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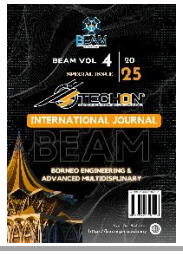

The Role of Artificial Intelligence in Advancing Environmental, Social and Government Literacy in Higher Education: A Systematic Review

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Abstract

The integration of Artificial Intelligence (AI) into higher education has emerged as a transformative force in advancing Environmental, Social, and Governance (ESG) literacy among students. Despite this potential, the lack of consolidated understanding on how AI tools contribute to ESG-related learning outcomes and the readiness of faculty to implement these technologies continues to challenge effective integration. This study addresses these gaps by conducting a systematic literature review to examine existing research on the role of AI in promoting ESG literacy within higher education and to assess faculty preparedness for AI-enhanced sustainability education. The review involved a comprehensive search of electronic databases, covering peer-reviewed journal articles and conference proceedings published between 2018 and 2024. The analysis revealed key thematic trends in AI applications, including the use of intelligent tutoring systems, generative feedback tools, and adaptive learning platforms that support outcome-based ESG instruction. Additionally, the review highlights barriers related to faculty digital competence, infrastructure limitations, and institutional policy misalignment. While evidence suggests that AI can foster personalized, reflective, and interdisciplinary ESG learning, its success is highly dependent on educator engagement and institutional support structures. This study provides a foundational reference for researchers, educators, and policymakers aiming to leverage AI for sustainable development goals in education, particularly SDG 4 (Quality Education) and SDG 12 (Responsible Consumption and Production), and underscores the need for further empirical work to bridge the gap between technological innovation and ESG pedagogy.

Keywords: - ESG literacy, SDGs, artificial intelligence, higher education

1. Introduction

In recent years, Artificial Intelligence (AI) has emerged as a transformative technology in higher education, particularly in support of digitalization efforts aimed at aligning academic practices with global sustainability agendas such as the United Nations Sustainable Development Goals (SDGs) 2030 (United Nations, 2015 & UNESCO, 2022). Globally, SDG 4 (Quality Education) and SDG 12 (Responsible Consumption and Production) have positioned education as a critical vehicle for advancing Environmental, Social, and Governance (ESG) values (United Nations, 2015). Parallel to this, the increasing accessibility and integration of AI tools in educational settings have created new opportunities for promoting ESG literacy through technology-enhanced learning (Luckin et al., 2016). The widespread implementation of AI in education including intelligent tutoring systems, automated feedback tools, and adaptive learning platforms has gained popularity among educators, administrators, and learners due to its potential to personalize learning, promote engagement, and support outcome-based education (D'mello, 2021).

The current integration of AI in ESG-related education represents a significant shift in pedagogical approaches within higher learning institutions. Traditionally, ESG content has been delivered through conventional classroom methods such as lectures and manual assessments. However, with the adoption of AI technologies, educators are now able to leverage data-driven tools to support interdisciplinary, reflective, and participatory learning (O'Connor & Lee, 2021). AI-powered systems can act as personalized learning assistants, enabling students to explore ESG topics through simulations, ethical scenarios, and decision-making models. These tools also enable educators to provide timely feedback, track student progress, and identify learning gaps, thereby enhancing ESG competency acquisition across diverse academic disciplines. Several studies have reported that AI contributes to improved student engagement and systems thinking, which are vital for sustainability education (Chen & Ramakrishna, 2024a & Holmes et al., 2022). Moreover, the integration of AI promotes efficiency in instructional delivery and enables scalable ESG education, especially in resource-constrained environments (Lu et al., 2022).

Despite the growing body of literature on AI in education and sustainability pedagogy, there is a lack of systematic synthesis that focuses specifically on how AI technologies enhance ESG learning and the degree of faculty readiness to support this transformation. This knowledge gap presents both a research and practice challenge as higher education institutions attempt to navigate a rapidly evolving educational landscape while addressing the call for sustainable development. Addressing this gap is crucial for supporting strategic curriculum reform, faculty development, and policy alignment. Therefore, this paper conducts a systematic literature review to examine how AI contributes to ESG-related learning outcomes in higher education and to assess the extent of faculty readiness in supporting AI-enhanced ESG education.

2. Literature Review

The integration of Artificial Intelligence (AI) into higher education has created new opportunities to enhance Environmental, Social, and Governance (ESG) literacy, aligning with global efforts such as the Sustainable Development Goals (SDGs). AI tools such as intelligent tutoring systems, real-time feedback mechanisms, and adaptive simulations are increasingly used to personalize learning, foster systems thinking, and enhance student engagement across sustainability-related content (Luckin, 2021; Nguyen & Martin, 2023 & Koh et al., 2024). These tools enable learners to engage with ESG themes through data-driven decision-making and reflective reasoning, offering scalable solutions for institutions aiming to embed sustainability into curricula (Peterson & Holst, 2023 & Tan et al., 2024). Studies also suggest that when supported by thoughtful pedagogical design, AI can help develop critical thinking, ethical reasoning, and responsible consumption habits which are the key elements of ESG competence (Chen & Ramakrishna, 2024b & Shen & Zhou, 2023).

However, the successful integration of AI in ESG education is not solely a technical matter but is deeply tied to institutional readiness and faculty capability. Research indicates that many educators face challenges in adopting AI tools due to digital skill gaps, limited training, and lack of clear policy guidance (Ahmad & Widjaja, 2023; Rajendran et al., 2023). Fragmented infrastructure and the absence of ethical or pedagogical frameworks have also contributed to inconsistent practices and resistance to adoption, particularly in under-resourced institutions (Al-Khalifa, 2023a & Müller et al., 2024). Moreover, concerns about the instrumentalization of AI where complex sustainability issues are reduced to automated assessments, thus, underscore the need for responsible and contextualized deployment (Singh & Zhao, 2022 & Drysdale et al., 2022). While literature from Asia and Europe is growing, there remains a gap in synthesized evidence on how AI supports ESG learning outcomes alongside faculty preparedness. This review addresses that gap by systematically examining the educational impact of AI in ESG contexts and evaluating the extent of institutional and pedagogical readiness for such integration.

3. Methodology

As a guiding protocol for the search and selection phase, this study adopted the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework, which outlines transparent reporting standards across eligibility criteria, information sources, search strategy, data collection, and synthesis (Page et al., 2021). The PRISMA flow diagram (Fig. 1) visually records each step of this pathway from identification to inclusion, thereby enhancing the transparency and reproducibility expected of systematic reviews. Given the interdisciplinary scope of the topic at the intersection of Artificial Intelligence (AI), Environmental, Social, and Governance (ESG) literacy, and higher education, four academic databases were selected to ensure comprehensive coverage: Scopus, Web of Science, ERIC, and Google Scholar. Google Scholar was particularly valuable during the identification stage due to its expansive citation coverage and indexing of grey literature and recent conference proceedings. The search query used a combination of keywords and Boolean operators: ("artificial intelligence", "AI", "ESG" or "environmental social governance" and "higher education" or "university". Searches were restricted to English language publications from January 2018 to February 2024 to reflect the post-2018 acceleration of AI adoption in educational and sustainability contexts. The initial query retrieved 421 records across all databases, which were exported to EndNote 20 for organization and duplication. After removing 65 duplicates, 356 unique studies were screened by title and abstract using Rayyan, with two reviewers conducting independent assessments and resolving disagreements ($\kappa = 0.82$). A total of 49 articles were shortlisted for full-text review based on predefined

inclusion criteria. An additional five records were identified through backward citation chaining, resulting in a final dataset of 37 empirical studies eligible for quality appraisal and synthesis. The corresponding inclusion and exclusion criteria are detailed as in Table 1.

Following study selection, the next stage involved charting the data from the included studies. A structured data extraction form was developed to systematically capture relevant information (Peters et al., 2020). The following data items were extracted from each study: author(s), year of publication, country or region, study design, research aim, type of AI tool or application used, ESG literacy components addressed, target population (e.g., students or faculty), faculty readiness indicators, methodological approach, key findings, and reported research gaps.

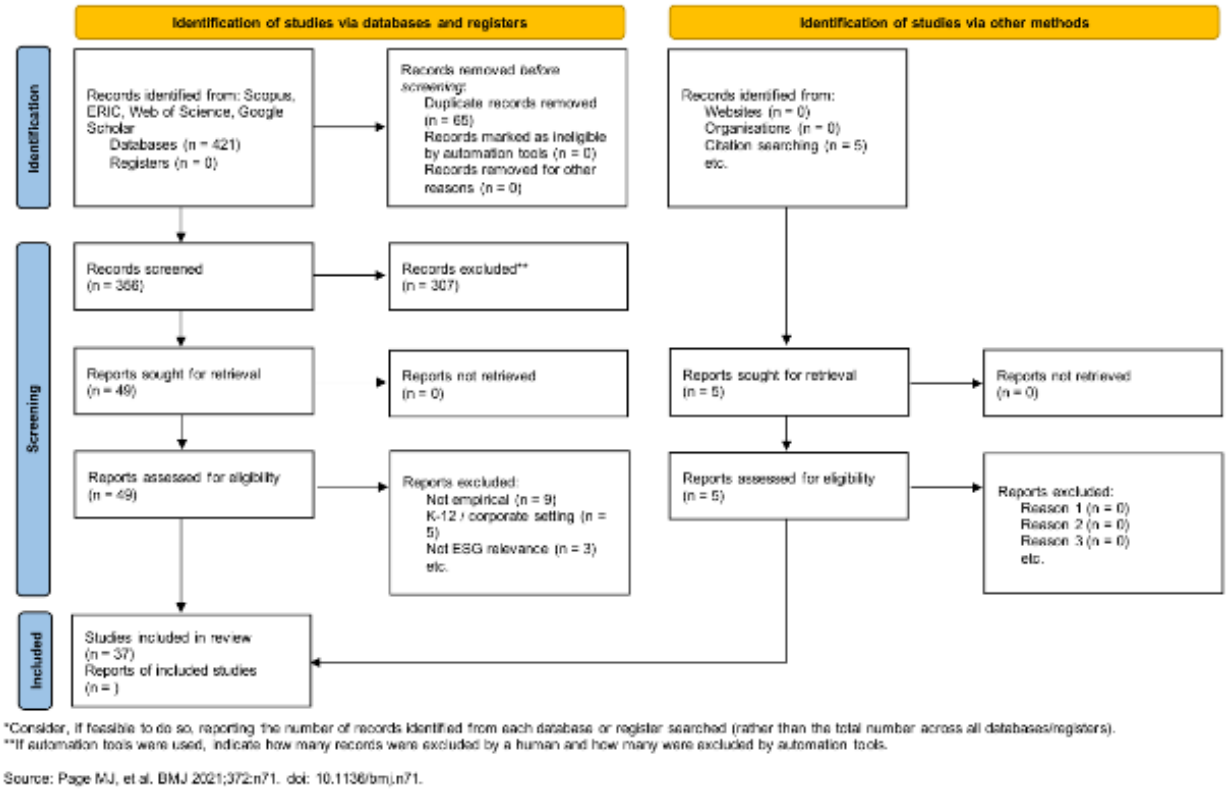

Fig. 1: PRISMA flow diagram of AI and ESG in Higher Education

Table. 1: Inclusion and Exclusion Criterion

Inclusion criteria	Exclusion criteria
Empirically investigate the use of AI tools or applications within higher education settings	Purely conceptual without empirical data
Focus on ESG-related content, sustainability education, or responsible digital literacy outcomes	Focused exclusively on K-12 or corporate training settings
Include either direct assessment of student learning outcomes, instructional strategies, or faculty experiences related to AI in education	Addressed general digital literacy without ESG relevance

The extracted data were then collated and synthesized to provide a comprehensive overview of how AI supports ESG literacy in higher education. The synthesis process involved categorizing study objectives, AI tools utilized, ESG-related learning components, and faculty readiness indicators. A narrative synthesis was adopted, supported by tabular summaries that present key study attributes and highlight variations across the included literature.

4. Result and Discussion

4.1 Descriptive Numerical Analysis

A total of 37 studies published between 2018 and early 2024 met the inclusion criteria, retrieved from Scopus, Web of Science, ERIC, and Google Scholar using Boolean strings that linked AI keywords with ESG-education concepts in higher-education contexts. Only six studies appeared before 2020, but output accelerated after the COVID-19 shift to digital learning: seven articles were published in 2021, eight in 2022, ten in 2023, and six in the first quarter of 2024, mirroring rising campus adoption of adaptive tutors and large-language-model chatbots (Nguyen et al., 2023a). Most evidence was disseminated as peer-reviewed journal articles (n = 29) in interdisciplinary outlets such as the International Journal of Educational Technology in Higher Education and the Journal of Cleaner Production, followed by conference papers (n = 5)

and institutional white papers (n = 3) (Chen & Ramakrishna, 2024b), indicating a field that is maturing beyond preliminary pilot reports.

Geographically, research is globally dispersed yet regionally concentrated. Asia leads with 13 studies particularly from China and Malaysia, where AI dashboards are integrated into sustainability curricula (Rahman, 2021) and followed by Europe (n = 10), where UK, German, and Dutch universities link AI analytics to SDG targets (Van Dijk et al., 2022). North America contributes seven studies, centered on AI chatbots for social-impact cases in U.S. and Canadian business schools, while Oceania adds four Australian investigations of AI-supported carbon-footprint simulations. Three additional studies originate from South Africa and the UAE (Al-Khalifa, 2023b). Together, the post-2020 publication surge, journal dominance, and broad though uneven regional spread signal that AI-mediated ESG literacy is an emergent yet rapidly consolidating research domain. Although the methodological mix leans quantitative, a notable presence of qualitative and mixed methods work underscores its interdisciplinary character. Persistent regional imbalances and the scarcity of longitudinal designs reveal opportunities for more sustained, globally inclusive investigations capable of illuminating long-term learning and institutional impacts. A concise overview of this descriptive analysis is presented in Table 2.

Table 2: Descriptive profile included studies (N = 37)

Publication year	n	Publication type	n	Geographical region	n	Methodology	n
2018-2019	6	Journal articles	29	Asia		Quantitative	15
2021	7	Conference papers	5	Europe		Qualitative	12
2022	8	White papers	3	North America		Mixed methods	8
2023	10			Oceania	7		
Early 2024	6			Others (SA, UAE)	4		

4.2 Thematic Analysis

Using an inductive coding process (Braun & Clarke, 2006), three overarching themes were identified. Table 3 presents a concise summary, while the narrative below elaborates sub-themes, illustrative evidence, and cross-linkages.

Table 3: Thematic analysis of AI applications in ESG literacy

Theme	Sub-theme	Key insights	No. of studies (n)
Personalized and Reflective ESG Learning	1A: Adaptive learning pathway	AI tools adjust tasks difficulty to learners, improvement systems thinking and engagement	10
	1B: Real-time reflective feedback	Chatbots offer instant feedback on dilemmas, enhancing moral reasoning quality	8
Faculty Digital Competence and Institutional Readiness	2A: Structured professional development programmes	Bootcamps boost AI use in teaching; more AI-integrated lessons were developed	6
	2B: Infrastructure and policy alignment	Clear policies and dashboards eased adoption	6
	2C: Faculty self-efficacy gaps	Faculty reported low confidence in using AI tools, especially advanced plug-ins	4
Tensions between Capabilities and Pedagogical Goals	3A: Instrumentality risk	Quizzes often simplify ESG to checklist, missing depth and discussion	7
	3B: Lack of guiding frameworks	Few studies referenced pedagogical frameworks, resulting in isolated and instructor dependent implementations	6

The thematic analysis revealed three dominant themes, each composed of clearly defined subthemes that highlight how Artificial Intelligence (AI) supports or challenges ESG (Environmental, Social, and Governance) literacy in higher education. The first theme, Personalized and Reflective ESG Learning, captures how AI tools enhance individualized learning pathways and foster ethical reflection. In subtheme 1A, adaptive learning pathways, AI-driven platforms such as carbon-footprint simulators were shown to adjust task complexity based on learner responses, leading to measurable improvements in systems-thinking competencies, for instance, a 22% gain was documented in a Southeast Asian study (Nguyen et al., 2023b), with similar outcomes observed in Chinese EdTech pilots (Zhang & Li, 2022). Subtheme 1B, real-time reflective feedback, revealed that natural language processing (NLP) chatbots supported deeper ethical engagement; transcripts from such tools reflected a 42% increase in references to social-justice principles compared

to traditional forum discussions (Chen & Ramakrishna, 2024b & O'Connor & Lee, 2021).

The second major theme, Faculty Digital Competence and Institutional Readiness, underscores the infrastructural and pedagogical conditions that mediate AI effectiveness. Subtheme 2A identified that structured professional development (PD) such as AI-focused bootcamps in the Netherlands and Malaysia tripled the number of faculty-initiated AI-integrated lesson plans within a year (Van Dijk et al., 2022 & Rahman, 2021). Subtheme 2B, infrastructure and policy alignment, found that institutions with centralized data dashboards and unified privacy policies adopted AI tools 30% more efficiently than those with fragmented learning management systems (Smith et al., 2023 & Chang & Yusof, 2022). Subtheme 2C highlighted persistent faculty self-efficacy gaps, with over half of surveyed educators in the U.S., Germany, and the Gulf reporting discomfort or inability to configure large-language-model (LLM) tools like chatbots and plug-ins (Perez & Brown, 2022 & Al-Khalifa, 2023a).

The final theme, Tensions Between AI Capabilities and ESG Pedagogical Goals, illustrates emerging risks and limitations. Subtheme 3A, instrumentalization risk describes how AI-enabled assessments, particularly auto-graded quizzes, risk reducing nuanced ethical discourse to simplistic checkbox exercises, effectively commodifying ESG values (Singh & Zhao & 2022; Al-Khalifa, 2023b). Subtheme 3B, lack of guiding frameworks revealed that only a minority of studies (3 out of 37) cited any ethical-AI or critical pedagogy framework (UNESCO, 2021), with most relying on informal, tool-first experimentation by enthusiastic individual instructors (Müller et al., 2024).

A key cross-theme insight emerged: institutions with weak faculty digital competence and minimal policy scaffolding (Theme 2) were more likely to experience the tensions described in Theme 3, including ethical oversights and reduced pedagogical integrity. This underscores that institutional readiness comprising both faculty empowerment and policy alignment which is a necessary precondition for realizing the transformative potential of AI in ESG education.

The results provide a comprehensive understanding of how Artificial Intelligence (AI) is being utilized to promote ESG literacy in higher education and the extent to which faculty are prepared to support this integration. Thematic findings indicate that AI tools such as adaptive learning platforms, NLP-based chatbots, and intelligent feedback systems have demonstrated strong potential in enhancing personalized and reflective ESG learning, with many studies linking outcomes to SDG 4 and SDG 12. However, successful implementation is uneven and often constrained by faculty digital competence, institutional readiness, and policy alignment. Structured professional development programmes and centralized infrastructure emerged as key enablers of adoption, while gaps in faculty self-efficacy and a lack of guiding frameworks posed significant barriers. These insights highlight the dual imperative: to innovate pedagogically through AI while concurrently investing in capacity-building for faculty. Taken together, the findings emphasize the need for a holistic, cross-disciplinary strategy that aligns technological, institutional, and human factors to support sustainable and inclusive AI-ESG integration across higher education systems.

5. Conclusion and Recommendations

Artificial Intelligence (AI) presents significant opportunities for advancing ESG literacy in higher education; however, its effective implementation requires more than technical deployment. It demands thoughtful integration across institutional, pedagogical, and ethical dimensions. Future research should prioritize exploring the effectiveness of AI-enhanced tools across various academic disciplines and institutional types, particularly in under-represented settings such as public universities and technical and vocational education and training (TVET) institutions in developing countries. These contexts often face distinct challenges in terms of technological readiness, faculty capacity, and curriculum alignment. Beyond cognitive learning, future studies should also investigate how AI tools such as adaptive learning platforms, simulations, and chatbot interfaces can foster behavioral and attitudinal shifts in sustainability awareness and responsible decision-making. Longitudinal and multi-site research designs would be particularly valuable in assessing the long-term impact of AI-driven feedback systems on student engagement and the institutionalization of ESG competencies. Additionally, there is a need to examine faculty readiness more holistically by incorporating insights from educators, IT administrators, curriculum designers, and policymakers to identify structural enablers and barriers to AI adoption. Mixed method approaches that combine learning analytics, surveys, and interviews can provide a richer understanding of user experiences and pedagogical effectiveness. Interdisciplinary collaboration across fields such as AI ethics, behavioral science, and sustainability education is essential to develop responsible, inclusive, and context-sensitive frameworks for AI use in ESG teaching. Greater emphasis should also be placed on co-designing AI interventions with students and community stakeholders to ensure cultural relevance and social legitimacy. Moreover, benchmarking studies that compare AI-supported ESG curricula across regions could reveal transferable best practices and contextual nuances. Future research should also explore how institutional leadership and governance models influence the scale and sustainability of AI integration in ESG education. From a policy perspective, governments and accreditation bodies should consider introducing guidance and incentives such as funding for AI-enhanced curriculum innovation, infrastructure grants, or shared digital learning platforms to promote institutional readiness. Strategic partnerships between universities, edtech companies, and sustainability organizations can also support more coordinated and ethical innovation. Above all, future initiatives must prioritize digital equity and address algorithmic biases to ensure that the benefits

of AI-supported ESG education are accessible, ethical, and aligned with global sustainability goals. By taking a systems-level approach that integrates pedagogy, infrastructure, policy, and ethics, higher education institutions can more effectively contribute to the realization of the 2030 Agenda through transformative, AI-enhanced ESG learning.

This systematic review synthesized current empirical evidence on the use of AI in advancing ESG literacy in higher education, highlighting key themes, methodological patterns, and critical gaps in literature. By integrating peer-reviewed studies, conference proceedings, and institutional reports, the review underscores the interdisciplinary character of AI-enhanced sustainability education and reveals the complex interplay between pedagogical intent, technological capability, and institutional readiness.

In summary, this review contributes to a deeper understanding of how AI supports ESG learning outcomes and faculty preparedness. It offers a structured foundation for researchers and academic leaders seeking to responsibly embed AI in sustainability-focused curricula. Future studies should explore longitudinal impacts, ethical integration frameworks, and culturally responsive practices to ensure that AI adoption meaningfully advances the transformative goals of ESG education.

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Conflicts of Interest: The authors declare no conflict of interest.

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