A Systematic Review Study on the Use of Artificial Intelligence in Environmental Education

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Article Info	Abstract
	Environmental education is the solution to the environmental problems caused by technological advancements. Technological advancements make human life easier in many aspect. Today, artificial intelligence is one of the current technological advancements. The purpose of this research is to determine the general trend in studies on the use of artificial intelligence in environmental education, identify gaps in the relevant literature, and explain how current developments in educational technologies impact environmental education. This research is a systematic review. In this research, studies on the use of artificial intelligence in environmental education were systematically compiled to reveal how new developments in artificial intelligence affect the environmental education process. Seventeen studies were included in the review process. This research has two main conclusions. First, artificial intelligence in environmental education is a relatively new and current topic in literature. Second, the use of artificial intelligence tools causes water waste and carbon emissions. Therefore, the conscious use of artificial intelligence is essential for both teachers and students to be aware of it.

Introduction

Unusual temperatures, unstoppable forest fires, melting glaciers, the disruption of life cycles, loss of biodiversity, drought, and hunger… Today, environmental problems, with their underlying causes and consequences, have escalated into unavoidable environmental disasters. These issues affect not only the physical environment but also all of humanity, creating numerous economic and social challenges. Addressing environmental problems has become a priority on the global agenda. The key to solving these problems lies in transforming environmentally harmful behaviors into environmentally friendly ones. This transformation is not a simple, linear process; rather, it is a complex undertaking involving multiple disciplines, encompassing cognitive, affective, and psychomotor domains, and depending on both knowledge and positive attitudes. The foundation of this process is environmental education. Environmental education seeks to cultivate environmentally conscious individuals who strive for sustainable solutions to environmental problems (Tilbury, 1995; Erten, 2004; UNESCO, 2017).

Environmental problems began with the developments that followed the Industrial Revolution. After this period, technology advanced rapidly, living standards improved, and the population grew significantly. The needs of this expanding population also increased, leading to the reckless exploitation of natural resources (Köseoğlu, 2023). Technology has transformed many aspects of daily life, particularly human behavior (Akgün, 2019). Education is undoubtedly one of these areas. The integration of technology into education is a widely studied topic today. Factors such as the rapid advancement of technological products, the widespread availability of internet access, and the expansion of online education during the COVID-19 pandemic (UNESCO, 2023) have begun to reshape the education systems of countries worldwide (Arslan et al., 2022). One of the most prominent technological innovations today is artificial intelligence. The use of artificial intelligence in education often involves developing new curricula and producing teaching materials such as virtual reality tools and robotics. While artificial intelligence is recognized for enabling more lasting and effective learning experiences for students, the question of how best to integrate it into education remains a highly debated issue (Chen et al., 2020). Consequently, there appears to be no consensus in the literature on how educational processes can most effectively benefit all stakeholders (Güzey et al., 2023).

Artificial intelligence plays a crucial role in addressing many global crises, particularly climate change. It accelerates the process of describing current situations and obtaining existing data. Teaching processes incorporating artificial intelligence have brought many benefits. However, when it comes to environmental education, the issue becomes more complex. The primary goal of environmental education is to find solutions to

environmental problems. One of the root causes of environmental problems is technological advancements itself. When the use of ChatGPT, one of the most widely adopted artificial intelligence applications, is examined in the context of its carbon and water footprint, the picture that emerges is concerning: A 2023 study by Cheng et al. found that a short conversation (20–50 questions and answers) with ChatGPT consumed approximately half a liter of water. Considering its global use, with billions of questions asked daily, this clearly points to significant water consumption. The same study also reported that a single training session in a data center required about 700,000 liters of fresh water. A similar situation exists regarding carbon footprints. To further analyze this issue, the researcher asked ChatGPT the question: "Does using you harm the environment?" (queried on July 28, 2025). ChatGPT's response is summarized as follows (Table 1):

"Using me consumes a small amount of energy with each query, which indirectly leads to carbon emissions. However, this harm is minimal for single uses but becomes significant for millions of uses. If 100 million ChatGPT queries are made per day, this translates to tons of CO_2 emissions.

Table 1. Approximate estimated data

	Carbon Emissions (CO_2)
Making a single ChatGPT query	~1-5 gram
Google search	~0.25 gram
Watching YouTube for 1 hour	~150 gram
Send 1 email	~4 gram

"If the purpose of an AI is to benefit humans and increase productivity, this benefit must be achieved without harming nature and the environment. By using me responsibly and consciously, I will help make this process more sustainable."

A similar concern exists regarding cryptocurrency mining. Cryptocurrency is a product of new technology and is used by a wide range of investors as a payment product. This process consumes significant energy. It is known that cryptocurrency mining consumes the same amount of energy as a small country, thus significantly increasing fossil fuel use. The intensive use of cryptocurrencies means more fossil fuels and causes serious environmental damage (Elbir-Mermer & Kurtulgan, 2024). Therefore, it can be considered a new generation environmental problem. The unlimited use of artificial intelligence will create a similar situation. Carbon emissions are one of the most significant factors disrupting the fundamental balance of the environment and are the root cause of many environmental problems. With the widespread use of artificial intelligence today, and its integration into education proving controversial, it is neither possible nor logical to isolate children from this technology. Therefore, incorporating these current technologies, which are among the root causes of environmental problems, into environmental education is a challenging process.

In summary, environmental education is the solution to the environmental problems caused by technological advancements. Technological advancements make human life easier in many aspect. Today, artificial intelligence is one of the current technological advancements Many studies have investigated the role of artificial intelligence in education, both nationally and internationally. However, a detailed examination of this literature reveals an absence of research specifically addressing its role in environmental education (Ateş, 2025; Yeşilyurt et al., 2024; Kutlucan & Seferoğlu, 2024; Çavuş, 2024; Meço & Coştu, 2022; Güzey et al., 2023; Akdeniz & Özdinç, 2021; Chen et al., 2020; Huang et al., 2021).Therefore, conducting a systematic review on the use of artificial intelligence in environmental education will fill a gap in the literature and offer a current perspective on this emerging topic. Identifying the trends in studies conducted on this topic will also provide insight into how artificial intelligence is being incorporated into environmental education from an environmentally friendly perspective. The purpose of this research is to determine the general trend in studies on the use of artificial intelligence in environmental education, identify gaps in the relevant literature, and explain how current developments in educational technologies impact environmental education. To this end, the research problem was defined as "What are the general trends and characteristics of studies on the use of artificial intelligence in environmental education?"

Method

This research, conducted to determine the general trend in studies on the use of artificial intelligence in environmental education, is a systematic review. When conducting systematic reviews, a core topic is first identified. Research on this topic is scanned in detail and examined based on inclusion/exclusion criteria. At the end of this process, studies to be included in the review are identified and analyzed in depth (Higgins & Green,

2011). In this research, studies on the use of artificial intelligence in environmental education were systematically compiled to reveal how new developments in artificial intelligence impact the environmental education process. The systematic review process was conducted in five steps (Table 2). This process was conducted under the supervision of an expert with publications in the field of environmental education.

Table 2. Systematic review process

Step	Name	Explanation
1	Determining the Purpose of the Research	1. The research objective has been established. 2. The research problem related to the purpose of the research has been determined.
2	Creating the Review Protocol	1. Keyword definitions were determined. 2. Databases were selected. 3. Inclusion and exclusion criteria were established.
3	Literature Search	1. Studies were searched in specific databases. 2. Reviews were conducted based on inclusion and exclusion criteria.
4	Finding Studies to be Included in the Review	1. The studies to be undertaken have been finalized. 2. The studies have been summarized in an Excel spreadsheet. 3. The studies have been reviewed.
5	Analysis of Research	1. The summary table was analyzed using content analysis. 2. Trends and gaps in the literature were identified. 3. The research text was written.

Determining the Purpose of the Research (Step 1)

In compiling studies, it is first necessary to determine the topic, purpose, and problem of the research. The topic chosen for this systematic review is the use of artificial intelligence in environmental education. The aim of this research is to "determine the general trend in studies on the use of artificial intelligence in environmental education, identify gaps in the relevant literature, and explain how current developments in educational technologies impact environmental education."

Creating the Review Protocol (Step 2)

After determining the research purpose, it is necessary to identify studies to be included in the review. A review protocol should be developed to facilitate this process. This will create a roadmap. First, the keywords that will shape the literature review were identified. The keywords identified for this research were "environmental education, artificial intelligence," "environmental education, artificial intelligence tools," "environmental education, ChatGPT," "education for sustainable development, artificial intelligence," "education for sustainable development, artificial intelligence tools," and "education for sustainable development, ChatGPT."

Alternatively, a search was conducted using the keyword "artificial intelligence in education." The databases to be searched were then determined. Scopus, ERIC, Web of Science, ProQuest, TR Index, and YÖKTEZ were selected. After determining the keywords and databases, inclusion and exclusion criteria were determined. All studies combining environmental education and/or education for sustainable development with artificial intelligence technologies were included in this search. Studies written on environmental protection but related to disciplines such as engineering, health, technology, and economics that included a dimension of AI were not included in the review. Similarly, existing studies on the use of AI in education were not included if they did not emphasize environmental education and/or education for sustainable development.

Literature Search (Step 3)

A literature search was conducted using relevant keywords in the identified databases. The studies identified through the literature search were examined in detail based on the inclusion and exclusion criteria described above. At the end of this process, 17 studies were identified. The number of studies retrieved from all databases during the literature search was 920. When duplicates (identical studies found in different databases) were removed from these databases, the remaining number of studies decreased to 210. A review of the inclusion and exclusion criteria, as well as the titles and abstracts of the studies, determined that 30 studies were suitable for the scope of the study. A detailed review of these studies revealed that the content of 13 articles was not suitable for educational research. At the end of this process, a total of 17 studies were included in the systematic review process.

Finding Studies to be Included in the Review (Step 4)

Following the literature search process, a summary Excel file was created listing the 17 studies to be included in the systematic review and their characteristics. The studies were recorded in a summary table by examining and evaluating the characteristics required for scientific research. This way, the data was created, organized, and made ready for content analysis.

Analysis Process (Step 5)

Content analysis was deemed appropriate for analyzing the data from the 17 studies included in the review. Content analysis is an analysis conducted to identify concepts that explain the data and the relationships between these concepts. This process involves conceptualizing the data, organizing these concepts, deriving themes that explain the data, and then numerically explaining the codes and themes (Yıldırım & Şimşek, 2016).

During the data analysis, studies from national and international literature were analyzed individually to reveal trends related to the characteristics specified in the research subproblems. The studies were then considered as a whole to determine the general trend in literature. Following this analysis, gaps in literature were also identified, in addition to the general trends of studies. The findings of the analysis were explained using frequencies and percentages as predicted by the content analysis and summarized in tables. The analysis process was conducted under the supervision of a researcher with publications in the field of environmental education. Relevant information is described under the Findings section of the study.

Results and Discussion

The research problem for this article was defined as "What are the general trends and characteristics of studies on the use of artificial intelligence in environmental education?" The characteristics of studies on the use of artificial intelligence in environmental education are described by article type, year of publication, method, sample, and sample size. The general trends of the relevant studies include an analysis of the articles' aims and results. The relevant findings are presented in tables below.

Table 3. Type of article

Type of article	f	%
Research	13	76.5
Theoretical	4	23.5

All of the studies included in the review were articles. Thirteen (76.5%) of the articles were research articles and four (23.5%) were theoretical articles (Table 3).

Table 4. Publication year of articles

	f	%
2018	1	5.9
2021	2	11.8
2022	1	5.9
2023	3	17.6
2024	4	23.5
2025	6	35.3

The first example of research focusing on environmental education and artificial intelligence was seen in 2018. 1 study (5.9%) was published in 2018. No research was found on this topic published in 2019 and 2020. 2 studies (11.8%) were found in 2021 that investigated environmental education and artificial intelligence together, and 1 (5.9) in 2022. It has been observed that there has been an increase in research on the place of artificial intelligence in environmental education since 2023. 4 studies (23.5%) were conducted in 2024 and 6 (35.3%) in 2025. This can be interpreted as that the place of artificial intelligence in environmental education has just started to attract attention with the developments in technology (Table 4).

Table 5. Articles methods

Method	f	%
Experimental	4	23.5
Case study	2	11.8
Survey	2	11.8
Mixed	1	5.9
Design development	2	11.8
None (theoretical paper)	4	23.5
Not specified	2	11.8

Of the 17 articles included in the review, 4 (23.5%) were theoretical and therefore lacked methodological information. Of the 13 articles that were research articles, 2 (11.8%) did not specify any methodology. Of those with methodological information, 4 (23.5%) were experimental, 2 were case studies, design development, and screening (11.8%), and 1 (5.9%) was a mixed methods study. All these findings indicate that the research conducted focused primarily on quantitative methods (Table 5).

Table 6. Sample of articles

Sample	f	%
Students	8	47.1
Documents (programs-key case studies, AI tools)	3	17.6
Experts	2	11.8
Faculty members	1	5.9
Teachers	1	5.9
People	1	5.9
Green Entrepreneurs	1	5.9
None (theoretical article)	4	23.5

Of the studies included in the review, 8 (47.1%) were conducted with students. Among these, 3 involved university students, 2 involved college students, 2 involved elementary school students, and 1 focused on children in early childhood. In 3 studies (17.6%), data were collected from documents such as curricula, notable case studies, and AI tools. In 2 studies (11.8%), expert opinions were gathered on projects developed within the scope of the research. In 1 study (5.9%), data were collected from faculty members; in another (5.9%) from teachers; in another (5.9%) from green entrepreneurs; and in one (5.9%) from the people (Table 6).

Table 7. Sample number of articles

Sample number	f	%
1-49	4	23.5
50-99	1	5.9
100-149	0	0.0
150-199	1	5.9
200-249	1	5.9
250 and more	3	17.6
None (theoretical article)	4	23.5
Not specified	2	11.8

When the sample size of the studies included in the review is examined, it is seen that the density is 1-49 people and 250 and above. There are 4 articles (23.5%) working with sample sizes in the range of 1-49, and 3 articles (17.6%) working with sample sizes of 250 and above. The sample size of 1 article (5.9%) is in the range of 150-199, and 1 article (5.9%) is in the range of 200-249 (Table 7).

Table 8. Purposes of articles

Purposes of the articles	f	%
Demonstrating the benefits of AI		
Helping to gain awareness of sustainable development	3	17.6
Supporting green education	3	17.6
Facilitate the development of environmentally friendly projects/curriculum	2	11.8
Ensuring efficient use of resources	1	5.9
The impact of AI-supported teaching processes		
Sustainable development awareness	2	11.8
Environmental awareness		
Positive attitude towards the environment	3	17.6
Ecological knowledge	2	11.8
Environmentally friendly behavior	2	11.8
Gaining individual experiences	2	11.8
Demonstrate their intention to accept AI technologies in environmental protection	2	11.8

An examination of the objectives of the studies included in the review revealed that all data were grouped under three themes: "Exposing the benefits of AI," "Impact of AI-supported teaching processes," and "Exposing intentions to accept AI technologies in environmental protection." There are four codes under the theme of "Exposing the benefits of AI." Raising awareness of sustainable development and supporting green education are the most frequently mentioned codes (17.6%). These studies also observed benefits of AI, such as facilitating the development of environmentally friendly projects/curriculum (11.8%) and ensuring the efficient use of resources (5.9%). Most of the studies discussing the benefits of AI are theoretical articles.

There are two codes under the theme of "Impact of AI-supported teaching processes." These are sustainable development awareness and environmental awareness. The proportion of studies examining sustainable development awareness is 11.8%. The number of studies on environmental awareness is higher and also addresses environmental awareness elements. Of the relevant articles, 17.6% addressed positive attitudes toward the environment, while 11.8% addressed acquiring ecological knowledge, environmentally friendly behavior, and personal experience. The aims of the research articles were largely concentrated around the theme of the impact of AI-supported learning processes. Another theme was "Exposing intentions to accept AI technologies for environmental protection." The proportion of studies under this theme was 11.8% (Table 8).

Table 9. Results of the articles

Results of the articles	f	%
Raising environmental awareness		
Increasing attitudes towards the environment	7	41.2
Increasing environmental knowledge	4	23.5
Environmentally friendly behavior		
Proposing sustainable solutions to environmental problems	2	11.8
Protecting the environment	1	5.9
Accessing information about environmental issues		
More	4	23.5
Easier	4	23.5
Simplifying complex ecological concepts	2	11.8
Making environmental education interdisciplinary		
Creating environmentally friendly STEM projects	4	23.5
Meaningful learning	4	23.5
Raising awareness of sustainable development		
Developing environmental ethics	3	17.6
Creating a future-oriented learning environment	3	17.6
Supporting inclusive/quality education	3	17.6
Supporting the SDGs	2	11.8
Eco-citizenship	1	5.9

An examination of the results of the articles included in the review revealed that artificial intelligence technologies increase environmental awareness, facilitate access to information about environmental issues, make environmental education interdisciplinary, and foster sustainable development awareness. Overall, while the articles' purposes and types vary, their results appear to be supportive. Articles claiming that artificial

intelligence technologies increase environmental awareness also mentioned elements of environmental awareness. 41.2% of these articles indicated an increase in positive attitudes toward the environment, while 23.5% indicated an increase in environmental knowledge. Furthermore, there is a dimension of environmentally friendly behavior. These behaviors include proposing sustainable solutions to environmental problems (11.8%) and protecting the environment (5.9%). The articles' results indicate that accessing information about environmental issues is more frequent (23.5%) and easier (23.5%) thanks to artificial intelligence technologies. Furthermore, it is said that the complex nature of ecological knowledge has become simpler (11.8%) with artificial intelligence. According to the articles, environmental education is becoming more interdisciplinary with the support of artificial intelligence. Creating environmentally friendly STEM projects (23.5%) and thus developing meaningful learning (23.5%) becomes possible. The incorporation of artificial intelligence technologies into environmental education raises awareness of sustainable development, as does environmental awareness. The articles' results also emphasize the societal and social dimensions of sustainable development. It is stated that artificial intelligence improves students' environmental ethics (17.6%), creates future-focused learning environments (17.6%), and supports quality education (SDG Goal 4) (17.6%). In other words, 11.8% of these articles also support the 2030 UN Sustainable Development Goals by integrating artificial intelligence into environmental education. One study also mentioned the concept of ecological citizenship (5.9%, Table 9).

Conclusion

This research is a systematic review that aims to determine the general trend in studies on the use of artificial intelligence in environmental education. The review identified 17 studies combining environmental education and artificial intelligence, all of these studies were published in the form of articles. No articles on the subject were found in national literature; all of the articles belong to international literature. The publication years range from 2018 to 2025. The first article was published in 2018, and there has been an increase since 2023. These findings indicate that artificial intelligence was gaining a new place in the relevant literature. The fact that 4 of the articles on artificial intelligence in environmental education in the relevant literature were theoretical articles also supports this interpretation. Many of the research articles were experimental or involved in new product design. . Overall, the articles either present theoretical knowledge on the subject or demonstrate the effectiveness of new interventions or products.

A review of the literature revealed multiple compilations on artificial intelligence in education. These studies suggested that the integration of artificial intelligence into education increases student achievement and learning motivation, facilitates teachers' instructional design processes, and individualizes student experiences (Baker & Inventado, 2014; Luckin et al., 2016; Holmes et al., 2019; Zawacki-Richter et al., 2019). The findings of this study align with these interpretations in the context of environmental education. The objectives of the articles included in the systematic review indicate the importance of examining the effects of artificial intelligence-supported teaching processes on environmental awareness and sustainable development awareness. Three fundamental elements are mentioned in the theoretical context of environmental awareness: environmental knowledge, positive attitudes toward the environment, and environmentally friendly behavior (Erten, 2004). In parallel with this information, the reviewed articles also provided specific information on the knowledge, attitude, and behavior dimensions of environmental awareness. The research aims to explain the benefits of artificial intelligence specifically in environmental education. Particularly in theoretical articles, the aim was to explain how sustainable development awareness is fostered through artificial intelligence, how artificial intelligence supports environmentally friendly (green) education processes, and how it facilitates the development of environmentally friendly projects and curriculum. While the articles' objectives vary, their results offer a common picture. The articles' results suggest that artificial intelligence increases environmental awareness, particularly its attitude dimension. As for environmentally friendly behavior, they demonstrate its benefits in proposing sustainable solutions to environmental problems and protecting the environment. However, the research appears to focus more on the knowledge and attitude dimension. The article results also demonstrate that artificial intelligence increases the environmental knowledge dimension of environmental awareness and facilitates access to more and easier information about environmental issues. Indeed, as environmental knowledge increases, positive attitudes toward the environment also increase. More research is needed on environmentally friendly behavior. While the results of relevant studies highlight the benefits of artificial intelligence in environmental education, no information was available on the environmentally friendly use of artificial intelligence. Another observation in the research results was that some of the studies included in the review emphasize environmental education as a transdisciplinary process. Artificial intelligence made the process transdisciplinary and provided meaningful learning with environmentally friendly STEM projects.

Another result offered by research was that it raises awareness of sustainable development. It was said that artificial intelligence makes it easier to create learning environments based on the future. Another significant finding was that Quality Education, one of the 2030 UN Sustainable Development Goals, supports the context of inclusive education. Quality Education emphasizes equal opportunities in education and forms the basis of all Sustainable Development Goals. AI-based technologies facilitate access to teaching materials for disadvantaged children and children with special needs (Good, 2021). Furthermore, according to a 2019 UNESCO report, they also provide appropriate learning opportunities for children who have difficulty integrating into society, those with disabilities, migrants and refugees, and those who are out of school. Indeed, the results of relevant research were known to support the implementation of the 2030 UN Sustainable Development Goals. This clearly demonstrates that artificial intelligence has a significant place both in teaching sustainable development approaches and in achieving the goals of the global sustainable development agenda.

The ethical context of artificial intelligence is also a topic of debate. It is believed that artificial intelligence can have a misleading effect on data privacy, access to accurate information, and impartiality. For all these reasons, information obtained from artificial intelligence must be integrated into teaching processes as a facilitator and continuously monitored (Baker & Inventado, 2014; Luckin et al., 2016; Holmes et al., 2019; Zawacki-Richter et al., 2019). In addition to the ethical concerns in the findings of this research, relevant articles have concluded that it can improve environmental ethics. A report by the Council of Europe on artificial intelligence states that teachers' literacy on this topic must be improved so that they can use artificial intelligence more consciously in teaching processes. It also emphasizes that teachers must be decision-makers in every process they use artificial intelligence and question all information. This will ensure that artificial intelligence is reliably incorporated into education (Holmes et al., 2022). Both teachers and students should be aware that the use of artificial intelligence tools causes water waste and carbon emissions, and therefore, their conscious use is essential. In this context, consideration should be given to whether artificial intelligence is a solution to environmental problems or a new factor that will exacerbate them. Carbon and water footprints are increasing due to new environmental problems. While carbon emissions can be reduced through the use of renewable energy sources, reducing the water footprint in this way does not seem possible. The 2030 UN Sustainable Development Goals and the 2015 Paris Climate Agreement are two recent developments aimed at addressing all environmental problems, especially climate change. The primary goal of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping global temperature rise to 2 degrees Celsius above pre-industrial levels this century and to strive to limit the temperature increase to 1.5 degrees Celsius. The most fundamental step to this goal is to reduce carbon emissions globally. It is imperative to be aware of this global effort when using emerging technologies like artificial intelligence.

Recommendations

In light of all this information, the following recommendations have been reached:

This article is a systematic review of research on the use of artificial intelligence in environmental education. 17 articles were identified that focused on this topic. This demonstrates the emerging position of this topic in the relevant literature. Future studies should expand research on this topic. The majority of studies reviewed are theoretical, while research articles are mostly experimental in design. Future research should employ a wider variety of methods to strengthen sample selection, sample size, and the generalizability of findings. The correct and conscious use of artificial intelligence is considered a necessity. The integration of artificial intelligence into education is also an important and current issue. It is recommended that faculty members be supported in this area. This can increase both the use of artificial intelligence in education and the number of research on the subject. Simply using artificial intelligence to access accurate information and conscientiously address privacy will be insufficient. Artificial intelligence must be used in an environmentally friendly manner. Experts in the field should inform faculty members, principals, teachers, students—in short, all stakeholders in the educational process.

Scientific Ethics Declaration

Conflict of Interest

Funding

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