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Integrating Digital Tools in Environmental Education: A Systematic Literature Review of Impact and Challenges

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Abstract

The growth in integration of digital tools in environmental education reflects the prominence of digital learning. Despite its rise, limited studies have examined its effective application in school-based environmental education. This systematic literature review (SLR) investigates the impact of digital tools in enhancing environmental education in schools, along with the linked challenges. The review employed five key steps: developing a review protocol, formulating research questions, applying the PRISMA framework, conducting a systematic search across Scopus, Web of Science, and Google Scholar, and thematic analysis. A total of 25 articles published between 2015 and 2025 were selected based on the inclusion criteria. Four key themes emerged: student engagement, immersive learning, experiential and adaptive learning, and personalised instruction, while the challenges included limited access to technology, insufficient teacher readiness, and digital overdependence. This review highlights the need for inclusive strategies to implement digital tools in environmental education effectively.

Keywords: Digital Tools, Environmental Education, School, Impact, Challenges

Introduction

The evolution of digital tools has become irresistible in the education system, especially during the pandemic, educators and students utilised digital tools as the medium of the teaching and learning process (Dennis, 2024) and that has become a norm in the education system. The digitalised education makes learning innovative and more interesting (Dancsa et al., 2023). Aligned with the Sustainable Development Goals (SDGs), education plays a key role in empowering students, promoting social justice, and fostering skills like

critical thinking, problem-solving, and self-directed learning (United Nations, 2015; Biasutti et al., 2017; Kwee, 2021)

As technology advances, tools as interactive websites and platforms, learning apps and software, e-books and digital textbooks make learning more flexible. Digital tools are defined as software, programs, applications, platforms, and online or offline resources that can be used with computers, mobile devices or other digital devices that contribute to people completing a task efficiently (Oikonomou & Patsala, 2021), navigating the classroom and students towards the complexities of a technology-driven society (Dooley et al., 2016). This shift represents a fundamental re-evaluation of learning, aligning with the digital competencies required in the modern world.

With environmental education playing a crucial role, it was first introduced at the Stockholm Conference in 1972, as a process to develop a generation that is aware of and concerned about environmental issues with the knowledge, skills, values, and motivation to work individually and collectively toward environmental solutions (Habibah Lateh et al., 2009). Environmental education empowers individuals to investigate environmental issues through problem-solving and action (EPA, n.d.), and as Yarkandi et al. (2012) noted, it serves to educate people about how nature functions while guiding them to manage their behaviour and ecosystems sustainably.

The lack of environmental education in schools has become a primary concern in strategising improvement to the national education framework (Kamaruddin et al., 2019). Unlike countries like Denmark, where environmental education is taught as a standalone subject, in Malaysia, it is integrated across subjects such as Science and Geography without formal assessment (Larsen & Azizi, 2000), and its objectives often remain unfulfilled (Rohana et al., 2013). Although this approach promotes sustainability, it is criticised for relying heavily on traditional chalk-and-talk methods (Isaac, 2004), which limit interactivity and real-world application. Overdependence on notes and rote learning further restricts student engagement, critical thinking, and problem-solving (Abdul Malek, 2016).

According to IPGKT (n.d.), environmental education can raise awareness about the preservation of flora and fauna as human life and the environment are interdependent, through curriculum pedagogy and co-curricular activities (Yarkandi et al., 2012). It aims to provide knowledge but also to encourage sustainable practices in daily life. Now that the strategy has become inevitable, it makes learning more accessible, interactive, and data-driven. From virtual simulations to AI-powered platforms, technology enhances learning and equips students with the digital literacy and skills needed to confront the real-world sustainability challenges (Hoffman, 2025).

Numerous studies have explored the integration of digital tools into the teaching and learning of sustainability topics in schools. Digital tools act as a smart approach to help students in understanding issues related to sustainability, climate change and conservation of natural resources through innovative methods such as virtual ecosystem simulations, real-time environmental data analysis and the use of chatbots as learning assistants. These tools not only enhance students' understanding but also promote collaborative learning and more effective problem-solving, which is beneficial for a sustainable future.

Despite their effectiveness, limited research has studied how these tools are applied effectively in school-based environmental education, mainly in the Malaysian context. Driven by this gap, this study conducts a systematic literature review (SLR) to evaluate the impact of digital tools in enhancing environmental education in schools and to identify the challenges involved. The key contributions of this study are: (1) synthesising recent evidence on how digital tools influence student engagement, learning outcomes, and sustainability awareness; and (2) providing a thematic analysis of the barriers and opportunities for integrating these tools effectively, offering practical insights for policymakers, educators, and curriculum designers.

Background of the Study

This section provides a comprehensive study into the application of digital tools in environmental education in schools by reviewing existing literature. It highlights how these tools enhance environmental education and also identifies the challenges to incorporating these tools into the learning of sustainability, providing a deeper understanding of the role of digital tools in transforming environmental education. The discussion offers a comprehensive view of the concepts, impact, and obstacles involved in promoting sustainable education through digital means.

Driven by the limited research on the effective integration of digital tools, particularly in Malaysian schools, this review aims to mend that gap by evaluating their impact on student engagement, conceptual understanding, and sustainability awareness. Its key contributions lie in synthesising recent evidence on best practices for digital tool implementation and providing a thematic analysis of the barriers and opportunities that can guide educators, policymakers, and curriculum designers. In doing so, this study not only enhances understanding of technology-enhanced environmental education but also offers practical insights to support its effective implementation in schools.

Research Objectives

1. To study the impact of the integration of digital tools in environmental education at the school level.
2. To identify the challenges associated with implementing digital tools for environmental education in schools.

Research Questions

1. What are the impacts of the integration of digital tools into environmental education in schools?
2. What are the challenges in implementing digital tools for environmental education at the school level?

Methodology

This study conducts a systematic literature review to explore the impact of integrating digital tools in environmental education at the school level. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, the research applies a structured approach to identify, select and analyse relevant literature to provide a comprehensive summary of digital tools' role in environmental education as well as to identify the challenges that hinder its effectiveness in the teaching and learning processes.

Phase 1: Identification

Table 1 shows the structured search strategy that was conducted using Scopus, Web of Science (WoS) and Google Scholar as the primary databases. Based on the research questions, the key terms identified include “digital tools,” “environmental education,” and “schools”. The keyword “challenges” was used to narrow down the results for challenges of digital tools. This approach ensures a systematic and inclusive identification of literature to explore the digital tools applications in environmental education and the challenges associated with their
implementation at the school level. Table 2 outlines the search strings for each database.

Table 1
Selection criteria

Criteria	Inclusion	Exclusion
Year of Publication	2015 - 2025	2014 and earlier
Type of document	Journal articles	Conference papers, books, book chapters, theses, reports, and reviews
Language	English	Non-English
Access to full text	Open access	Limited or no access

Table 2
Search strings

Criteria	Inclusion
Scopus	("environmental education" *) AND ("digital tools" *) AND ("school" *)
Web of Science	("environmental education" *) AND ("digital tools" *) AND (“schools”*)
Google Scholar	("digital tools"*) and ("environmental education"*)and (“school”*) and ("challenges"*)

Phase 2: Screening

The articles were screened by title and abstract to ensure relevance to the research keywords. Irrelevant studies were excluded, and duplicates across Scopus, Web of Science, and Google Scholar were removed. Only eligible and relevant articles were included for analysis in the systematic literature review.

Phase 3: Eligibility

The articles were assessed for eligibility based on inclusion and exclusion criteria. Only those meeting all criteria were selected for final review to ensure relevance in addressing the research questions.

Phase 4: Exclusion

9 articles were removed from the list. 4 articles were removed due to limited or no access for viewing, while 5 articles were removed because they were duplicates in other databases.

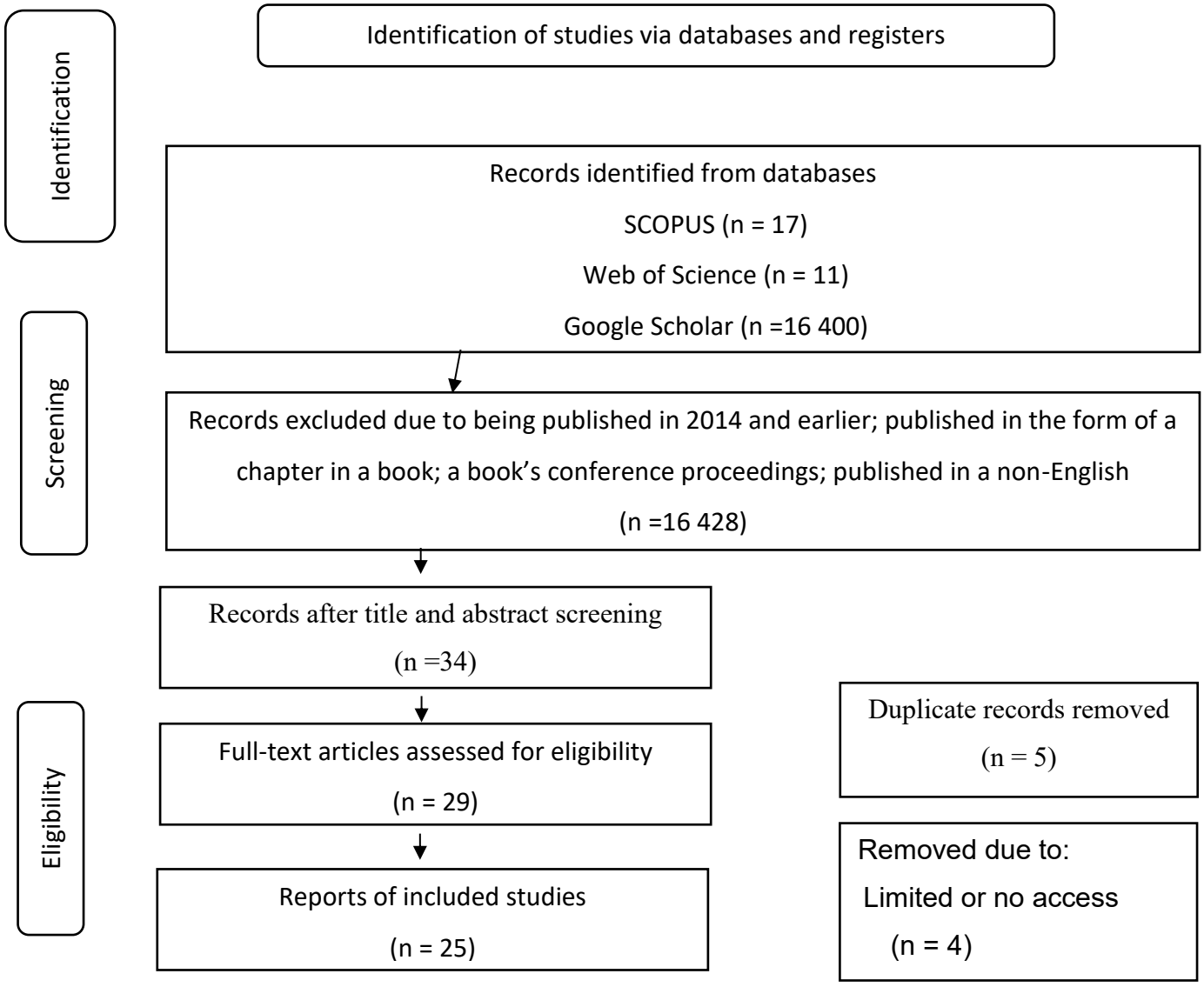

Figure 1: PRISMA flowchart of the article screening and selection process

Findings and Results

Year of Publication

Figure 2 shows that a total of 8 articles were published in 2023 (32.0%). As 5 articles published in 2024 (20.0%) highlight the use of AI in environmental education, 4 articles published in 2021 (16.0%) and another 4 articles in 2022 (16.0%), highlighting the application of vast technologies in environmental education. 2 articles (8.0%) published in 2025 illustrate the future developments in using AI-based tools and other digital tools in environmental education. Finally, each article published in 2017 (4%) and 2019 (4%) shows the development of digital tools in engaging young students in exploring environmental education.

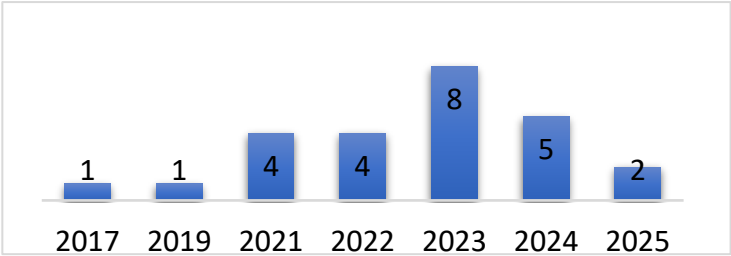

Figure 2: Year of publication

Research Methodology

Based on Table 3, 10 studies (40.0%) used a qualitative method, focusing on conceptual analysis, case studies and curriculum development, while 7 articles (28.0%) used a quantitative approach like experimental designs. The remaining 8 articles (32.0%) used a mixed-method approach, noting a balanced study between the theory-leaning interest in AI and digital tools in environmental education.

Table 3
Summary of research design

Research Design	Number of articles
Qualitative	10
Quantitative	7
Mixed	8

Geographical Distribution

Based on Table 4, 14 articles were published in Asia (56.0%), followed by a rise in the use of technology post-pandemic. The development of technology and the advanced implementation of digital tools in the curriculum boosted another 4 studies (16.0%) in European countries. 2 studies were conducted in North America (8.0%) while 3 studies were conducted in the context of global (12.0%), and 2 articles were published in the Oceania region (8.0%)

Table 4
Geographical distribution

Region	Number of Articles
Asia	14
Europe	4
North America	2
Oceania	2
Global	3

Size of Sample and Research Method

Table 5

Size of sample and research method

Author(s)	Target Group	Research Method
Xia (2024)	Not specified	Survey
Guo (2021)	32 students from two elementary schools	Case study
Pratiwinindya et al. (2021)	32 students of an elementary school	Scenario-based learning
Sadykova (2024)	Not specified	Case study
Chen S.-Y. (2022)	26 elementary sixth-grade Taiwanese students and 26 elementary sixth-grade Japanese students	Experimental
Lo et al. (2021)	80 students in a primary school in Taiwan	Experimental
Hara, M. (2023)	Educators and policymakers in lower-middle-income ASEAN countries	Literature review and conceptual analysis
Chang et al. (2023)	Geography and environmental education professionals	Conceptual analysis and case studies
Ardyansyah et al. (2023)	30 natural science class students from a high school	Experimental research
Arici, F. (2024)	70 students of the 5th grade	Experimental research with pre-/post-assessments
Arvola et al. (2021)	5th-grade students participating in outdoor education programs	Case study and field research
Brečka, 2022	Not specified	Case study
Khan et al. (2024)	Environmental education students	Experimental research, survey
Aggarwal (2023)	Educators and students	Literature review and theoretical framework
Lee (2022)	Elementary school students	Conceptual analysis and curriculum design
Reshmi et al. (2024)	Learners	Case study
Arif, M. et al. (2025)	3 students and 5 teachers	Case study with pre-/post-assessments
Mulders et al. (2023)	172 German secondary school students	Experimental research with pre-/post-assessments
Nguyen et al. (2025)	14 participants (high school students and teachers, undergraduates and environmental education experts)	Design-based research and user study
Ricoy & Sánchez-Martínez. (2022)	83 students, 68 parents, 5 teachers	Case study
Jardin (2023)	6 teachers and 20 students from diverse grade levels	Exploratory
Akay, C. Ö., & Çakır, Ö. (2023)	38 preschool children & 18 parents	Experimental
Schönfelder & Bogner (2017)	354 students from different secondary schools	Pre-test/post-test assessments
Buchanan et al. (2019)	None	Case study
Nakamura et al. (2023)	Not specified	Experimental

Table 5 summarises the types of research methods and sample size applied in the selected articles. Notably, 48% (n=12) of the studies applied experimental research to describe the impacts of the interventions, with comprehensive outcomes (Zubair, 2023).

Another 24% (n=6) of the articles applied case studies. A total of 3 (12%) studies used a conventional research method, which is the literature review. 2 studies (8%) applied a survey method, while another 2 (8%) used a design-based research method.

Educational Level of the Schools Involved

Table 6

Educational level of the schools involved in the study

School Level	Article
Kindergarten	Arif et al. (2025), Akay (2023)
Elementary	Lo et al. (2021), Lee (2022), Nakamura et al. (2023)
Primary	Guo (2021), Pratiwinindya et al. (2021), Chen S.-Y. (2022), Arvola et al. (2021), Brečka et al. (2022), Ricoy & Sánchez-Martínez (2022), Buchanan et al. (2019)
Secondary	Sadykova (2024), Chang & Kidman (2023), Ardyansyah & Rahayu (2023), Arici (2024), Khan et al. (2024), Reshmi et al. (2024), Mulders et al. (2023), Nguyen et al. (2025), Schönfelder & Bogner (2017), Jardin (2023)
General	Xia (2024), Hara (2023), Aggarwal (2023)

Based on Table 6, 10 articles (40%) were conducted at the secondary education level, indicating that integration of digital tools in education has been generalised among teenagers. Meanwhile, 7 studies (28%) focused on primary school contexts, emphasising students' readiness to incorporate digital tools into learning. 3 articles (12%) explored general education levels, involving mixed groups of students to assess the broader impact of digital tools in environmental education. Another 3 studies (12%) were conducted at the elementary level. Notably, only 2 studies (8%) focused on the kindergarten context.

Area of Environmental Education

Table 7

List of subjects focused on in the research

Subject Focus	Article
Environmental Education / Awareness	Xia (2024), Brečka et al. (2022), Khan et al. (2024), Lee (2022), Reshmi et al. (2024), Arif et al. (2025), Nguyen et al. (2025), Ricoy & Sánchez-Martínez (2022), Guo (2021), Jardin (2023), Akay et al. (2023), Buchanan et al. (2019)
Sustainability / Sustainable Development	Sadykova (2024), Hara (2023), Lo et al. (2021), Aggarwal (2023), Schönfelder & Bogner (2017)
Science	Ardyansyah & Rahayu (2023), Arici (2024), Mulders et al. (2023)
Environmental Attitudes / Action	Chen S.-Y. **(**2022), Pratiwinindya et al. (2021), Nakamura et al. (2023)
Language / Geography	Guo (2021), Chang & Kidman (2023)

Table 7 shows that 12 articles emphasise environmental education and awareness (48%), noting the increase in students' understanding of environmental issues, interactively. Another 5 studies (20%) addressed sustainability by using digital platforms to adopt long-term thinking and global responsibility. A cluster of 3 articles (12%) focused on science education, particularly in general science, chemistry, and environmental science contexts. 3 studies (12%) explored the environmental attitudes and actions among the students, while 2 articles (8%) studied the integrated environmental themes within language and geography education.

Types of Digital Tools

Table 8

Types of digital tools used

Cluster	Article	Digital Tool Used
Augmented Reality (AR)	Chen S.-Y., (2022)	AR digital picture books
	Lo et al. (2021)	AR-based science inquiry
	Ardyansyah & Rahayu (2023)	AR-based card game
	Arici (2024)	AR
	Arvola et al. (2021)	Mobile AR
Artificial Intelligence (AI)	Hara (2023)	AI
	Chang & Kidman (2023)	Generative AI
	Khan et al. (2024)	Klipaa.Id App (AI-supported)
	Aggarwal (2023)	AI
	Lee (2022)	AI programming
	Reshmi et al. (2024)	AI tutoring
	Arif et al. (2025)	AI-powered platforms
	Nguyen et al. (2025)	AI chatbots
Digital Storytelling & Multimedia	Guo (2021)	Digital storytelling
	Sadykova (2024)	Digital storytelling
	Pratiwinindya et al. (2021)	Interactive multimedia
	Buchanan et al. (2019)	Digital storytelling
Extended Reality (XR)	Mulders et al. (2023)	XR (Extended Reality)
Gamification	Ricoy & Sánchez-Martínez (2022)	Gamification
Smart Tools & Interactive Platforms	Brečka et al. (2022)	Smart Notebook
	Nakamura et al. (2023)	Web Application
Digital Tools (General)	Xia (2024)	Digital tools
	Schönfelder & Bogner (2017)	Digital tools
	Akay et al. (2023)	Web 2.0 tools
	Jardin (2023)	Digital tools

Table 8 shows that 8 studies (32.0%) explored AI-driven tools to enhance personalised learning and streamline tasks in environmental education. Five studies (20.0%) focused on Augmented Reality (AR) for immersive and interactive learning. Four studies (16.0%) examined digital storytelling and multimedia, while another four (16.0%) focused on general digital tools. One study each (4.0%) investigated Extended Reality (XR) and gamification, and two studies (8.0%) explored smart tools and interactive platforms. These tools enhance engagement by providing interactive, multimedia experiences, gamified elements, virtual explorations beyond physical limits, and dynamic content that fosters environmental awareness and learning.

Developed Themes

The thematic analysis conducted on 25 selected articles resulted in four main themes: (1) Engagement and Motivation, (2) Personalised Learning, (3) Immersive and Visual Learning Experiences, and (4) Experiential and Adaptive Learning. The analysis of these themes provides comprehensive answers to the main research question of this systematic literature review: “What are the impacts of the integration of digital tools into environmental education in schools?” The background and context of the selected studies are further elaborated in the subsequent section.

Table 9
Summary of impacts of the research and the identified themes

Article	Impact	Engagement & Motivation	Personalised Learning	Immersive & Visual Learning Experiences	Experiential and Adaptive Learning
Xia (2024)	Enhances engagement with environmental education, enabling diverse learning experiences.	/		/	/
Guo (2021)	Uses storytelling to immerse students in environmental issues	/		/	
Pratiwinindya et al. (2021)	Boosts interaction through engaging multimedia content	/		/	/
Sadykova (2024)	Extends learning beyond the classroom with interactive exploration	/		/	/
Chen S.-Y. (2022)	Visualises environmental concepts through immersive experiences.	/		/	
Lo et al. (2021)	Promotes active learning via hands-on AR activities	/		/	/
Hara (2023)	Increases engagement through personalised learning tools	/	/		/
Chang & Kidman (2023)	Enables adaptable, dynamic learning in environmental education	/	/		/
Ardyansyah & Rahayu (2023)	Integrates playful AR for engaging, interactive learning	/		/	/
Arici (2024)	Integrates playful AR for engaging, interactive learning	/		/	
Arvola et al. (2021)	Offers flexible, accessible ways to engage with topics	/	/	/	
Brečka et al. (2022)	Delivers dynamic content and interactive learning experiences	/		/	/
Khan et al. (2024)	Personalises content to suit individual learning needs	/	/		

Aggarwal (2023)	Adapts to learners' needs to enhance engagement	/	/		
Lee (2022)	Teaches coding through real-world environmental challenges	/	/		/
Reshmi et al. (2024)	Provides real-time, personalised concept reinforcement	/	/		
Arif et al. (2025)	Adapts to progress with interactive learning environments	/	/		/
Mulders et al. (2023)	Offers immersive spaces for in-depth topic exploration	/		/	/
Nguyen et al. (2025)	Supports real-time, conversational learning and reinforcement	/	/		/
Ricoy & Sánchez-Martínez (2022)	Makes learning fun through game-based engagement	/		/	/
Jardin (2023)	Fosters engagement, creativity, and active learning	/		/	/
Akay et al. (2023)	Improves preschoolers' attitudes through engaging experiences	/			/
Schönfelder & Bogner (2017)	Boosts knowledge, especially for less-aware learners	/		/	/
Buchanan et al. (2019)	Encourages creativity and reflection via media creation	/		/	/
Nakamura et al. (2023)	Deepens understanding through localised, real-time data use	/		/	/

Engagement and Motivation

Table 5 illustrates that all articles (100%) reported an increase in student engagement and motivation when using digital tools in environmental education. Xia (2024) and Ricoy & Sánchez-Martínez (2022) noted that the digital learning environments dynamically draw students into sustainability content. Traditionally, the engagement of students often became a challenge due to the abstract concepts. Now, application of digital tools has enhanced learning to be interactive and simulates real-life environmental problems (Nguyen et al., 2025; Reshmi et al., 2024; Chen S.-Y., 2022). Guo (2021) highlighted how immersive storytelling builds compassion toward environmental issues, while Nguyen et al. (2025) adapted real-time conversational learning and involvement towards environmental issues.

Schönfelder & Bogner (2017) signified the need to support low-interest students, allowing them to create their digital media interest (Buchanan et al., 2019), increasing curiosity and strengthening students' connection with environmental challenges (Nakamura et al., 2023).

Personalised Learning

Personalised learning allows the implementation of differentiated pedagogy based on every student's needs, progress, preferences and social background (n=9; 36%). Hara (2023), Khan et al. (2024) and Chang & Kidman (2023) discussed the adaptive content delivery where digital tools analyse the students' behaviour in real time and allow the educators to adjust the difficulty level, type of content, or pace accordingly. Aggarwal (2023) emphasised its benefits in diverse classrooms where students may have varying levels of prior knowledge about environmental issues. Tools such as AI tutors and adaptive platforms offers on-the-spot feedback and tailored resources (Reshmi et al., 2024) while Arif et al. (2025) highlighted the importance of realising and understanding the students' geographical and social backgrounds as it can provide the teachers to personalise the teaching of environmental issues by choosing the right tool to be incorporated into the process to enhance the contextual learning.

Immersive & Visual Learning Experiences

Digital tools provide immersive & visual learning experiences for the students to engage interactively with environmental issues (n=16; 64%) as it allow students to see the abstract environmental phenomena through interactive simulations, improving the students' memory retention and reasoning skills (Xia, 2024; Arici, 2024). It also provides a deeper exploration of the interdependence between environment and humans (Mulders et al., 2023) as well as reshaping students' perceptions and interactions with environmental issues beyond the classroom, fostering emotional engagement and empathy through virtual observation, multimedia creation, and interactive tools (Guo, 2021; Schönfelder & Bogner, 2017; Buchanan et al., 2019; Nakamura et al., 2023). Digital storytelling and simulations stimulate emotions by visualising issues like habitat loss or rising seas, fostering awareness and responsibility as students actively 'experience' rather than passively 'read' about environmental issues.

Experiential and Adaptive Learning

Digital tools promote experiential and adaptive learning by enabling students to actively engage in hands-on, real-world problem-solving. 18 studies (72%) highlighted how immersive environments, such as AR-based activities and simulations, allow students to explore environmental challenges, test solutions, and apply critical thinking skills (Lo et al., 2021; Ardyansyah & Rahayu, 2023; Pratiwinindya et al., 2021). Simultaneously, tools that support creativity and adaptability—like coding platforms and interactive media—foster flexible thinking, innovation, and customised responses to environmental issues (Chang & Kidman, 2023; Lee, 2022; Buchanan et al., 2019). This combination of experiential and adaptive approaches empowers students to take ownership of learning, strengthens their decision-making skills, and encourages deeper connection with sustainability themes.

Challenges in Integrating Digital Tools in Environmental Education in Schools

Table 10

Challenges in integrating digital tools in environmental education

Article	Infrastructure & Accessibility	Teacher Readiness & Training	Curriculum Alignment	Cognitive Overload / Distraction	Lack of Longitudinal Evidence
Xia (2024)	/				/
Guo (2021)		/	/		/
Pratiwinindya et al. (2021)	/	/	/	/	
Sadykova (2024)	/				/
Chen S.-Y. (2022)	/	/		/	/
Lo et al. (2021)		/	/		/
Hara (2023)		/	/		/
Chang & Kidman (2023)		/	/		/
Ardyansyah & Rahayu (2023)	/	/		/	
Arici (2024)	/				/
Arvola et al. (2021)	/		/		/
Brečka et al. (2022)	/			/	/
Khan et al. (2024)		/			/
Aggarwal (2023)		/	/		/
Lee (2022)	/	/	/	/	/
Reshmi et al. (2024)		/			/
Arif et al. (2025)	/	/	/		/
Mulders et al. (2023)	/			/	/
Nguyen et al. (2025)		/			/
Ricoy & Sánchez-Martínez (2022)		/	/		/
Jardin (2023)	/	/		/	
Akay et al. (2023)				/	/
Schönfelder & Bogner (2017)					/
Buchanan et al. (2019)	/	/	/		/
Nakamura et al. (2023)	/	/	/		/

Table 10 shows that a notable challenge in 22 articles (88%) is the lack of long-term or in-depth studies, stressing the difficulty in realising the effectiveness of these tools in environmental education. Another major concern raised in 17 studies (68%) is that teachers often feel unprepared or lack proper training to use these tools. Limited infrastructure and poor accessibility, reported in 56% of the articles, also pose barriers, especially in rural schools. Curriculum misalignment (48%) further complicates things, as digital tools do not fit skilfully into learning activities, making it difficult to teach environmental topics effectively. Cognitive overload (32%) is another issue, where students may feel overwhelmed by too much or too complex information.

Discussion

Post pandemic, digital tools have been providing real-life experiences for school-goers, in observing, reasoning and making decisions in solving environmental issues. However, the lack of studies on the effectiveness of digital tools hinders educators in identifying suitable tools and methods to integrate these tools, minimising students' positive engagement in the sustainability-related activities, reducing their motivation towards Sustainable Development Goals (United Nations, n.d.). As Xia (2024) urged for equal opportunities for students to engage with the environment physically and tactilely, Guo (2021) and Chen S.-Y. (2022) urged the need for comprehensive and long-term studies on the effectiveness of digital tools in sustainability learning.

Another challenge is the limited implementation of personalised learning for the students, which can be linked to the lack of teachers' readiness and training. Educators are responsible for planning and executing the teaching and learning activities using digital tools according to the students' background and abilities in perceiving the knowledge about environmental issues. Arif et al. (2025) implied the need for collaboration between the researchers and educators to design an AR program that fuses the students' learning and behavioural skills while Guo (2021) indicated that teachers may need more professional development training to build their confidence in integrating digital tools effectively into teaching environmental education.

Integrating technology in education is not just about placing the tools in the classrooms or supporting the traditional methods (Smaldino et al., 2008), but it is a shift toward student-centred learning, technologically (Inan et al., 2009). As traditional learning methods are gradually fading among the youngsters, digital tools offer dynamic, interactive learning and problem-solving (Balińska et al., 2021). As McMillan (2022) stated that mixed reality is less accessible than Augmented Reality (AR) or Virtual Reality (VR) because it cannot be utilised effectively on smartphones, on the other hand, Xia (2024) suggested unbiased access to technology for all students, where schools must invest in the infrastructure and resources to provide all students with access to digital tools, which promotes engaging learning about sustainability programs globally.

The emergence of artificial intelligence as the front-runner of all digital tools provides personalised learning experiences, adapts to individual student needs, and enhances innovation in educational practices to address sustainability issues efficiently. However, Hara (2023) stated that being overly dependent towards AI-driven tools reduces the interaction and personalised instruction, as well as a distraction to the students to be active and experience effective learning of sustainability. Hara (2023) illustrated how AI tools can diminish critical thinking skills, creativity, and problem-solving abilities. Hence, it is vital to balance integrated technology with traditional teaching methods to ensure an efficient education.

The integration of digital tools has significantly promoted environmental education in schools as it creates opportunities for developing personalised instruction that meets students' individual learning needs and preferences. Above and beyond, digital tools are incorporated in the learning of environmental education or sustainability to offer immersive and visual learning experiences of ongoing environmental issues, which allows the young

learners to explore the issues virtually and practice problem-solving skills using tools such as Chatbots, AI-driven tools and Augmented Reality (AR).

However, to fully realise these benefits, several challenges must be addressed. Many students still lack access to digital tools, and educators often require professional training to integrate technologies effectively and creatively. Continuous support and development are essential to build teachers' digital literacy and pedagogical strategies. Therefore, ongoing professional development and equitable access to digital tools must become a priority for policymakers to ensure meaningful and inclusive environmental education.

Conclusion

In short, the review shows the positive impacts of the integration of digital tools in environmental education, which encourages student engagement, personalised learning, and promotes interactive learning experiences that bring real-world environmental issues into the classroom setting. Challenges such as limited evidence, poor access, and insufficient teacher training must be addressed through a holistic approach to ensure digital tools support—rather than replace—critical thinking, creativity, and hands-on learning in environmental education. Future research should focus on long-term, context-specific studies that examine student perceptions and pedagogical effectiveness, while ensuring equitable access to infrastructure and professional training to fully realise the transformative potential of digital tools in fostering environmental responsibility among students.

Recommendations

In this review, the least discussed themes, personalised learning, creativity, and adaptability, require further studies to explore the effectiveness of digital tools in promoting engaging and meaningful learning experiences for the students, crucially in guiding the educators to foster personalised learning based on the students' individual needs. Furthermore, future research should study the challenges linked to the overdependence on digital tools, on top of how effective digital tools can be incorporated into environmental education. Also, the use of digital tools in environmental education over an extended period needs to be studied to ensure the validity of data collection and offer a more comprehensive understanding of how these tools can effectively support the education of the younger generation in sustainability.

Limitation

Despite addressing both research questions, several limitations were identified in this study. Firstly, the literature review was limited to articles published between 2015 and 2025, potentially excluding relevant studies outside this range. Secondly, only 3 databases were selected: Web of Science, Scopus and Google Scholar, excluding others like ERIC and IEEE Xplore that may offer a broader literature. Finally, the limitation in variability of research methodologies and educational levels across the selected studies may affect the validity of the findings.

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