy for Europe and Central Asia.* Retrieved from https://www.unicef.org/eca/media/33221/file/Digital%20Learning%20and%20Transformation%20of%20Education%20Strategy.pdf

Vietnam Briefing. (2023). AI in Vietnam: Opportunities and challenges for foreign investors. Retrieved from https://www.vietnam-briefing.com/news/ai-in-vietnam-opportunities-and-challenges.html/

World Bank. (2007). *10 years after the crisis: Special focus: Sustainable development in East Asia's urban fringe.* East Asia and Pacific Update, 1-69. Retrieved from https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=50758b201535cdeb7200c71f03ae37e9e304b07e

World Bank. (2022). *Positioning the Lao PDR for a digital future: Priority measures to accelerate digital economy development.* Retrieved from https://thedocs.worldbank.org/en/doc/c01714a0bc2ca257bdfe8f3f75a64adc-0070062022/original/Positioning-The-Lao-PDR-for-a-Digital-Future-11-10-22.pdf

World Economic Forum. (2023). How AI can accelerate students' holistic development and make teaching more fulfilling. Retrieved from https://www.weforum.org/stories/2023/05/ai-accelerate-students-holistic-development-teaching-fulfilling/

World Economic Forum. (2024). *Shaping the future of learning: The role of AI in Education 4.0.* Retrieved from https://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Learning_2024.pdf

Yung, N. and Anna, D. (2023). *Technology in education: A case study on Lao People's Democratic Republic.* Background paper prepared for the 2023 Global Education Monitoring Report: Technology and Education, Southeast Asia. UNESCO Publishing. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000387741.locale=en

Zawacki-Richter, O., Marín, V. I., Bond, M., and Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – Where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), 39. https://doi.org/10.1186/s41239-019-0171-0