# “ROLES OF ARTIFICIAL INTELLIGENCE IN EDUCATION FOR SUSTAINABLE DEVELOPMENT IN ASIA-PACIFIC CONTEXTS”

*Research Paper*

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## “Abstract”

*This study explores the intersection of artificial intelligence (AI) and sustainable educational development in Asian contexts, proposing a framework to delineate the multifaceted roles of AI in fostering educational advancement. By embracing AI innovations while upholding principles of equity, inclusivity, and ethical governance, Asian nations can forge a more resilient and equitable educational landscape. The suggested framework encompasses inputs, outputs, and AI converters, prioritizing educational access and completion, particularly in low- and lower-middle-income countries, and emphasizing higher education expansion and research in higher-income nations. Outputs include enhanced employability, job creation, and productivity, whereas concerns revolve around overreliance on technology, bias, digital divide, and job displacement. Policy implications highlight the need for awareness campaigns, policy reforms, infrastructure investment, and partnerships to maximize AI benefits while mitigating potential challenges. However, the study’s conceptual framework lacks a specific methodology, warranting the development of robust research methods tailored to investigate AI’s roles in promoting education for sustainable development. This initial study serves as a foundation for future research endeavors in this burgeoning field.*

*Keywords: Artificial Intelligence, Education, Sustainable Development, Roles, Asia-Pacific*

## 1 Introduction

Since the early 2010s, Artificial intelligence (AI) has appeared as a formidable power with far-reaching effects across diverse fields, including the realm of education. Within the dynamic landscape of Asian contexts, where diverse cultures, economies, and educational systems intersect, the integration of AI presents unique opportunities and challenges in shaping sustainable educational development policies. The pivotal roles that AI plays in fostering sustainable educational advancement within the diverse tapestry of Asian-Pacific countries will be explored firs.

AI technologies offer innovative solutions to longstanding educational challenges, ranging from personalized learning experiences to efficient administrative management. For example, by leveraging AI-powered adaptive learning platforms, educational institutions can tailor instructional content to individual student needs, thus fostering enhanced engagement and comprehension (Lamba Solutions, 2023). Furthermore, AI-driven analytics enable educators to gain invaluable insights into student performance, facilitating data-informed decision-making to optimize teaching methodologies and curriculum development (Doque, 2023).

In the context of Asia-Pacific nations grappling with disparities in access to quality education, AI presents a promising avenue for bridging the gap. Through the proliferation of online learning platforms and AI-enabled educational resources, marginalized communities can gain equitable access to educational opportunities previously beyond their reach. Moreover, AI-powered language

translation tools facilitate multilingual instruction, breaking down language barriers, and fostering inclusivity within diverse educational settings (Lau, 2020; UNESCO, 2024).

However, the integration of AI into educational policy formulation necessitates a nuanced approach that addresses ethical considerations and safeguards against worsening existing inequalities. As Asian countries navigate the ethical implications of AI surveillance in educational settings and the potential for algorithmic bias, policymakers must prioritize the development of robust regulatory frameworks to ensure responsible AI deployment.

Furthermore, education for sustainable development (ESD) in the Asia-Pacific context demands a concerted effort to cultivate digital literacy and computational thinking skills among educators and students. By incorporating AI education into curricula and professional development programs, Asian nations can empower their citizens to navigate the complexities of the digital age and harness AI technologies for societal benefit. Still, Asia comprises nations with different socio-economic development status; high-income status economies, including Japan, South Korea, and Singapore, are expected to introduce AI functions to educational sites, while other middle-income Asian economies, especially in Southeast Asia and South Asia, do not have enough capital to introduce AI to education. UNESCO (2021) has launched “Education 2030” to promote sustainable education for development in developing countries. They argued that AI has the capability to tackle major hurdles in the education sector, revolutionize methods of teaching and learning, and drive advancements toward achieving Sustainable Development Goal 4. Nonetheless, the swift evolution of these technologies introduces numerous risks and obstacles that have thus far surpassed discussions on policies and frameworks for regulation (UNESCO, 2021). Though UNESCO (2021) provides advice to policymakers on how to effectively utilize the advantages and mitigate the challenges arising from the increasing intersection of AI and education, it needs to be further elaborated, especially in the context of Asian development. As well-recognized, particularly referred to as the "Asian Century," attention has been drawn not only to the densely populated countries of China and India but also to the development of the Southeast Asian region. In recent years, Southeast Asia has formed an economic community known as ASEAN, where the movement of capital, labor, and various services has been liberalized, and regional connectivity has significantly increased through infrastructure development. Through initiatives such as the ASEAN Economic Community (AEC), further economic development of the ASEAN region is anticipated (Hara, Karikomi & Hashi, 2023).

In this way, this study delves into the intersection of AI and sustainable educational development in Asian contexts, representing a dynamic frontier with immense potential to reshape the future of learning, presenting a suggested framework on the diverse roles of AI in cultivating educational development in Asia. By embracing AI-driven innovations while upholding principles of equity, inclusivity, and ethical governance, Asian nations can pave the way for a more equitable and resilient educational landscape capable of meeting the evolving needs of the 21st-century learner.

# 2 Review of the Literature and Identification of Study Gaps

Here summarizes the literature review and the identification of study gaps to be demonstrate.

## 2.1 Review of the literature

The literature review comprises “Roles of Artifical Intelligence (AI),” “Roles of Education in Sustainable Development,” “Education for Sustainable Development in Asia” and “Roles of AI in Educational Development in Asia” accordingly.

### 2.1.1 Roles of Artificial Intelligence

Artificial intelligence (AI) has emerged as a transformative force across various domains, revolutionizing decision-making processes, automating tasks, and enhancing personalization. This section delves into the multifaceted landscape of AI, examining its roles, advantages, disadvantages, and ethical considerations through previous studies. Through an analysis of symbolic AI, data-driven approaches, and decision support systems, I will explore the diverse applications of AI technologies.

While AI offers unparalleled efficiency, automation, and personalization, it also presents challenges such as bias, job displacement, and ethical dilemmas. By comprehensively understanding these nuances, stakeholders can navigate the evolving AI landscape responsibly and ethically.

AI stands at the forefront of technological innovation, promising to redefine how we interact with information, make decisions, and automate processes (EPRS, 2020a). From symbolic AI systems rooted in expert knowledge to data-driven algorithms inspired by neural networks, the spectrum of AI technologies continues to expand, presenting a myriad of opportunities and challenges. This section aims to dissect the complexities of AI, elucidating its roles, advantages, disadvantages, and ethical implications (EPRS, 2020b).

AI manifests through various paradigms, each serving distinct purposes in different contexts. Symbolic AI, exemplified by expert systems, employs rule-based procedures crafted by human experts to facilitate decision-making in specific environments. Conversely, data-driven AI harnesses algorithms, such as artificial neural networks (ANNs), to autonomously learn from data, mimicking cognitive processes akin to human brains. Decision Support Systems (DSS), bolstered by AI capabilities, furnish organizations with comprehensive insights, aiding in informed decision-making processes. Intelligent DSS (IDSS) epitomize the fusion of AI and data analytics, enabling organizations to extract actionable intelligence from vast datasets (TechTarget, 2021)

According to Madhugiri (2023), the advantages of AI are manifold, underpinning its widespread adoption across industries. AI confers unparalleled efficiency by swiftly processing vast volumes of data with precision. Automation, another hallmark of AI, streamlines workflows, enhancing productivity and mitigating human errors. Moreover, AI facilitates personalization by tailoring recommendations and services based on individual user preferences, thereby enriching user experiences and engagement (Madhugiri, 2023).

However, the proliferation of AI has certain drawbacks and challenges. Chief among these is the issue of bias, where AI systems may inadvertently perpetuate or intensify biases present in the data on which they are trained. Additionally, the automation facilitated by AI raises concerns regarding job displacement, as certain roles become redundant despite AI-driven efficiencies. Ethical considerations loom large over the AI landscape, encompassing issues of privacy, security, and the potential for misuse or manipulation of AI technologies (Madhugiri, 2023).

Overall, AI epitomizes both promise and peril, heralding unprecedented advancements while evoking profound ethical quandaries. By comprehensively understanding the roles, advantages, disadvantages, and ethical implications of AI, stakeholders can navigate this rapidly evolving landscape with foresight and responsibility. Embracing AI with a nuanced appreciation of its complexities is imperative for fostering a future where technology serves humanity ethically and equitably.

### 2.1.2 Roles of Education in Sustainable Development

Education plays a vital role in society, serving various functions that shape individuals and communities. Theoretical perspectives offer insights into the roles of education, highlighting both manifest and latent functions that contribute to socialization, social integration, and social placement (University of Minnesota, 2016; Robinson & Robinson, 2022). Education serves multifaceted roles in society, as depicted by theoretical perspectives and observed in educational practices. Understanding these roles is essential for shaping effective educational policies and practices that promote social cohesion, equality, and individual development.

On the other hand, beyond its societal and individual functions, education also plays a crucial role in driving economic development. Education plays a crucial role in economic development by enhancing people's access to knowledge, improving efficiency, and fostering the absorption of new technologies. It also increases labor mobility, raises awareness of potential opportunities, and contributes to the development of human capital. Investment in education is vital for a country's economic progress, as it enables individuals to be more productive, innovative, and adaptable to societal changes and scientific advancements (Salgür, 2013; Patrinos, 2016; GFG, 2024)

Patrinos (2016) and GFG (2024) also pointed out that the relationship between education and economic growth is significant, with education considered human capital due to its essential role in driving economic growth. Educational investments create opportunities for national economic development by equipping individuals with the skills and knowledge necessary for innovation and technological advancement. Education not only enhances individual capabilities but also contributes to societal welfare by promoting democracy, public order, and social cohesion (Patrinos, 2016). Further, Hara (2022a) developed a theoretical framework depicting the relationship between education level and economic development stage in his work, which was primarily applied by Tran's (2016)model. This theoretical framework can help clarify the relationship between education and economic development. It comprises key elements such as income stages and educational attainment levels required for advancement, particularly in developing nations. This framework facilitates understanding of how critical variables such as gross national income (GNI) per capita (measured using the Atlas Method in USD) and secondary education enrollment rates are interconnected, as examined in this study conducted at MIT (Hara, 2022a)

In summary, education is a fundamental driver of economic development as it empowers individuals, enhances productivity, fosters innovation, and contributes to society's overall progress. Understanding the pivotal role of education in economic growth is essential for policymakers and stakeholders aiming to promote sustainable development and prosperity.Overall, education serves as a linchpin of societal development, shaping individuals and communities through processes of socialization, integration, and placement. Theoretical perspectives offer valuable insights into the role of education, illuminating its functions and dynamics within society. In practice, education plays a pivotal role in fostering social cohesion, equality, and individual development. Moreover, education serves as a catalyst for economic growth by fostering human capital, innovation, and societal welfare. Understanding the reciprocal relationship between education and economic development is essential for policymakers and stakeholders aiming to promote sustainable development and prosperity. By harnessing the transformative power of education, societies can unlock their full potential and forge a path toward a brighter future.

### 2.1.3 Education for Sustainable Development in the Asia-Pacific

The Asia-Pacific region is located in or around the Western Pacific Ocean and encompasses South Asia, Southeast Asia, East Asia, Oceania, and Australia. This expansive region covers an area from Mongolia in the north to New Zealand in the south, and from Central Asia and the Islamic Republic of Iran in the west to Kiribati in the east. The region is generally divided into five subregions: South Asia, Southeast Asia, Northeast Asia, Central Asia, and the Pacific. The Asia-Pacific region's economic, strategic, military, and political significance underscores its pivotal role in shaping international relations, driving global economic growth, and influencing key geopolitical dynamics (Ullah, 2021)

Education for sustainable development (ESD) in the Asia-Pacific region is crucial for addressing environmental challenges, promoting societal well-being, and fostering a sustainable future. The region's diverse geography, culture, and economy necessitate a comprehensive approach to integrating sustainable development strategies into education systems. Higher Education Institutes (HEIs) play a transformative role in this process by incorporating ESD into curricula, encouraging social change through research and education, and influencing sustainability practices across various sectors (UNESCO (2019) and Pandey (2022)).

Educational achievement in the Asia-Pacific region is notable, with a quarter of the world's school-age children residing in East Asia and the Pacific. Indeed, Qian & Walker (2023) explained that this region boasts some of the top-performing education systems globally, characterized by significant investments in school infrastructure, teacher development, parental involvement, high standards, and a culture that values education and respects teachers. However, challenges persist, such as disparities in education equity, high parental expectations, a tradition of shadow education, and the pursuit of high-quality education by well-resourced families, which can hinder efforts to ensure educational equity (Qian & Walker, 2023).

Despite progress in access and participation, disparities in education quality and equity persist in the region. While primary and lower secondary enrollment rates are high, completion rates at the upper secondary level remain a challenge, with less than 40% of adolescents completing this cycle in half of the countries. Additionally, learning achievement levels are concerning, with less than 56% of students proficient in reading and less than 50% proficient in math in many countries. The COVID-19 pandemic has intensified these challenges, leading to disruptions in education delivery, learning outcomes, student engagement, and well-being, particularly affecting vulnerable learners and hindering progress toward Sustainable Development Goal 4 (UNESCO, n. a.).

Furthermore, UNESCO (n.a.) emphasized that efforts to address these issues include immediate actions such as learning recovery to prevent permanent learning losses, as well as broader strategies to transform education systems to be more resilient, equitable, inclusive, relevant, and flexible. The UNESCO Futures of Education Report emphasizes the need to rethink education content and delivery to promote peaceful, inclusive, and sustainable futures, focusing on key areas such as pedagogies, curricula, the teaching profession, schools, and creating a learning ecosystem. Key competencies identified for learners include foundational literacy and numeracy skills, 21st-century skills, work-related skills, lifelong learning abilities, and competencies to address global challenges such as climate change and sustainable development (UNESCO, n. a.).

OverallWhile the Asia-Pacific region has made strides in education, challenges remain in achieving universal access, quality, and equity in education. Addressing these challenges requires a multifaceted approach that prioritizes learning recovery, transformative education system reforms, and the development of key competencies to effectively prepare learners for the future.

The Asia-Pacific region, home to more than half of the world's population, faces environmental issues intensified by climate change and natural disasters. According to Pandey (2022) by 2025, the region is expected to see a rise in legalities and increased resource utilization due to urbanization trends. To counter these challenges, the Asia-Pacific countries have the opportunity to reshape their growth patterns by fully embracing sustainable development strategies and implementing projects that prioritize sustainability (Pandey, 2022). In this context, Pandey (2022) also suggested that collaboration between universities is essential to support the modernization of higher education, facilitate mutual learning across nations, and promote cross-cultural understanding. By integrating ESD into both the formal and non-formal education sectors, HEIs can equip individuals with the knowledge, skills, attitudes, and values needed to create a sustainable future. This holistic approach to education not only enhances individual capabilities but also contributes to societal welfare by promoting democracy, public order, and social cohesion (Pandey, 2022). Overall, ESD in the Asia-Pacific region is a multifaceted endeavor that requires collaboration, innovation, and a long-term vision to effectively address environmental challenges and promote sustainable development across the region.

### 2.1.4 Roles of AI in Education for Sustainable Development in Asia-Pacific

In the context of education for sustainable development (ESD) in the Asia-Pacific region, artificial intelligence (AI) plays a crucial role in advancing sustainability goals and transforming education systems. Here are several critical roles of AI in ESD in Asia-Pacific based on the sources provided, primarily by Korwatanasakul, Nguyen, and Seth (2022) and Pandey (2022).

First, AI can enhance learning and innovation. AI technologies such as machine learning and data analytics can personalize learning experiences, adapt to individual student needs, and enhance innovation in educational practices to address sustainability challenges effectively (Korwatanasakul, Nguyen, and Seth, 2022).

Second, AI can support research and knowledge generation. AI can facilitate research in sustainability by developing new analytical methods, tools, and assessment indicators that consider sustainability concerns. It enables the creation of new knowledge and applications to address societal issues related to sustainability (Pandey, 2022).

Third, AI helps the Asia-Pacific region promote collaboration and knowledge sharing, especially in higher education. AI fosters collaboration between universities to support the modernization of higher education, mutual learning across nations, and cross-cultural understanding. By sharing resources, expertise, and research outputs, AI contributes to the promotion of the sustainability paradigm in education (Pandey, 2022).

Fourth, AI can address environmental challenges. AI applications can help monitor and control environmental issues such as plastic waste management, urban planning, and climate change. Initiatives such as image recognition tools for monitoring pollution and AI-enabled projects for health and environmental targets demonstrate the potential of AI in addressing sustainability challenges (Korwatanasakul, Nguyen, and Seth, 2022).

Finally, AI can help students improve efficiency and effectiveness. AI can enhance the efficiency and effectiveness of educational processes, curriculum design, and teacher training by integrating ESD principles into the formal and non-formal education sectors. This integration ensures that professionals are equipped to effectively handle complex sustainability issues (Pandey, 2022).

AI in Education for Sustainable Development in the Asia-Pacific region plays a pivotal role in enhancing learning experiences, supporting research, promoting collaboration, addressing environmental challenges, and improving the efficiency and effectiveness of educational practices to foster a sustainable future.

In line with ESD, the "Education 2030 initiative," led by the OECD and UNESCO, aims to shape the future of education by determining the knowledge, skills, attitudes, and values that students need to thrive in and contribute to society by 2030 (UENSCO, 2021). This project focuses on preparing students for a rapidly changing world in which they will face new jobs, technologies, and social challenges. The Education 2030 Framework for Action, adopted by UNESCO Member States, provides guidance on implementing Education 2030, mobilizing countries and partners around the Sustainable Development Goal (SDG) on education, and ensuring inclusive, equitable, and quality education for all (OECD, 2018; OECD, n. a.; UNESCO, n. a.).

Artificial intelligence (AI) holds great promise in addressing challenges related to sustainability, climate change, and the development of more sustainable cities and communities. AI technologies can advance these goals by offering innovative solutions, data-driven insights, and automation capabilities that can contribute to more efficient and effective approaches in various sectors, including education. AI's role in education includes enhancing learning experiences, supporting research and knowledge generation, promoting collaboration, addressing environmental challenges, and improving the efficiency and effectiveness of educational practices to foster a sustainable future (UNICEF (n.a.) and AI Asia Pacific Institute (2024)).

In summary, Education 2030 focuses on preparing students for the future through a transformative education framework, while AI offers innovative solutions to address sustainability challenges and enhance educational practices in the Asia-Pacific region and beyond.

## 2.2 Study Gaps

In the Literature Review section,I discussed the intersection of Artificial Intelligence (AI) and Education for Sustainable Development (ESD) in the Asia-Pacific region. This study explores how AI plays pivotal roles in enhancing learning experiences, supporting research, fostering collaboration, addressing environmental challenges, and improving educational efficiency and effectiveness. The Education 2030 initiative, led by the OECD and UNESCO, aims to prepare students for a rapidly changing world, emphasizing the importance of knowledge, skills, attitudes, and values needed for societal contribution by 2030 (UNESCO, 2021). AI holds promise in advancing sustainability goals by offering innovative solutions, data-driven insights, and automation capabilities. Initiatives such as image recognition tools for monitoring pollution and AI-enabled projects for sustainable development demonstrate AI's potential. The Asia-Pacific region, home to diverse cultures and economies, requires a comprehensive approach to integrating ESD into education systems. Higher Education Institutes

(HEIs) play a transformative role by incorporating ESD into curricula, promoting social change, and influencing sustainability practices. Despite notable achievements in education, challenges persist, including disparities in quality and equity. The COVID-19 pandemic has intensified these challenges, emphasizing the need for learning recovery and transformative education system reforms. Efforts to address these issues include immediate actions and broader strategies outlined in UNESCO's Futures of Education Report. Overall, collaboration between universities and the integration of AI into education are crucial for promoting sustainable development and addressing environmental challenges in the Asia-Pacific region. Although AI is a state-of-the-art technology, much less research on specific AI for ESD in the Asia-Pacific region has been identified in previous studies, especially from the aspects of finding potential in human development through education with AI. Thus, it would be necessary to address the convergence of AI and ESD in the Asia-Pacific region by proposing a framework to provide the roles of AI in fostering ESD.

# 3 Study Purpose

This study explores the convergence of AI and education for sustainable development within the Asia-Pacific context, with a particular focus on ASEAN, China, and India. These regions represent dynamic frontiers with significant potential to redefine the future of learning. This study proposes a framework outlining the various roles of AI in fostering educational development across Asia.

# 4 Frameworks

## 4.1 Suggested Frameworks

In tackling the research objective, a suggested framework was constructed from two aspects below.

The first perspective is to examine the relationship between AI and Education for Sustainable Development (ESD). The goal of sustainable development is to meet the needs of the present without compromising the ability of future generations. It involves balancing economic growth, social inclusion, and environmental protection to ensure a more desirable situation for all. Sustainable development aims to create a world where economic prosperity, social well-being, and environmental stewardship go hand in hand, ensuring a more equitable, resilient, and sustainable future for people in the world (IFBA, 2024; United Nations, 2023). In the Asia-Pacific region, one of the most urgent development issues is to promote socioeconomic development through education. Investing in education is a crucial avenue for societal advancement. A closer examination of statistical data reveals a clear positive correlation between educational achievement and gross national income (GNI) per capita. Schultz (1971) extensively studied the impact of education on economic progress. His analysis, particularly regarding the agricultural and manufacturing sectors, demonstrated how enhancing human capital through education and training empowers workers to bolster their literacy and numeracy skills, thus broadening their job prospects, elevating income levels, and mitigating poverty. This underscores the conceptual link between education and economic growth. Kuchiki, Nogami, and Yamagata (2010) developed a theoretical framework outlining the relationship between income and years of schooling. This framework elucidates how both uneducated and educated laborers can improve their income prospects, with the latter experiencing a more significant increase over time. The authors concluded that while there isno singular solution to fostering economic development and alleviating poverty, education has emerged as a vital avenue for poverty reduction by expanding employment opportunities (Banergee & Duflo, 2012). In essence, education undeniably shapes individual and societal income statuses. Technology can help developing Asian economies solve educational problems, including lack of opportunities, teaching inefficiency, students' academic performance, and institutional improvement. Indeedn, in the realm of online education, information and communication technology (ICT) has played a pivotal role in expanding educational opportunities worldwide. This has been achieved through the digitization of textbooks, implementation of online classes (E-Learning), use of virtual teaching platforms, creation of educational materials accessible via tablets, and provision of laptops to students, among other advancements (UNESCO, 2013). ICT has revolutionized our daily lives with the advent of cutting-edge devices such as tablets, smartphones, IC cards, and ATMs.

Scholars have extensively studied the impact of ICT on education, with Nisar, Munir, and Ali shad (2011) highlighting its cost-effectiveness and time-saving benefits in their previous study involving 429 participants in Pakistan. They propose a comprehensive framework for ICT education, comprising four key aspects: "Availability," "Usage," "Knowledge," and "Efficiency" (Nisar, Munir & Ali shad, 2011, p.579). Their findings suggest that improving the availability and usage of ICT enhances students' knowledge and learning skills, thereby improving educational efficiency and informing educational policies. Ultimately, this contributes to poverty reduction by increasing income levels (Nisar, Munir & Ali shad, 2011). In line with this, once AI is introduced to ICT education, the effectiveness of AI on educational achievement can be huge. Seo et al. (2021) conducted a study examining how AI influences interaction between learners and instructors in online education. They collected insights from 12 students and 11 instructors, who discussed various scenarios involving potential AI applications. The findings implied that integrating AI systems into online learning could facilitate personalized interaction between learners and instructors on a large scale; however, there is a potential downside of infringing upon social boundaries (Seo et al., 2021). The relationship between AI and ESD is explored, emphasizing the importance of sustainable development in meeting present needs without compromising the future. Education is identified as pivotal for societal advancement, with a clear correlation between educational achievement and economic progress. Technology, particularly ICT, has significantly expanded educational opportunities globally. Scholars advocate for the integration of ICT into education to improve efficiency and effectiveness, ultimately contributing to poverty reduction. With the introduction of AI in ICT education, the potential for enhancing educational achievement becomes substantial. Seo et al. (2021) highlight the potential of AI in facilitating personalized interaction between learners and instructors in online education, although acknowledging the risk of social boundary violations. In summary, the integration of AI into education holds promise for advancing sustainable development goals and improving educational outcomes.

The second aspect is to gain insight into the framework presenting the roles of AI in fostering ESD. Notably, ChatGPT is one of the most useful tools with potential in promoting ESD eventually. Su and Yang (2023) formed the IDEE framework for using ChatGPT in education with the four realms of "Identify the Desired Outcomes," "Determine the Appropriate Level of Automation," "Ensure Ethical Considerations," and "Evaluate the Effectiveness" (Su & Yang, 2023, pp. 358-359) representing that using ChatGPT, an online tutor can offer tailored feedback and conversational exercises for language learners. The tutor is capable of adjusting to each learner's proficiency level and preferred learning pace, delivering a highly personalized educational journey. This feature proves particularly advantageous for individuals without access to traditional in-person language tutors or those who prefer the flexibility of self-paced learning.

Meanwhile, socio-economic development status is different in Asia. Indeed, specific regions, especially East Asian countries, e.g.) Japan, South Korea, Taiwan, and China have made substantial strides in development since World War II (Perkins, 2013). However, there remains a need to foster further development, growth, and social well-being in other parts of Asia. Gill and Kharas (2007) have focused on strategies to overcome the middle-income trap (MIT), a concept they introduced in 2006 to describe the difficulty many countries have encountered in raising their national income levels over the past four decades (Tran, 2016). Middle-income economies, with their varying situations, were classified into higher-middle-income economies (HMIEs) and lower-middle-income economies (LMIEs) by the World Bank (2007). This income classification demonstrates that while East and Southeast Asian economies such as China, Indonesia, Thailand, and Malaysia have elevated themselves to higher-middle income status, countries in South Asia, including Bangladesh, India, Nepal, Pakistan, and Sri Lanka, remain at the lower-middle income tier, in reviewing the socioeconomic development status in the whole Asia. Finally, the framework put forward by Hara, Karikomi, and Hashi (2023) outlining the development strategy for middle-income ASEAN nations, alongside the analytical framework introduced by the World of Work Project (2019) for strategic development, hold relevance. Acknowledging the presence of both low-middle-income and high-middle-income countries within ASEAN, it becomes imperative to devise distinct strategies tailored to each income bracket due to notable disparities in development and industrial capacities.

| Income Level** | Input (Educational Training with AI) | | Roles of AI as a Possible Converter of Output | Outputs (Sustainable Development) | Expected Obstacles of AI that can Hurt Educational Output |
|---|---|---|---|---|---|
| | Primary focus on the quantity of education (Access and Completion) | Primary focus on the quality of education (Learning Achievement) | | Primary focus on human capital development | |
| Low-income | Generalization of Basic (Primary and Secondary) Education | Students' Learning achievements and Motivation | 1. Efficiency in teaching, learning, and administration due to automation<br><br>2. Effectivities of Academic Performance through Tutoring and Virtual Assistance | 1. Employability<br>2. Job-Creation<br>3. Job Productivity | (Educational Concerns)<br>1. Overreliance on Technology<br>2. Bias and Lack of Fairness<br><br>(Economic Perspective)<br>1. Digital Divide<br>2. Job Displacement |
| Lower-middle Income | Generalization of Basic (notably, Secondary) Education | Students' Learning achievements and Motivation | | 1. Employability<br>2. Job-Creation<br>3. Job Productivity | |
| Higher-middle Income | Promoting Higher Education both in Research and Education | 1. Students' Learning achievements and Motivation<br>2. Research and Development | | 1. Employability<br>2. Job-Creation<br>3. Job Productivity | |
| High-Income | Refining Higher Education both in Research and Education | 1. Students' Learning achievements and Motivation<br>2. Research and Development | | 1. Employability<br>2. Job-Creation<br>3. Job Productivity | |

*Table 1. A Conceptual Framework for Presenting the Roles of AI in Education for Sustainable Development*
*Note.* Based on Hara (2022b, p.12), the author revised the table to discuss the roles of AI in education for sustainable development per income stage.
** Income Level: Hamadeh, Rompaey, and Metreau (2023) estimated the four income stages: low-income (less than US$1,135), low-middle Income (US$1,136 to 4,465), high-middle Income (US$4,466 to 13,845), and high income (over US$13,846).

On the basis of the frameworks from the two perspectives, I draw a suggested framework, primarily by referring to the framework drawn by Hara (2022b, p.12). The author created a hypothetical framework on the roles of AI in ESD. As shown in Table 1, the two main platforms of "INPUT" and "OUTPUT" were arranged. Further, I have included "Roles of AI as Possible Converters into Output" between these two platforms. These are the representative factors predicting "OUTPUT" according to Otsuka and Kurosaki (2003) and UNESCO(2012). The former is represented as "Educational Training," while the latter as "Sustainable Development." As explained earlier, the most critical point in illustrating the framework relevant to education for sustainable development would be to classify the entire world's economies into income levels of low-income, lower-middle income, higher-middle income, and high-income in Asia. Referring to Hara (2022b), under the "INPUT," I put two sequences of "QUANTITY" and "QUALITY," respectively. These results indicate that the quantity of education, especially access and completion, should be prioritized, and the quality of education focusing on students' learning achievement follows it sequentially. Every time educational development is discussed, prioritizing "Quantity of Education" over "Quality of Education" has become one of the most controversial issues. Still, in consideration of the current situation of lower enrollment and completion rate in secondary education, it would be appropriate for me to choose the improvement in quantity of education. Indeed, Esposito, Kebebe, and Maddox (2011) emphasized the importance of improving educational access in surveying in low- and lower-income economies. Thus, I arranged these two components sequentially. Then, for the most significant part of "Roles of AI as Possible Converters into Output", I added two items to "1. Efficiency in Teaching, Learning, and Administration due to Automation" and "2. Effectiviness of Academic Performance through Tutoring and Virtual Assistance" in reference to Nisar, Munir, and Ali shad (2011) and Su and Yang (2023). Ultimately, AI plays a major role in maximizing the efficiency and effectiveness of education with technologies.

In gaining insight into the "Low-income income" and "Lower-middle income," especially Bangladesh, Cambodia, India, Lao PDR, Myanmar, Pakistan, Philippines, Vietnam, etc., when reviewing some documents relevant to sustainable development through education, one of the most indispensable elements is to improve access to basic education from the perspective of lower enrollment rate in secondary education, especially for gaining basic ability of reading, writing, and numeracy (UNESCO, 2012). Then, as Hara (2022b) suggested, moving on to the quality of education, the elements of "1. Students' Learning achievements and Motivation" and "2. Arrangement of Learning Environments" should primarily be addressed in reference to UNESCO's report that youth skills depend on their motivation and learning environment (UNESCO, 2012). Meanwhile, as for "higher-middle income" and "high-income," notably China, Indonesia, Japan, Singapore, South Korea, etc., they should focus on the expansion of higher education opportunity ("INPUT) for realizing "2. Research and Development," and "1. Students' Learning Achievement and Motivation" when reviewing government agencies' education policies and Tran's suggestion that the enhancement of total-factor productivity (TFP) and human resource development could help national economies escape the HMIT (Tran, 2016). In addition, higher education plays the roles of education and R&D for knowledge economy (Oketch, 2016).

For the "OUTPUTS," I added three essential elements: "Employability," "Job-Creation," and "Job Productivity" in reference to Kyosaki's Job-type Matrix (2000). On behalf of the diffusion of state-of-the-art AI tools, including ChatGPT, Zapier, Grammarly, Descript, Notion AI Q&AClaude. These AI instruments can help skyrocket productivity and expand business opportunities, even in the developing world. Nevertheless, without the basic skills of writing, reading, and numeracy, it would be next to impossible to earn enough money to avoid poverty. Before the 2010s, skills gained through education were only confined to the employability to work in business organizations, while "Job-Creation" can be possible for those who have not been highly educated. Leaning and practicing business can be the key to success regardless of education degree levels, especially for avoiding educated unemployment and brain drain in low- and lower-middle-income countries (LLMICs) as potential threats. In a way, cultivating entrepreneurship individually can be implied as a key in ESD. Such an opportunity should be provided through education.

Finally, regarding "Expected Obstacles of AI that can hinder Educational Output," I arranged four concerns per component relevant to sustainable development; for example, from the aspect of "Educational Concerns," "1. Overreliance on Technology" and "2. Bias and Lack of Fairness" were raised. Overdependence on AI technology may reduce human interaction and personalized instruction. Students may become overly reliant on AI-driven tools for learning, diminishing critical thinking skills, creativity, and problem-solving abilities. Balancing technology with traditional teaching methods is crucial for maintaining a well-rounded education. On the other hand, AI algorithms can perpetuate and even worsen biases present in the data used to train them. This can result in unfair treatment of students, especially those from underrepresented or marginalized groups. For example, if historical data reflect biased grading practices, AI systems may inadvertently reinforce these biases. Furthermore, from an economic perspective, I raised "1. Digital Divide" and "2. Job displacement," representatively. Indeed, AI implementation in education may widen the digital divide between students who have access to technology and those who do not. Socioeconomic disparities, inadequate infrastructure, and limited internet connectivity can hinder access to AI-powered educational resources, disadvantaging students from disadvantaged backgrounds. In addition, in reference to Frey & Osborne (2017), the automation of certain educational tasks, such as grading and administrative duties, may lead to job displacement among educators and support staff. While AI can streamline workflow and improve efficiency, it may also threaten employment opportunities for those whose roles are automated.

## 4.2 Insights into Benefits and Challenges

While AI holds immense potential to transform education and promote sustainable development, addressing challenges related to equity, bias, human interaction, and workforce disruption is essential to effectively harness its benefits. Collaborative efforts involving policymakers, educators, technologists, and stakeholders are necessary to navigate these challenges and realize the full potential of AI in advancing education for sustainable development.

The primary benefit of suggesting the hypothetical framework is that it provides a structured approach to understanding the complex interactions between AI, education, and sustainable development. By delineating different components and relationships, the framework offers clarity and organization, facilitating communication and decision-making among stakeholders. In addition, it helps identify key areas for intervention and investment in AI-driven educational initiatives. By categorizing the roles and functions of AI in education, policymakers and educators can prioritize actions that align with sustainable development goals, such as improving access to quality education, enhancing learning outcomes, and promoting inclusive growth. Further, the framework can be tailored to specific contexts, needs, and priorities, allowing for customization and adaptation to diverse educational settings and developmental challenges. By incorporating local insights and expertise, stakeholders can design AI interventions that are culturally relevant, contextually appropriate, and responsive to community needs. Finally, a framework provides a basis for monitoring and evaluating the impact of AI in education on sustainable development outcomes. By establishing clear indicators, benchmarks, and performance measures, stakeholders can assess the effectiveness, efficiency, and equity of AI-driven educational initiatives, enabling continuous improvement and learning. In summary, suggesting a framework representing the roles of AI in education for sustainable development offers a systematic and structured approach to leveraging AI technologies to address global challenges in education. By providing clarity, strategic guidance, evidence-based insights, and opportunities for collaboration, such frameworks facilitate informed decision-making and collective action toward achieving sustainable development goals in education.

However, several challenges can also be available. For instance, developing a comprehensive framework that captures the multifaceted roles of AI in education and their impact on sustainable development requires navigating the complexity and interdisciplinary nature of these domains. Integrating insights from education, technology, economics, sociology, and environmental science poses challenges in terms of conceptualization, synthesis, and coherence. Furthermore, the field of AI and its applications in education are constantly evolving, driven by advances in technology, changes in educational practices,

and emerging trends in sustainable development. Designing a framework that remains relevant and adaptable to evolving contexts and needs poses challenges in terms of keeping pace with rapid developments and incorporating emerging insights and innovations. In addition, implementing AI in education requires building capacity and enhancing digital literacy among educators, policymakers, administrators, and learners. Addressing disparities in digital skills, access to technology, and awareness of AI's potential and limitations poses challenges in terms of providing training, resources, and support to enable meaningful and responsible use of AI in educational contexts. Finally, developing, implementing, and sustaining AI-driven educational initiatives require financial resources, infrastructure, technical expertise, and institutional support. Securing funding, garnering political commitment, and mobilizing resources for AI in education pose challenges in terms of competing priorities, budget constraints, and resource allocation decisions at the national, regional, and global levels. Navigating these challenges requires collaboration, innovation, and concerted efforts among diverse stakeholders, including governments, academia, civil society, industry, and international organizations. By addressing these challenges thoughtfully and proactively, stakeholders can harness the transformative potential of AI in education to advance sustainable development goals and create a more equitable, inclusive, and prosperous future for all learners.

# 5 Limitations, Future Research, and Implications for Policymakers

This section includes limitations, future research, and implications for policymakers as follows.

## 5.1 Limitations

First, one of the major study limitations would be the development of specific research methods to investigate the roles of AI in promoting education for sustainable development (ESD). This limitation revolves around the need to determine which AI tools, such as ChatGPT, Zapier, Grammarly, Descript, Notion AI Q&AClaude2, etc., are most appropriate for the study and which specific countries or areas in the Asia-Pacific region should be selected for case studies. Essentially, the study faces the challenge of methodological development, as it must carefully select AI tools and geographical areas to ensure the research effectively addresses the roles of AI in advancing ESD. This limitation highlights the complexity of researching the intersection of AI and education for sustainable development, which requires thoughtful consideration and methodological rigor.

Second, the specificity of data concerning AI for education needs to be further elaborated. This limitation suggests that there is a lack of detailed or comprehensive data available regarding the use and impact of AI specifically within educational contexts. Consequently, this study faces the challenge of accessing and analyzing relevant datasets that provide insights into the implementation, effectiveness, and implications of AI in education. Without detailed data, it is difficult to thoroughly examine the roles and potentials of AI in educational settings, hindering the depth of analysis and understanding. This limitation underscores the importance of robust data collection efforts and highlights potential gaps in existing research on AI in education that need to be addressed for a more comprehensive understanding of the subject.

Finally, a particular school level should be chosen when discussing the roles of AI in promoting education for sustainable development. This suggests that the study may struggle with determining which specific level of education, such as primary, secondary, or tertiary, should be the focus of analysis when exploring the impact of AI on promoting ESD. Consequently, the study may face challenges in providing a nuanced understanding of how AI can be effectively integrated into different educational contexts to advance sustainable development goals. This limitation underscores the complexity of tailoring AI interventions to specific educational levels and highlights the need for careful consideration of the target audience and educational objectives when designing AI-based educational initiatives for sustainable development.

These three study limitations can be, in turn, potential for maximizing the studies on AI and ESD in the future. To maximize the study potential, it would be necessary to disclose the research directions. In this way, I will provide future research directions in the next section.

## 5.2 Future Research

On the basis of the described study limitations, several future research directions can be suggested to address these challenges and further advance the understanding of the roles of AI in promoting education for sustainable development (ESD):

First, future research should focus on developing robust and innovative research methods specifically tailored to investigate the roles of AI in promoting ESD. This might involve the exploration of interdisciplinary approaches that integrate insights from education, technology, and sustainability studies. In addition, comparative studies across different AI tools and case studies in diverse regions within the Asia-Pacific region could help identify best practices and effective strategies for leveraging AI in educational contexts.

Second, to overcome the limitation regarding the specificity of data concerning AI for education, future research could prioritize efforts to collect and analyze comprehensive datasets that provide detailed insights into the use and impact of AI in educational settings. As Isono and Prilliadi (2023) suggested, encouraging collaborative endeavors, setting up research hubs, and fostering innovation centers are crucial steps for Asia-Pacific to foster AI solutions. ASEAN research efforts should draw upon empirical evidence not only from the US but also from Asia(Isono and Prilliadi, 2023). This could involve collaboration with educational institutions, governments, and technology companies to access relevant data and ensure its quality and relevance to the study objectives. Moreover, qualitative research methods such as interviews, surveys, and case studies could supplement quantitative data analysis to provide richer insights into the experiences and perceptions of stakeholders regarding AI in education.

Third, to address the challenge of choosing specific school levels when discussing the roles of AI in promoting ESD, future research could adopt a nuanced approach that considers the unique needs, contexts, and objectives of different educational levels, notably primary, secondary, or tertiary education. This might involve conducting comparative studies to examine the effectiveness of AI interventions across various educational levels and identifying strategies for effectively integrating AI into different curricula, teaching methods, and learning environments. In addition, research could explore the role of AI in promoting lifelong learning and continuous education beyond traditional school settings to support sustainable development goals across diverse communities and contexts.

Overall, future research in this area should prioritize interdisciplinary collaboration, methodological innovation, and empirical investigation to address the identified limitations and advance our understanding of how AI can contribute to promoting education for sustainable development in the Asia-Pacific region and beyond.

## 5.3 Implications for Policymakers

Sustainable development in Asia-Pacific countries hinges significantly on education, particularly in terms of preparedness. Policymakers must fully acknowledge the significance of integrating AI into education and use it to expedite policy formulation. Here are the potential tips and implications for them to consider.

First, policymakers should prioritize awareness campaigns to educate stakeholders, including educators, students, parents, and policymakers, about the rapid global shift toward an AI-driven society. These campaigns should be targeted not only at developed nations but also at the developing world, where awareness of AI's transformative potential may be lower. By increasing awareness, policymakers can ensure that stakeholders are informed about the opportunities and challenges presented by AI in education and are better equipped to adapt to these changes.

Second, policy reforms to facilitate the integration of AI technologies into the education system should be undertakenfurther. This may involve updating curriculum standards to include AI literacy, providing professional development opportunities for educators to learn about AI tools and methodologies, and incentivizing the adoption of AI-driven educational technologies through funding and grants. In addition, they should consider regulations to ensure the ethical and responsible use of AI in education, particularly concerning data privacy and algorithmic bias.

Third, further investment in the necessary infrastructure to support AI-enabled education initiatives, especially in the low- and lower-middle-income economies in Asia, should be prioritized. This includes ensuring access to reliable internet connectivity, providing access to hardware such as computers and tablets, and investing in training programs to build capacity among educators to effectively integrate AI technologies into teaching and learning practices.

Finally, partnerships and collaborations among government agencies, educational institutions, technology companies, and civil society organizations to leverage resources and expertise in implementing AI-driven education initiatives should be further fostered. By working together, stakeholders can develop innovative solutions that address the unique needs and challenges of their respective contexts and ensure that AI technologies are equitably and inclusively deployed.

Overall, policymakers play a crucial role in shaping the future of AI in education by raising awareness, enacting supportive policies, investing in infrastructure, and fostering collaboration. By taking proactive measures, policymakers can harness the potential of AI to revolutionize education and realize socioeconomic development goals for all learners.

# 6 Conclusion

This study delves into the intersection of AI and sustainable educational development in Asia-Pacific contexts, representing a dynamic frontier with immense potential to reshape the future of learning, and presents a suggested framework on the diverse roles of AI in cultivating educational development in Asia. By embracing AI-driven innovations while upholding principles of equity, inclusivity, and ethical governance, Asian nations can pave the way for a more equitable and resilient educational landscape capable of meeting the evolving needs of the 21st-century learner.

Consequently, the suggested framework, shown in Figure 1, for AI's roles in Education for Sustainable Development (ESD) encompasses INPUT, OUTPUT, and AI's converters. Prioritizing educational access and completion, AI enhances efficiency and effectiveness by aiding teaching, learning, and administration. For low-income and lower-middle-income countries, the focus lies on basic education access and quality. Higher-income countries emphasize higher education expansion and research. Outputs include employability, job creation, and productivity. AI tools can boost productivity, but basic skills remain crucial. Concerns revolve around overreliance on technology, bias, digital divide, and job displacement. Balancing AI integration with traditional methods is essential because biases and disparities may persist. Maintaining a comprehensive approach to AI implementation in education is key to fostering sustainable development globally.

However, the conceptual framework lacks a specific methodology, rendering it presented merely as a hypothesis, which constitutes a weakness in the study. Thus, robust and innovative research methods specifically tailored to investigate the roles of AI in promoting ESD need to be developed. However, several policy implications were raised. The executive summary outlines key actions for policymakers to maximize the benefits of AI in education while addressing potential challenges. First, awareness campaigns are essential to educate stakeholders worldwide about AI's transformative impact. Second, policy reforms should promote the integration of AI into education systems, including curriculum updates, educator training, and ethical regulations. Third, significant investment in infrastructure is needed, particularly in low- and lower-middle-income economies, to support AI-enabled education initiatives. Lastly, fostering partnerships among government, educational institutions, tech companies, and civil society will drive innovation and ensure equitable access to AI technologies.

Finally, policymakers must take proactive steps to harness AI's potential for revolutionizing education and achieving socioeconomic development goals globally. This initial study on AI in education for sustainable development will pave the way for future research to yield more fruitful results, ultimately contributing to Asia-Pacific development in the future.

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