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Learning Media for Environmental Education, What Can the Scopus Database Tell Us? A Review

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ABSTRACT

Environmental education plays a pivotal role in fostering sustainability awareness and behavioral change, especially when supported by effective pedagogical tools. In recent years, the integration of digital technologies—including mobile applications, augmented reality, videos, and interactive platforms—has increasingly reshaped traditional teaching strategies to enhance cognitive development and environmental literacy. However, persistent challenges such as limited resources, technological infrastructure, and teacher preparedness continue to hinder widespread adoption. This study contributes by mapping how digital learning media have evolved within environmental education research, highlighting conceptual shifts and emerging interdisciplinary intersections. Unlike prior reviews, this article offers a combined bibliometric and qualitative analysis of 17 Scopus-indexed articles published from 2018 to 2023, using Scopus AI and VOSviewer tools. Results show that digital media—such as gamification and social platforms—appear to be more promising than conventional methods in promoting environmental understanding and engagement. The most prominent research themes include environmental education, sustainable development, and learning media, with increasing attention to mobile learning, augmented reality, and interdisciplinary strategies. Five key conceptual clusters emerged: (1) sustainability integration in higher education, (2) innovative pedagogies, (3) links between environmental literacy and behavior, (4) cross-disciplinary approaches (e.g., through language learning), and (5) utilization of digital media. These findings underscore the transformative potential of technology while advocating for adaptive and inclusive learning designs. Nevertheless, the results should be interpreted in light of limitations related to database scope and publication context. Future research should investigate long-term behavioral outcomes, culturally adaptive media design, applications of AI, and strategies to bridge equity gaps across diverse educational settings.

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INTRODUCTION

Environmental education is fundamental in creating awareness and promoting sustainable lifestyles among individuals of all ages (Esteban Ibáñez et al., 2020; van de Wetering et al., 2022; Vladova, 2023). In the current era of digitalization, the incorporation of technology into education systems has revolutionized conventional pedagogical practices, providing innovative means of engaging learners on matters pertaining to the environment (Bitar & Davidovich, 2024; Çelik & Baturay, 2024; Haleem et al., 2022; Mhlanga, 2024; Mhlongo et al., 2023). Digital media, such as mobile applications, augmented reality, virtual reality, videos, and online discussions, has shown great promise in advancing environmental education through enhancing cognitive development, creativity, and environmental awareness (Pereira et al., 2020). However, notwithstanding its advantages, the use of learning media in environmental education is confronted with constraints such as restrictions on resources, technological hurdles, and the need for teachers' training (Adieva et al., 2024; Kohler et al., 2022).

Knowing the prevailing trends, gaps, and emerging opportunities in this area is essential for advancing the effective use of learning media in environmental education. Recent studies have highlighted the growing influence of digital media tools—such as AR-based card games and educational videos—on students' comprehension of environmental issues and their engagement in learning activities (Ardyansyah & Rahayu, 2023; Zuhriyah & Astra, 2021). While these studies demonstrate the potential of digital interventions to enhance conceptual understanding and motivation, most focus on small-scale experimental settings or specific technologies in isolated contexts. For instance, Ardyansyah and Rahayu (2023) examined the short-term gains in engagement from an AR card game, but did not explore its integration into broader curricular frameworks or long-term behavioral effects. Similarly, Zuhriyah and Astra (2021) provided evidence of increased interest through video-based learning, yet lacked a discussion of scalability or interdisciplinary application. This review addresses these gaps by providing a comprehensive overview of the conceptual landscape through a bibliometric and qualitative analysis of 17 Scopus-indexed articles. Unlike prior research, which tends to evaluate isolated tools or learning outcomes, this study maps the broader evolution of research themes, identifies underexplored intersections (e.g., between digital media and cross-disciplinary pedagogy), and highlights the need for scalable, inclusive, and adaptive digital learning designs in environmental education.

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In addition to that, social media and citizen journalism online have enhanced cultural communication and knowledge sharing in a manner that transcends geographical boundaries in environmental education (Hassan et al., 2023). Increasing numbers of families and educators depend on digital technologies in facilitating environmental learning, which reflects the contribution of collective digital experiences towards developing ecological literacy (Lin & Ardoin, 2023). In spite of these developments, the impact of various media formats is mixed and contingent on matters such as accessibility, interactivity, and pedagogical integration.

Despite the recent literature highlighting the potential of learning media in environmental education, several limitations remain. Most studies tend to examine specific tools—such as augmented reality (AR) applications (e.g., Ardyansyah & Rahayu, 2023) or video-based instruction (e.g., Zuhriyah & Astra, 2021)—in isolated settings without exploring how these tools can be integrated into broader pedagogical frameworks. These studies often focus on short-term outcomes, such as student engagement or immediate comprehension, while neglecting long-term behavioral change, cross-context adaptability, and interdisciplinary linkages. Furthermore, there is limited discussion on how such media can be scaled across diverse educational environments or aligned with sustainability competencies. This review aims to address these gaps by synthesizing research trends, mapping conceptual frameworks, and identifying underexplored intersections between digital media, pedagogy, and sustainable education practices.

There is the absence of overarching reviews that discuss trends in digital and traditional environmental education according to extensive bibliometric data, especially from databases such as Scopus. Studies tend to be centered on one digital tool (for instance, augmented reality or videos) without critically assessing their efficacy across a variety of learning settings. Issues like high expense, technological infrastructure, and teacher readiness (Kohler et al., 2022) are often debated but need systemic solutions. Additionally, the contribution of media to non-formal and informal environmental education is under-explored, implying a call for wider studies.

This review aims to: (1) Analyze trends in learning media for environmental education from Scopus database publications (types of learning media and keyword trends); (2) Discuss about the concept map research trend of media in facilitating environmental education; and (3) Identify Emerging themes in research trend of media in facilitating environmental education. This review offers a new synthesis of how digital learning media have evolved within environmental education, combining bibliometric mapping with qualitative analysis. Unlike previous research, this paper

systematically maps the interdisciplinary connections, thematic shifts, and emerging trends in the field between 2018 and 2023. The study contributes to the literature by uncovering five core research clusters, revealing conceptual gaps, and proposing directions for future research, particularly in the context of long-term behavioral change, cross-disciplinary integration, and the potential use of AI tools in environmental learning.

Findings from this study can inform educators, curriculum designers, and policymakers about the most promising forms of digital media for enhancing environmental literacy. The review also supports the development of adaptive, inclusive, and scalable learning environments aligned with sustainability goals. Future studies should investigate the long-term behavioral impact of digital learning media, assess their contextual adaptability in diverse educational settings, explore the integration of generative AI, and examine how interdisciplinary approaches can strengthen environmental education across various domains.

Give suggestions for further research and uses in the future in this field. Contribution This research adds to the literature by presenting a systematic review of digital media application in environmental education based on Scopus data. Through the synthesis of evidence across various studies, this article identifies the most successful digital tools, discusses implementation constraints, and recommends approaches to the optimization of technology-supported environmental learning. The recommendations from this review can inform teachers, policymakers, and researchers on how to create more impactful and inclusive digital learning solutions for environmental education.

RESEARCH METHODS

Data search uses two methods, namely Scopus AI and the regular search menu on Scopus subscription. Data retrieval was conducted using two complementary approaches: Scopus AI and the conventional search interface available through the institutional Scopus subscription. Scopus AI was selected for its advanced semantic search capability, which enables the identification of relevant articles based on conceptual proximity and emerging thematic relevance rather than relying solely on keyword matching. This approach helps capture nuanced and interdisciplinary studies that might otherwise be overlooked. In parallel, the regular Scopus search menu was used to ensure precision in filtering by publication year, document type, subject area, and database indexing criteria. To support data visualization and thematic clustering, VOSviewer was employed due to its strength in mapping co-occurrence networks of keywords, authors, and sources.

VOSviewer facilitates a clear visual representation of research trends and thematic relationships within a body of literature. The combined use of Scopus AI and VOSviewer offers a robust methodology for identifying and analyzing research patterns. However, this approach also has limitations. Scopus AI may occasionally retrieve articles with weak contextual relevance, requiring additional manual screening, while VOSviewer is constrained by its reliance on frequency-based relationships, which may overlook deeper semantic connections. Despite these limitations, this dual-method approach strengthens the validity and comprehensiveness of the bibliometric review.

In the Scopus AI performing keyword search facility is: ("learning media" OR "educational media" OR "instructional materials" OR "teaching resources") AND ("environmental education" OR "eco-education" OR "sustainability education" OR "environmental literacy") AND ("digital media" OR "multimedia" OR "interactive tools" OR "e-learning") AND ("curriculum" OR "program" OR "course" OR "training") AND ("engagement" OR "participation" OR "awareness" OR "outreach"). Meanwhile, in the Scopus search we use search within Keyword; title, and abstract with the following history: TITLE-ABS-KEY ("learning media" OR "teaching media" AND "environmental education"). Data simulation uses the facilities available in the Scopus AI output, Analyze results in the Scopus search results, and simulation using VOSviewer.

In the search using search within Keyword; title, and abstract on Scopus, we found 17 articles. All data were analyzed. Based on the Scopus search, the subject area of the articles analyzed is as presented in Figure 1. In the initial search using the Scopus database (search within title, abstract, and keywords), a total of 17 relevant articles were identified and included in the analysis. The limited number of articles is primarily due to the highly specific search syntax applied, which focused exclusively on the intersection of environmental education and the use of digital learning media (e.g., “environmental education” AND “digital media” OR “mobile learning” OR “augmented reality”), as well as the restriction to peer-reviewed journal articles published between 2018 and 2023. This time range was selected to capture the most recent developments in digital pedagogical tools aligned with current technological trends. Article selection was conducted based on several inclusion criteria: (1) the article must be written in English, (2) must be indexed in Scopus as a journal article (excluding conference papers and reviews), and (3) must explicitly focus on environmental education involving digital learning media. Abstracts were thematically validated to ensure conceptual relevance before inclusion in the dataset. While bibliometric studies typically rely on larger datasets for generalizability, this review prioritizes depth over breadth by targeting a

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focused and emerging niche within the broader field of environmental education. Nevertheless, the relatively small number of articles is acknowledged as a methodological limitation, and results should be interpreted within the scope of this specific research focus.

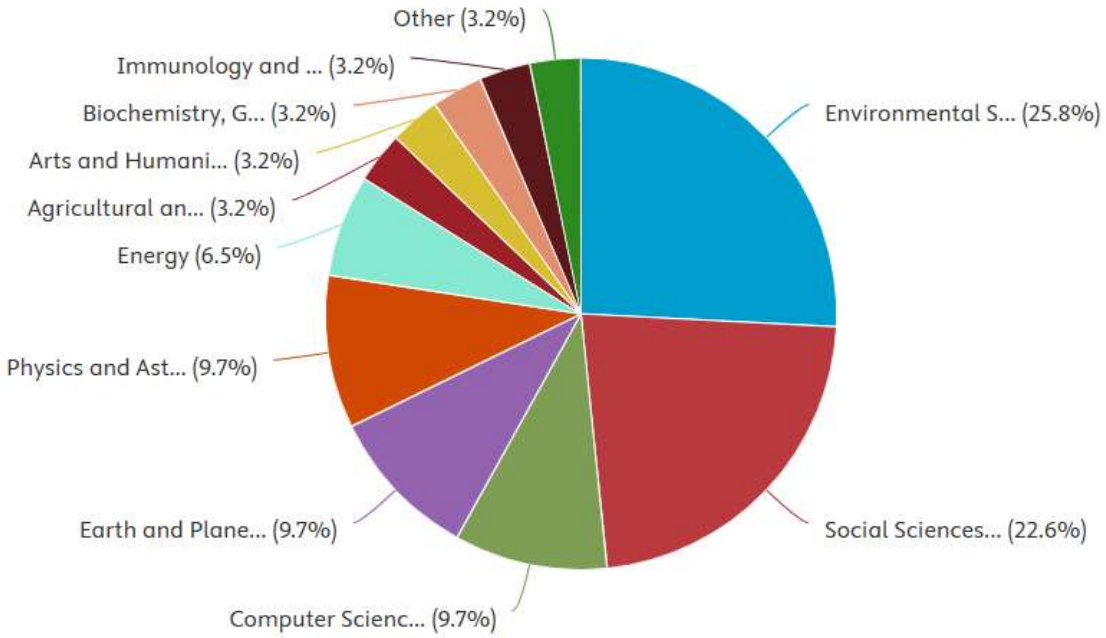

Figure 1. Subject area of the documents found

Based on Figure 1, it can be seen that the documents are dominated by Environmental Science (28.8%) and social sciences (22.6%). While others with smaller percentages are computer science, earth and planet, physics and astronomy, energy, agricultural and biological science, arts and humanities, biochemistry, genetics, and molecular biology, and immunology and microbiology.

Data analysis in this study was conducted through a mixed-method approach combining both quantitative and qualitative techniques to ensure a comprehensive understanding of current trends in digital learning media for environmental education. The analysis was carried out through three main steps: (1) Bibliometric Analysis: Bibliometric data retrieved from Scopus were processed using the built-in "Analyze Results" function to identify publication trends based on subject areas, document types, and publication years. (2) Science Mapping with VOSviewer: VOSviewer was used to generate visual maps of keyword co-occurrence, helping to identify research patterns, clustering of themes, and the conceptual relationships among articles. This simulation provided insight into how specific technologies (e.g., AR, mobile apps) are situated

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within the broader discourse of environmental education. (3) Qualitative Content Analysis: A manual content analysis of the 17 selected articles was conducted by two independent reviewers with research expertise in environmental education and educational technology. The reviewers performed open coding based on article abstracts and full texts to extract themes related to the types of learning media used, pedagogical strategies, and sustainability outcomes. To ensure consistency and objectivity, the coding framework was jointly discussed and refined through consensus. Discrepancies were resolved through discussion and re-evaluation of source content. Emerging themes were then categorized into five dominant clusters.

To increase transparency and methodological rigor, the article selection process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Although the final dataset includes only 17 articles, a PRISMA-based flow diagram was developed to outline the identification, screening, eligibility, and inclusion stages of article selection. This combination of bibliometric analysis, science mapping, and validated content analysis offers a balanced quantitative–qualitative approach that strengthens the reliability and depth of the findings.

RESEARCH RESULT

Learning Media for Environmental Education

Environmental Education (EE) aims to build awareness and responsibility towards the environment. Various learning media have been explored to enhance the effectiveness of EE, including digital technologies, interactive multimedia, and traditional methods. This is as presented in Table 1.

Table 1. Types of learning media for environmental education

No	Types of Learning Media	Specification	Important information/Effect	References
1	Digital Media and Technologies:	Interactive Multimedia	Effective in increasing environmental knowledge and ecosystem preservation. Studies show that multimedia learning is more effective than traditional lecture methods in enhancing environmental knowledge	(Wahyudi, 2022)
		Digital Technologies in Home Contexts	Families use digital technologies to support environmental learning, sparking discussions and supplementing other activities. This approach extends beyond passive screen time and involves active family engagement	(Lin & Ardoin, 2023)

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No	Types of Learning Media	Specification	Important information/Effect	References
		Video Media	Using videos, such as those depicting natural disasters, can significantly increase students' environmental sensitivity and awareness	(Zuhriyah & Astra, 2021)
2	Games and Simulations	Educational Games	Games can be used to teach environmental concepts, leveraging the natural inclination of young people to play. These games help develop critical thinking and decision-making skills	(Nagy et al., 2005).
		Playful Activities	Activities using mobile devices and applications like Kahoot! can enhance cognitive development, creativity, and awareness about environmental issues through interactive and collaborative learning	(Pereira et al., 2020).
3	Integrated Media and Marketing Communication	Integrated Marketing Communication (IMC:	IMC strategies can effectively capture the attention, interest, desire, and action of youth towards environmental stewardship. This method leverages various media channels to communicate environmental issues effectively	(Azizan et al., 2015).
4	Traditional and School-Based Methods	School Environment Utilization	Utilizing the school environment as a learning medium can positively impact students' understanding, critical behavior, and motivation towards environmental issues. However, challenges include mastering the concepts and managing learning time	(Nofrianti et al., 2020).
		Social Networking and Internet Activities	Organizing activities through social networking sites and emphasizing internet news reports can foster environmental literacy among college students	(Zhang, 2015).

Keywords trend

The results of the VOSviewer simulation related to keyword trends are presented in Figure 2. Based on the data, there are dominant and interrelated keywords, namely environmental education, sustainable development, students, learning, planning and learning media. Keywords that have small nodes are learning process, environmental protection, ecological education, environmental knowledge, environmental behavior, and educational development. Meanwhile, there are only two keywords related to media, namely digital divide, motion pictures, and computer programs.

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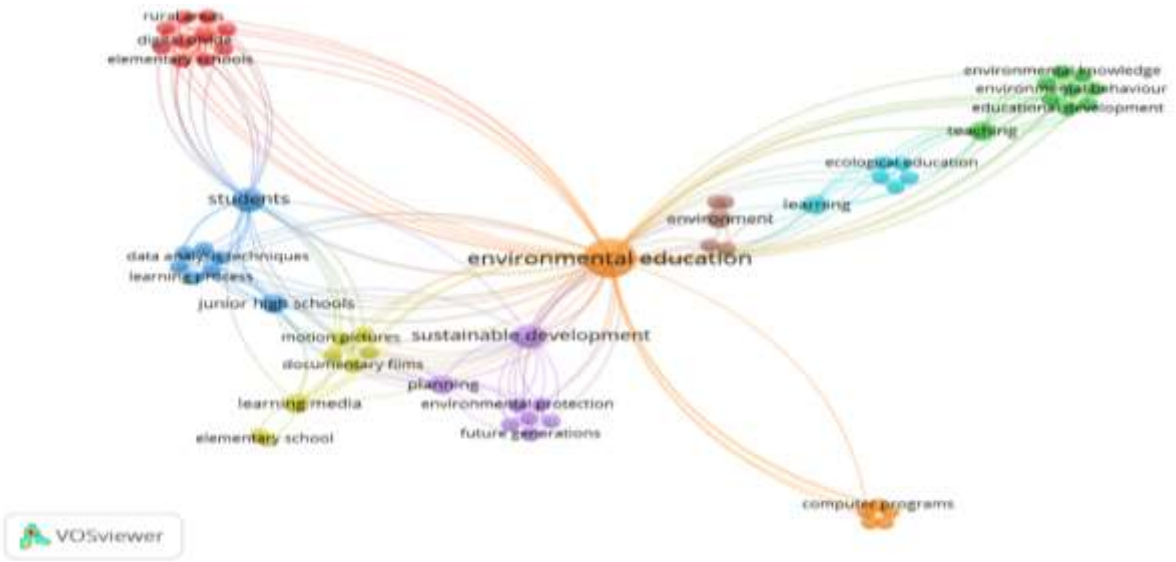

Figure 2. Keywords trends

Concept Map

The concept map of learning media for environmental education which is the output produced by Scopus AI is presented in Figure 3. Based on the figure, it can be seen that learning media for environmental education is divided into three, namely technological innovation, media objectives/designations, and types of media. In more detail, technological innovation focuses on mobile devices and augmented reality; media objectives/designations focus on transformative sustainability learning (STL), and Education for Sustainable Development (ESD); while types of media focus on Card Games and Environmental journalism.

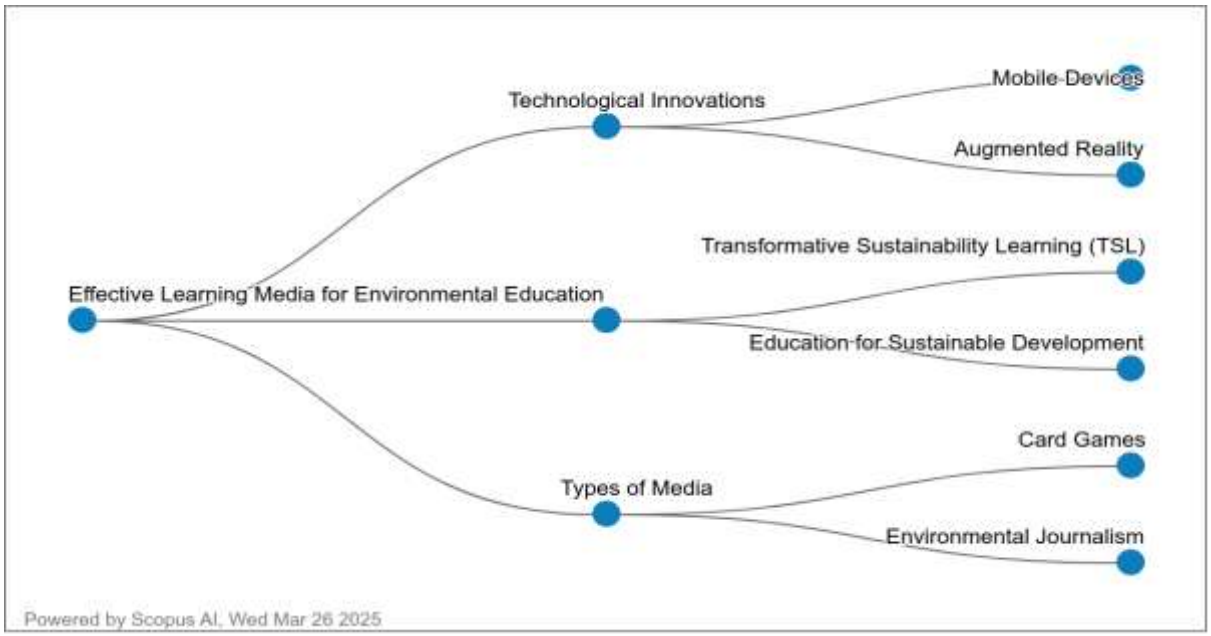

Figure 3. Concept map

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Emerging themes

Emerging themes are needed for identifying areas for further exploration and development. Based on the review of the Scopus AI search, we present five emerging themes, complete with Type of Theme and Important information as presented in Table 2.

Table 2. Emerging themes in learning media for environmental education topics

No	Emerging themes	Type of Theme	Important information	References
1	Sustainability Education in Higher Education	Consistent Theme	The focus on sustainability education within higher education institutions remains a consistent theme. This area explores the integration of sustainable practices and environmental literacy into university curricula, aiming to foster a generation of environmentally conscious graduates. The steady interest in this theme highlights its importance in shaping future leaders and professionals who are equipped to address environmental challenges	(Dundelová, 2024; Ewing et al., 2024; Fernandes et al., 2024; Hrei et al., 2024; Kuldoshev & Rahimova, 2024; Mousavi et al., 2024; Musa et al., 2024; Ushakov & Olexiva, 2024).
2	Innovative Strategies for Environmental and Sustainability Education	Consistent Theme	This theme focuses on the development and implementation of innovative strategies for teaching environmental and sustainability education. The consistent interest in this area suggests a continuous effort to improve educational methodologies and practices to better engage students and promote sustainable behaviors	(Dwyer, 2024; Goi, 2024; Maniatis, 2024; O'donoghue & Rosenberg, 2024; Papageorgiou et al., 2024).
3	Environmental Literacy and Pro-Environmental Behaviors	Rising Theme	The rising interest in environmental literacy and its impact on pro-environmental behaviors indicates a growing recognition of the importance of educating individuals about environmental issues to foster sustainable actions. This theme explores the relationship between knowledge, attitudes, and behaviors, and how education can bridge the gap between awareness and action	(Anderson et al., 2024; Bucea-Manea-Ţoniş et al., 2024; Meier et al., 2024; Rodway-Dyer & Barr, 2024).
4	Integration of Environmental Education in Language Learning	Rising Theme	The integration of environmental education into language learning is an emerging area of interest. This theme explores how language education can be used as a platform to raise environmental awareness and promote sustainability. The rising interest in this area suggests a novel approach to combining language skills with environmental consciousness	(Gunansyah et al., 2024; Ivorra-Catalá et al., 2024; Khodjakulova & Miceikiene, 2024; Koklu & Sulak, 2024).

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No	Emerging themes	Type of Theme	Important information	References
5	Digital and Social Media in Environmental Education	Rising Theme	The use of digital and social media in environmental education is gaining traction as a powerful tool for engaging and educating diverse audiences. This theme examines how digital platforms and social media can be leveraged to disseminate environmental knowledge, promote sustainable behaviors, and foster community engagement	(Rahmaulana & Sueb, 2024; Ramos-Luna et al., 2024; Salleh et al., 2025; Solís-Rojas, 2024; Tian et al., 2024).

DISCUSSION

As shown in Table 1, various forms of digital media—such as interactive multimedia (Wahyudi, 2022), video documentaries (Zuhriyah & Astra, 2021), and smart home devices (Lin & Ardoin, 2023)—have demonstrated the potential to enhance environmental learning outcomes more effectively than traditional lectures. While these studies report improvements in comprehension and engagement, most are limited to short-term assessments and do not evaluate long-term retention or behavioral change. For instance, although multimedia tools have been shown to improve students' understanding of ecosystem conservation (Wahyudi, 2022), there is still a lack of longitudinal research examining whether these effects persist over time. Similarly, Lin and Ardoin's (2023) findings highlight the role of digital devices in promoting environmental dialogue at home, but they stop short of exploring the socio-cultural factors that might influence such outcomes across different demographic contexts.

These gaps suggest a need for future studies to move beyond immediate learning gains and investigate how digital media interventions influence sustained environmental awareness, behavioral intention, and cross-context adaptability. Moreover, comparative research across various technological modalities and learner populations remains limited, leaving unanswered questions about which types of media are most effective for which groups, and under what conditions.

Environmental games and simulations is an interactive learning approach for understanding environmental concepts, especially suitable for younger students who are naturally inclined towards play-based learning (Nagy et al., 2005). Interactive software like Kahoot! enables cognitive development, imagination, and environmental literacy through collaborative learning (Pereira et al., 2020). The approach utilizes gamification to stimulate problem-solving and decision-making skills along with maintaining learner engagement.

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Aside from digital technologies, Integrated Marketing Communication (IMC) practices successfully engage young people in environmental conservation through the use of various media platforms (Azizan et al., 2015). In contrast, conventional approaches, such as the use of school settings as sites of learning, are still applicable despite limitations such as concept understanding and time management (Nofrianti et al., 2020). Web-based activities, such as social media marketing and news-oriented forums, also play a role in enhancing environmental literacy among university students (Zhang, 2015). The data suggests that environmental education can be delivered using a range of media, both traditional and new. A mix of these can enhance participation and effectiveness since it caters to various learning styles.

The results of the study show that learning media has effectiveness. The results of Quasi-Experimental Studies provide important information. Research indicates that learning media, such as interactive multimedia and video media, are effective in improving environmental literacy and sensitivity. For example, a study with a pre-test and post-test design showed significant improvements in environmental knowledge using multimedia learning (Rahmaulana & Sueb, 2024; Wahyudi, 2022). In addition, Qualitative and Descriptive Studies also strengthen this statement. Surveys and qualitative reports highlight the positive responses from students and teachers towards using various media for environmental education. These studies also identify constraints and recommend improvements in media availability and utilization (Ambe et al., 2024; Nofrianti et al., 2020). Based on this information it can be stated that the integration of various learning media, including digital technologies, interactive multimedia, games, and traditional methods, plays a crucial role in enhancing environmental education. These media not only improve knowledge and awareness but also engage students actively, fostering critical thinking and responsible behavior towards the environment.

Figure 2 illustrates the output of the VOSviewer simulation of keyword trends, displaying a network of terms that are interconnected and that constitute the prevailing research agendas within the field of environmental education. Environmental education, sustainable development, students, learning, planning, and learning media are the most common and most frequently co-occurring keywords. These words collectively constitute the elements of the research setting, which suggests that scholarly research is mostly concerned with pedagogy, incorporating sustainability, and learning processes among students. The close relationship between these keywords indicates that studies in environmental education tend to investigate the ways in which educational media

can support sustainability objectives in formal and informal educational settings (Hajj-Hassan et al., 2024; Karmasin & Voci, 2021; Paraskeva-Hadjichambi et al., 2020; Rahmania, 2024).

In contrast, terms associated with lower nodes—such as learning process, environmental protection, ecological education, environmental knowledge, environmental behavior, and educational development—are less commonly documented in the literature. Though still pertinent, these terms represent niche or emerging fields of research that have yet to receive the same degree of attention as the prevailing themes. Notably, few keywords explicitly mention specific media formats, with terms such as *digital divide*, *motion pictures*, and *computer programs* appearing only as minor nodes in the co-occurrence network. The limited presence of these terms suggests that certain areas of environmental education—particularly those concerning media accessibility and format diversity—remain underexplored. For instance, the keyword *digital divide* indicates underlying equity issues in access to technology, yet few studies explicitly address how disparities in connectivity or device availability affect the implementation of digital environmental education. Similarly, while *motion pictures* hold promise for immersive storytelling and emotional engagement, they are rarely the focus of empirical research in this field. The minimal representation of *computer programs* as a keyword may also reflect a lack of attention to the development or evaluation of structured educational software for environmental learning.

These minor keywords point to potential directions for future research, such as investigating the role of cinematic media in shaping environmental attitudes, developing inclusive strategies to bridge the digital divide, or designing specialized computer-based learning tools tailored to diverse learner needs. Addressing these gaps can contribute to a more equitable and diversified integration of digital media in environmental education. This is to say that while digital and multimedia tools are part of the discussion, they have yet to be at the core of the broader discussion about environmental education (Ardoin et al., 2020; Timotheou et al., 2023).

The keyword analysis identifies a research gap in the overt exploration of media technologies in environmental education. In spite of the growing incorporation of digital technologies into pedagogical settings, concepts such as interactive media, mobile learning, and augmented reality—concepts pervasive across other educational technology areas—are conspicuously absent or weakly represented. This presents the implication that future research must continue to more intentionally explore the possibilities of new media forms in advancing environmental learning outcomes (Lin & Ardoin, 2023; Mhlongo et al., 2023). Moreover, the emergence of digital divide as a secondary

keyword raises important questions regarding accessibility and equity in technology-supported environmental education, demanding more research in future studies.

The visualization indicates that the field divides into three general dimensions: technological innovation, media purpose/application, and media types. Within technological innovation, the dominant themes are augmented and mobile, reflecting how digital technology is shaping environmental education materials. In the meantime, media purpose/application centers on transformative sustainability learning (TSL) and Education for Sustainable Development (ESD), with a priority on the role of media in developing sustainability competencies. Finally, media types clusters around card games and environmental journalism, suggesting a variety of pedagogical approaches—from interactive, game-based learning to media-supported public awareness.

This systematic categorization highlights the interdisciplinary field of environmental education, where instructional objectives, technology tools, and forms of media intersect. The increased prominence of augmented reality and mobile technology speaks to an increased emphasis on immersive, accessible learning experiences (Alam & Mohanty, 2023; Anwar et al., 2025; Dwivedi et al., 2022; Lampropoulos & Evangelidis, 2025; Lazou & Tsinakos, 2023). Meanwhile, the emphasis on TSL and ESD here indicates that media in this category is not just serving an informational role but a transformative one, aimed at imparting long-term sustainability principles. The employment of card games and environmental journalism also shows a balance between experiential, interactive learning and narrative-based public engagement. In total, the concept map gives a good outline of the current trends and future directions of environmental education media research.

Table 3 shows that sustainability learning in university settings remains a periodic and current challenge, evidence that the mainstreaming of sustainable lifestyles in university curriculum remains a preoccupation. All over the world, institutions of higher learning now prioritize environmental literacy as a means of creating graduates who are environmentally sensitized yet also equipped with the ability to address environmental problems. This realization adds strength to the role that universities have as agents of making future leaders and professionals who would lead sustainable development. The sustained focus on this theme, as highlighted by a number of studies (Dundelová, 2024; Ewing et al., 2024; Fernandes et al., 2024), bears witness to its importance in terms of supporting long-term environmental stewardship.

The second ongoing theme is the development of innovative pedagogical strategies to advance environmental and sustainability education. Educators and researchers are continuously on the lookout for new methods to render sustainability education more interactive and efficient. Such approaches as experiential learning, interdisciplinary, and problem-based learning are aimed at developing sustainable behaviors in students. The ongoing interest in the area (Dwyer, 2024; Goi, 2024; Maniatis, 2024) is an indication of the commitment to changing pedagogical methods to address the demands of contemporary environmental challenges.

An emerging trend in recent research is the connection between environmental literacy and pro-environmental behaviors. Studies suggest that increasing individuals' awareness of environmental issues may positively influence their attitudes and actions toward sustainability. This topic highlights the role of education in bridging the gap between knowledge and behavioral change, with a particular emphasis on the need for well-designed environmental education programs. Although findings from the reviewed literature (Anderson et al., 2024; Bucea-Manea-Ţoniş et al., 2024; Meier et al., 2024) underscore education's potential contribution to fostering sustainable mindsets, these insights are drawn from a limited set of 17 articles. Therefore, conclusions should be viewed as preliminary. Further research with broader and more diverse datasets is necessary to validate these patterns and examine the long-term effectiveness of specific media formats in promoting environmental literacy and behavior.

One emerging trend is integrating environmental education as part of language learning, a new interdisciplinary model. With the incorporation of sustainability themes in language learning, instructors can potentially learn linguistic competence along with environmental literacy. This method not only increases the students' knowledge but also compels them to scrutinize world ecological issues critically. Growing interest in this area (Gunansyah et al., 2024; Ivorra-Catalá et al., 2024; Khodjakulova & Miceikiene, 2024) reflects its potential as a innovative pedagogy.

Use of internet and social media sites in environmental education is gaining momentum as an effective vehicle in accessing diversified groups. These sites offer convenient, interactive ways towards the transfer of knowledge, environmental practices, and community mobilization towards environmental cause movements. Academic research in the study (Rahmaulana & Sueb, 2024; Ramos-Luna et al., 2024; Salleh et al., 2025; Sueb et al., 2024) considers how the Internet can cultivate more inclusive and widespread environmental education.

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The issues addressed in this study reflect the dynamic and evolving landscape of sustainability and environmental education. By reviewing 17 Scopus-indexed articles, this study has successfully met its three primary objectives. First, it examined current trends in the use of learning media, revealing a dominant shift toward digital platforms such as augmented reality, mobile learning, and video-based instruction. Second, the use of bibliometric mapping through VOSviewer allowed for the visualization of conceptual relationships and thematic clusters—highlighting key research concentrations in sustainability integration, innovative pedagogy, and environmental literacy. Third, the content analysis identified five emerging research themes, including interdisciplinary approaches (e.g., language integration), media accessibility, and the link between literacy and pro-environmental behavior.

These findings reinforce the growing emphasis on education as a critical driver of sustainable development. As the boundaries of science and pedagogy continue to expand, such evidence-based insights are expected to influence the direction of future environmental education policies and instructional practices globally.

CONCLUSION

This review demonstrates that digital and interactive learning media—such as videos, gamification, and social media—show strong potential in enhancing environmental literacy, particularly when compared to conventional, lecture-based methods. Through keyword trend analysis and concept mapping, this study identified dominant themes including environmental education, sustainable development, and learning media, along with emerging focus areas like augmented reality, mobile learning, and interdisciplinary approaches. Unlike previous reviews that often focus on isolated technologies or pedagogical models, this study contributes a novel synthesis by integrating bibliometric and qualitative analyses to map both conceptual development and practical applications in the field. Five core themes emerged from the literature: (1) integration of sustainability education into higher education curricula, (2) adoption of innovative pedagogies, (3) the link between environmental literacy and pro-environmental behavior, (4) the use of cross-disciplinary strategies such as language learning, and (5) the employment of digital media to support inclusive learning. However, these findings should be interpreted in light of certain limitations, including the relatively small number of analyzed articles (n = 17) and the reliance solely on Scopus as a data source. These constraints may limit the generalizability of the conclusions and highlight the need for further validation using broader datasets and diverse academic databases. Despite

these limitations, the study provides valuable insights into how digital learning media are shaping the future of environmental education and highlights the need for pedagogical models that are adaptive, inclusive, and aligned with the demands of sustainability-focused learning.

Future studies will need to delve into the long-term behavioral consequences of digital media on sustainability habits, including comparison studies between analogue and digital methodologies to identify what works best. Studies will need to investigate ways in which learning media can be adapted in differing geographic and demographic contexts, together with institutional take-up challenges. Emerging technologies such as artificial intelligence and augmented reality in environmental studies must be examined, particularly the potential for use in personalized education. Interdisciplinary learning—such as arts or social sciences-based learning—could supplement environmental educational strategies. Studies in critical media literacy are also needed to battle environmental misinformation. Researchers, instructors, and decision-makers need to collaborate to allow for fair access and scalable scale-up of innovative learning media.

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