AI IN ENVIRONMENTAL EDUCATION: TOOLS, TRENDS, AND FUTURE DIRECTIONS

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Abstract

Artificial intelligence (AI) is rapidly advancing in education and has the potential to enhance various domains, including environmental education. Thus, the main purpose of this study is to identify AI tools that have the potential to support contemporary environmental education practices.

The research is methodologically conducted through a systematic review of academic contributions in scientific databases related to the application of AI in (environmental) education. The systematic review is structured in accordance with the PRISMA statement methodological framework.

The primary outcome is a classified overview of AI tools and a thematic synthesis of their applications across different educational levels within environmental education. Additionally, the findings contribute to the development of a currently underexplored theoretical framework for integrating AI into educational practice, laying the groundwork for future research and implementation of AI in environmental education.

Key words: artificial intelligence, systematic review, PRISMA statement. environmental education,

Introduction

The rapid advancement of artificial intelligence (AI) is transforming many aspects of contemporary life, including the way we teach and learn. In education, AI is increasingly seen not just as a technological tool, but as a catalyst for rethinking pedagogical approaches, curriculum design, and student engagement. As this transformation unfolds, it becomes essential to examine how AI intersects with specific educational domains—particularly those dealing with urgent global challenges, such as environmental and geographical education.

Therefore, the main goal of this article is to systematically review current academic literature on the use of AI in environmental education. Specifically, it aims to identify which AI tools are being utilised, examine their perceived educational benefits and limitations, and explore how they are applied within environmental learning.

Methodology

This review followed the principles of systematic searching outlined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses – PRISMA (Moher et al., 2009; Page et al., 2021). In accordance with the field-specific aims of this study, the PRISMA methodology was adapted, and the search for relevant sources was limited exclusively to selected academic journals (focusing solely on environmental and geographical education).

This field-specific search allowed our final search command to be reduced to these keywords: "artificial intelligence" OR "AI" OR "LLM*" OR "language model*". The search extended beyond empirical studies and included all peer-reviewed articles, review articles, and conference papers. Only studies published between 2022 and 2025 were included to ensure relevance to the latest AI developments and educational discourse.

Three independent coders searched and analysed articles published in specialised journals focused on geographical and environmental education. After the initial search, a total of 602 articles were found (Fig. 1). After collecting an initial set of articles, three coders independently skimmed through their titles. Articles that received unanimous agreement were selected for detailed analysis, while others underwent discussion to reach a consensus. Cohen's kappa—a statistical measure of inter-rater reliability—between coders was at 0.86, which allowed analysis to continue. In the subsequent phase, abstract analysis was conducted through independent coding. Three authors independently reached complete agreement (100%) on the inclusion and exclusion of articles, resulting in a Cohen's kappa value of 1.00. After excluding irrelevant articles, full-text analysis followed. Special attention was given to the types of AI tools, their modes of application in environmental and geographical education, and their possible pedagogical benefits or limitations.

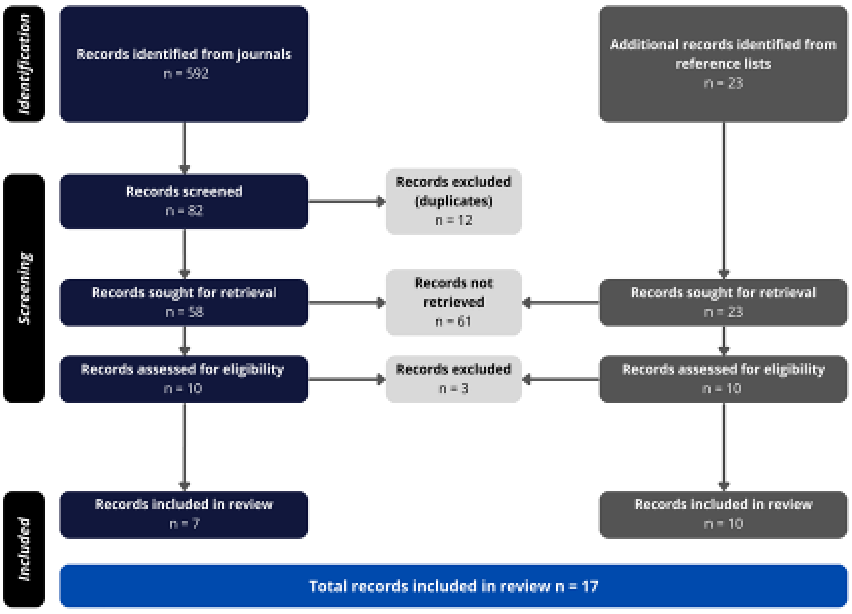

Fig. 1: PRISMA flow diagram for the conducted systematic review

Since the PRISMA method initially yielded only a limited number of suitable articles (n=7), a secondary method—snowball sampling—was employed. The use of this method was conducted with methodological guidelines and steps suggested by Blandino et al. 2023. This phase involved examining bibliographies of included studies and identifying further relevant publications. Through this process, an additional 10 relevant resources were identified, increasing the total number of analysed sources to 17 (Fig. 1). The addition of this methodological step disrupted the initially planned consistency of limiting the search exclusively to journals in the fields of environmental and geographical education. However, it simultaneously increased the reliability of the final findings, enabled comparisons of AI tool usage with other disciplines, and allowed the issue to be examined within a broader context.

Results

Our systematic review reveals three major themes in the use AI tools in environmental and geographical education. First, we identify the types of AI tools currently being discussed in literature. Second, we explore the perceived benefits and possible threats of these tools. Third, we highlight field-specific applications, showcasing how AI is being used in ways that are uniquely relevant to environmental and geographical contexts.

1. AI Tools Identified in Literature

The review identified a broad spectrum of generative and supportive AI tools utilised in educational contexts. Among the most frequently discussed were large language models such as ChatGPT (GPT-3.5 and GPT-4), used to generate teaching materials, create assignments, simulate classroom discussions on climate-related issues, and provide personalised feedback to students (Griffiths, 2023; Hickman & Ghosh, 2024). ChatGPT was also employed in lesson planning and curriculum development through predefined structures that helped reduce educators' workloads (Kamalov et al., 2023). Its role was also evaluated in GIS education, where it supported assignment design and facilitated student engagement with spatial analysis (Hsu & Lin, 2023). Notably, the review highlights a clear dominance of ChatGPT in the current research landscape, with significantly more attention given to this tool compared to other AI technologies (Tab. 1). This trend suggests both the widespread accessibility and versatility of large language models, but it may also reflect a certain narrowing of focus—where other potentially transformative tools, such as visual AI or domain-specific platforms, remain underexplored in environmental and geographical education.

Tab. 1: Most often used AI tools in current environmental and geographical research and practice

AI TOOL	MENTIONED IN (N OF 17)	CONTEXTS IN WHICH THE IDENTIFIED TOOLS WERE USED
ChatGPT	16	Personalised learning, lesson planning, GIS assignment creation, curriculum reform, generating educational content, climate change education, assessment feedback, tutoring, and geography education tools.
Dall-e	4	Generating visual content for educational materials; used for creative and illustrative purposes in geography.
MidJourney	3	Image generation and creative visualisation in educational projects and visual storytelling.
Copilot	2	Mentioned as an example of code generation and AI support for educators and learners.
Perplexity	2	Listed alongside ChatGPT and Claude as a modern LLM for text-based learning assistance.
GeoAI	2	Specialised tool for enhancing spatial thinking and geographic analysis and was once mentioned in sources
Claude	1	Named among emerging GenAI tools capable of providing coherent educational responses.
Gemini	1	Used in climate adaptation-aligned curriculum design; highlighted for localised content generation.
GPTeach	1	Used in teacher training simulations with AI-powered student interactions.

Other generative tools featured in the literature include Gemini, Microsoft Copilot, Claude, Perplexity AI, and GPTeach (a pedagogy-focused AI assistant). These tools were used for summarising academic texts, designing learning activities, supporting multilingual instruction, and translating course content (Baidoo-Anu & Owusu Ansah, 2023; Bahroun et al., 2023). Visual tools such as DALL·E 2 and Midjourney were employed to illustrate geographical processes and model environmental change (Lee et al., 2025; Richards et al., 2024). AI-powered educational platforms were also highlighted for their adaptive learning features and formative assessment capabilities, allowing for more differentiated and student-responsive teaching (Richards et al., 2024; Kamalov et al., 2023).

2. Educational Benefits and Threads of Identified AI Tools

Several key advantages of AI in education were repeatedly highlighted. The most prominent among them was AI's potential for personalised learning, allowing tools to adjust the pace, difficulty, and type of content according to individual student needs (Kamalov et al., 2023). Large language models and adaptive learning platforms were found to enhance not only cognitive learning outcomes but also affective and reflective dimensions of learning. Students used AI to create self-assessment rubrics, obtain formative feedback, and engage in reflective learning processes (Lee et al., 2025; Scheider et al., 2023; Richards et al., 2024).

Another commonly cited benefit was AI’s role in fostering environmental literacy by helping students grasp the complexity of natural systems, global interdependencies, and sustainability challenges (e.g. Atkins et al., 2024). Moreover, AI tools were often employed to enhance public engagement in climate change mitigation efforts by creating accessible and interactive content

(Rane et al., 2024). Educators described AI as both a support mechanism for lesson planning and an innovative force for reshaping assessment strategies (Dede, in Anderson, 2023).
At the same time, several authors highlighted the importance of approaching AI integration critically. Ethical concerns such as bias, data privacy, and unequal access were noted as ongoing challenges (Cowls et al., 2023). AI-detection tools like GPTZero were sometimes used to verify content authenticity, although their limitations necessitated complementary human judgment (Griffiths, 2023). Lastly, caution was raised about over-reliance on AI, which could potentially erode students' independent reasoning and critical thinking if not integrated within carefully designed pedagogical frameworks (Scheider et al., 2023).

3. Field-Specific Applications in Environmental and Geographical Education

Beyond general educational use, the literature also points to domain-specific applications of AI in environmental and geographical education. GeoAI—a field that merges spatial data analysis with machine learning—was frequently mentioned for its capabilities in monitoring land use changes, modelling urbanisation, and assessing climate-related risks (Redican & Davis, 2025; Rakuasa, 2023). Furthermore, retrieval-augmented generation (RAG) systems were noted for their ability to combine language models with verified datasets, thus improving the factual accuracy of AI-generated responses (Lee et al., 2025). These more technical applications were often complemented by pedagogically innovative approaches that use AI to engage students in experiential, situated learning.
In particular, scenario-based learning emerged as a promising strategy, where students interacted with AI to model future environmental conditions, explore conservation approaches, and simulate decision-making processes through role-play involving AI-generated stakeholder perspectives (Richards et al., 2024; Naidoo, 2024). Several studies further emphasised the integration of local knowledge and indigenous narratives into AI-supported learning, promoting culturally relevant and decolonised curricula—especially in contexts from the Global South (Naidoo, 2024; Richards et al., 2024).
In parallel, AI was also described as a structural agent that shapes how environmental topics are framed, taught, and understood in classrooms (Chang & Kidman, 2023), suggesting that these tools are not merely pedagogical aids but also influential actors in educational discourse. Taken together, these findings highlight the multifaceted and evolving role of AI in environmental and geographical education—not only in terms of technical applications but also in shaping critical, place-based, and culturally responsive approaches to learning.

Discussion and Concluding Remarks

The findings of this review underscore a pivotal shift in environmental and geographical education, where AI is not only enhancing traditional teaching methods but also reshaping how environmental issues are conceptualised, communicated, and acted upon. The integration of generative AI tools reflects a growing recognition of their pedagogical potential—particularly in terms of personalisation, student motivation, and engagement. These tools are not simply augmenting existing curricula; they are enabling new forms of learning that foreground interactivity, reflection, and scenario-based exploration. However, this innovation must be viewed in light of deeper pedagogical questions and concerns mentioned above.
At the same time, the applications of AI within environmental and geographical education identified in this review point to a broader transformation in how environmental knowledge is produced and negotiated in educational settings. Tools like GeoAI and RAG systems are expanding the analytical capacities of learners, while scenario-based simulations and the integration of indigenous knowledge offer pathways toward more inclusive and situated learning. Yet, these developments also highlight persistent tensions—between innovation and equity, automation and critical thinking, global tools and local contexts. Future research and policy must therefore attend not only to what AI can do, but also how, for whom, and under what conditions it is deployed.
While the findings of this review are inevitably limited by the relatively small number of studies that met the inclusion criteria, they nonetheless offer a valuable snapshot of the current state of research on AI in environmental and geographical education. The scarcity of relevant publications in this area—especially when compared to the significantly higher volume of AI-related studies in other educational fields—suggests that this domain is at risk of falling behind in engaging with emerging technological developments. Given the growing relevance of both

environmental issues and AI across society, this gap signals a pressing need for more focused attention within environmental and geographical education research. This review therefore not only maps the current landscape but also underscores the importance of expanding scholarly inquiry into how AI can support and reshape learning in these critically important fields.

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Souhrn
Studie systematicky mapuje využití nástrojů umělé inteligence v environmentálním a geografickém vzdělávání. Na základě analýzy 17 odborných zdrojů identifikuje klíčové AI nástroje, jejich přínosy i rizika a ukazuje, jak konkrétně jsou tyto nástroje využívány v kontextu environmentální výuky. Celkově studie dokládá, že AI zásadním může potencionálně ovlivnit způsob, jakým jsou environmentální témata chápána, vyučována a diskutována ve výuce, a zdůrazňuje proto potřebu kritické reflexe jejího využití v budoucnosti.

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