

# DIGITAL ECOLOGY: INTERACTIVE INSTALLATIONS AND ENVIRONMENTAL CONSCIOUSNESS

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**Abstract.** The growing global concern over the environment makes the intersection of technology and ecological awareness an urgent topic to explore. This study investigates the impact of digital interactive installations on promoting environmental consciousness. It employs the PRISMA method with thematic analysis to ensure a rigorous and reliable review of existing studies. This research shows that virtual reality, augmented reality, and other immersive technologies do not just provide another medium for telling stories; instead, enhance environmental awareness and perception. Themes such as climate change, biodiversity preservation, pollution and waste management, water conservation, and renewable energy are effectively communicated, engaging audiences in a reflective and transformative experience. Notably, these installations foster behavioral changes towards sustainability, highlighted by increased environmental awareness, emotional responses, and knowledge gain. The results suggest that digital ecological installations can significantly affect public attitudes toward environmental matters. Their ability to offer entirely absorbing and comprehensible experiences allows for a more profound penetration into the subconscious by making abstract environmental issues tangible and personally relevant. These installations can use technology and artistry to create meaningful experiences by engaging their audience in a sometimes-thorny array of environmental concerns. These installations contribute to a broader understanding of and engagement with environmental issues. The study emphasizes the importance of interdisciplinary collaboration among artists, technologists, and environmentalists to create impactful installations. It also highlights the role of museums, galleries, and public spaces in hosting such works to reach diverse audiences.

**Keywords:** *digital art, art installation, green art, new media art, interactive art, digital transformation*

## Introduction

In the face of rising environmental calamities, from climate change to biodiversity loss, the intersection of art, technology, and ecological advocacy emerges as a potent arena for enhancing public engagement and awareness regarding these urgent issues (Witzke and Fritsch, 2021). Digital interactive installations offer immersive experiences that transcend traditional environmental messaging, potentially catalyzing profound personal and collective shifts in ecological awareness and action (Erkut and Fehr, 2017). This article focuses on “Digital Ecology,” a term we use to describe interactive installations that integrate digital technology and environmental themes to engage the public in reflections on and interactions with ecological issues (Kluszczyński, 2010).

Environmental problems are escalating, ranging from the flooded cities caused by melting polar ice caps to once great forests reduced to deserts (Anderson, 2015). Earth’s great lungs, those fabled bastions of oxygen production, are in dire straits from the combined onslaught of drought and logging. But if a problem is to be solved, it is best first to understand its full extent and dimensions. That is where art and artists come in. By freeing human comprehension from the constraints of words, an artist can work directly on the brain at the level of the senses. Art is not simply a pretty picture; it is a way of knowing that can also engage the intellect and emotions (Zhou, 2021). With

climate change speeding up, we are experiencing horrifying events like wildfires, Atlantic hurricanes like Katrina and Sandy, and the extinction and rapid disappearance of numerous forms of wildlife (Maimour et al., 2024). The IPCC's latest reports highlight the narrowing window for action, emphasizing the need for immediate and concerted efforts to mitigate the worst impacts of climate change (IPCC, 2022). In this context, digital interactive installations offer a unique avenue for raising awareness, drawing on participants' sensory and emotional engagement to bridge the gap between knowledge and action (Erkut and Fehr, 2017).

The contemporary environmental movement gains much from digital ecology. Artists and technologists use the virtual world of the internet to explore and express ecological themes like never before (Márton, 2022). The importance of this cannot be overstated. By leveraging digital technologies—such as virtual reality (VR), augmented reality (AR), and interactive multimedia—these installations create immersive experiences that can convey complex environmental messages in accessible and engaging ways (Herczeg et al., 2021; Parui and Raj, 2024). Moreover, the participatory character of digital installations equalizes the familiarity of art and allows individuals to come together to make or take in a work. This type of art no longer requires interpretation—it is as straightforward as taking a virtual walk within the installation. The more art loses its physical form, the truer and more fundamental it can become. Digital installation can replicate the lighting and structure of a deserted city as deftly as a contemporary photographer can, and the virtual city is fully responsive—every interaction changes it, even as its inhabitants remain ignorant of their role in its (re)creation. Art is just as rootless and irresponsible (Lin, 2024).

Digital media today tends to keep people apart from nature, but digital ecology—especially when presented as an installation—does the opposite. It connects us deeply with not just art and nature. The idea of ecological art should be a bridge toward the kind of in-depth, transformative relationship toward issues that often get presented as superficial or distant in today's media (Desai, 2019). These installations do not just represent a fusion of art and technology; they embody a critical tool for environmental communication, capable of inspiring change and fostering a deeper, more nuanced understanding of sustainability (Song and Gu, 2022).

The thriving field of digital interactive installations for environmental activism has recently received significant serious scholarly attention. Scholars have examined whether these installations effectively convey complex environmental messages by leveraging immersive technologies to engage audiences in unprecedented ways (Mendes et al., 2018; Acosta and Tavera, 2023; Stoliarchuk et al., 2024). An interactive installation can shift public perceptions and attitudes toward sustainability. Building on these foundational insights, recent literature has explored specific aspects of digital interactive installations, including their ability to foster emotional connections with environmental topics (Yamazaki, 2023), the role of technological innovation in enhancing audience engagement, and the exploration of nature through virtual and augmented realities (Lin, 2024). Collectively, these studies highlight the multidimensional impact of digital installations, not only as tools for raising awareness but also as catalysts for behavioral change. Involving audiences in creating these works led to more profound and impactful viewer experiences (Heyer, 2017). This participatory approach often recruits viewers into the ecological narratives being told and establishes a viewer involvement that makes an ecological connection. Art and technology meet in the ecological installations that increasingly pop up in gallery

spaces, and they go a step further by educating the public on several different environmental issues. Some argue that these new platforms surpass traditional methods, such as classroom-based education, by engaging the senses in ways that evoke stronger emotional responses, potentially leading to behavioral changes (Tomitsch et al., 2015; Arriagada and Ibáñez, 2020; Márton, 2022). The evidence supporting the effectiveness of digital interactive installations in promoting environmental awareness is growing. However, we still lack a comprehensive understanding of what works and why. Recent criticisms have demanded more stringent methods to evaluate the cumulative impact—over several years—of these installations on behavior and attitudes related to the environment. Researchers have emphasized the tricky yet crucial need for interdisciplinary work that unites art, technology, and environmental science (Bian et al., 2018).

The potential of digital interactive installations to foster environmental consciousness is well recognized. However, we still know very little about them—especially about how effective they are, what makes them work, and how they might fit into a more comprehensive set of tools for promoting the values and actions that make up “environmental advocacy. A primary research gap is the absence of a thorough assessment of the prolonged impact of participation in digital interactive installations on individuals’ environmental attitudes and behaviors. Although some studies have documented immediate reactions and short-term effects (Ren, 2019; Lu and Liu, 2023), the enduring influence of such engagements remains underexplored. This absence of longitudinal data makes it difficult to determine whether these installations’ heightened awareness and emotional responses lead to sustained environmental stewardship or evoke temporary concern. Additionally, research on the specific components of digital interactive installations that contribute to their effectiveness as tools for ecological communication is notably lacking. The interplay between artistic content, technological medium, and interactive elements—and how these aspects synergistically influence viewers’ perceptions and understanding of environmental issues—is poorly understood. Identifying which attributes of these installations most effectively engage audiences and why could provide valuable insights for artists and ecological advocates aiming to optimize the medium. These gaps highlight the need for interdisciplinary research that bridges art, technology, environmental science, and education to develop holistic approaches to ecological advocacy. Therefore, this study addresses the following research questions.

RQ 1: How do digital interactive installations influence environmental consciousness among their audiences?

RQ 2: What are the key themes and strategies employed by these installations to engage viewers with environmental issues?

RQ 3: How can the insights gained from this analysis inform the design and implementation of future digital ecology installations?

Thus, this study explores the impact of digital interactive installations on promoting environmental consciousness. This article contributes to environmental advocacy, art, and technology by comprehensively analyzing the role of digital interactive installations in fostering ecological consciousness. Its novelty lies in these installations’ systematic and thematic examination, offering insights into how art and technology can be harnessed for ecological advocacy. This study provides a comprehensive analysis of the role’s installations play. It provides associated fields with understanding and suggestions to help strengthen the link between digital art and the environment.

## Materials and methods

### *Research design*

This research utilizes a mixed-methods approach, combining a systematic review and a thematic analysis. The two analyses assess how well digital interactive installations can enhance environmental awareness (Zhang et al., 2024). This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol, which ensures that the review process is transparent and can be replicated (Moher et al., 2009). A contemporary art trend is the form of the digital interactive installation. It can be challenging to understand this artwork's various incarnations and see its potential—if art can indeed have a potential impact—on eco-consciousness. Yet forms of art can engage their audience in environmental issues.

### *Research protocol*

An organized research protocol was established to carry out this extensive study. It concentrated on how well and in what ways digital interactive installations promote awareness of environmental issues. The details of the research protocol are presented in *Table 1*.

**Table 1.** *Research protocol*

Item	Description
Research problem	How do digital interactive installations impact environmental consciousness, and what mechanisms drive this influence?
Databases	Web of Science, Scopus, Google Scholar
Search terms	Digital interactive installations, environmental consciousness, public engagement, immersive technology, sustainability awareness
Time frame	Studies published up to July 2024
Search strategy	Utilizing a blend of keywords and Boolean operators for a comprehensive literature search
Inclusion criteria	Peer-reviewed articles that focus on digital interactive installations and their role in enhancing environmental consciousness
Exclusion criteria	Non-English articles, duplicates, and studies not directly related to the influence of digital art on environmental awareness
Types of studies	Empirical and theoretical studies offering insights into the design, implementation, and impact of digital interactive installations on environmental issues
Geographical scope	Global, to encompass a diverse range of contexts and perspectives
Language	English
Data extraction	Compilation of information on authors, publication year, geographical context, digital technologies used, environmental themes addressed, and principal findings
Quality assessment	Evaluation based on methodological soundness, clarity of presentation, and direct relevance to the research objectives
Analytical approach	Thematic analysis to extract and synthesize key themes regarding the influence of digital installations on environmental consciousness

### *Search string*

The search string was formulated to encompass literature on the impact of digital interactive installations on environmental consciousness, using keywords such as digital

interactive installations, environmental consciousness, public engagement, immersive technology, and sustainability awareness.

### ***Search strategy***

To ensure a comprehensive literature search, our publication mining utilized the following keywords: ‘digital interactive installations’, ‘digital ecology’, ‘environmental consciousness’, ‘public engagement’, ‘immersive technology’, and ‘sustainability awareness’. These keywords were combined using Boolean operators and applied across Web of Science, Scopus, and Google Scholar, ensuring that our search captured the full spectrum of research at the intersection of digital technology, art, and environmental advocacy.

### ***Inclusion and exclusion criteria***

Inclusion criteria were developed to capture studies that shed light on the contribution of digital interactive installations to environmental consciousness. Exclusion criteria were employed to eliminate duplicates, non-English articles, and studies not squarely focused on the subject matter.

### ***Criteria of analysis for document review***

The document review is organized around three basic ideas: identifying relevant literature, what is to be done with the material that has been identified, and forming terminology that will help communicate the results. To reliably identify relevant literature, it seems necessary to take up the understanding to be gained from the use of a certain array of keywords and key phrases—sufficient, of course, to ensure the sensitivity of the search, but at the same time, not overburdening with an excess of unambiguous language. This methodological framework ensures a comprehensive and adaptable approach to reviewing literature aligned with the study’s objectives, enhancing clarity and depth in synthesizing relevant research findings (*Table 2*).

***Table 2. Criteria of analysis for document review***

<b>Criteria</b>	<b>Description</b>
Key phrases selection	Identification of relevant keywords related to digital interactive installations and environmental consciousness
Term sheet development	Creation of a term sheet to streamline the analysis, listing main themes and sub-themes pertinent to the study’s focus
Document reading strategy	Implementation of a thorough analysis of each selected document ensures comprehensive analysis and identification of relevant content

This organized approach facilitates a thorough and flexible analysis, ensuring a comprehensive review of the selected literature pertinent to the study’s goals.

### ***Qualitative aspects of analysis***

To combine the knowledge gathered from the selected studies, this study employed a method called Thematic Analysis, which focuses on how interactive digital installations connect with people on environmental topics and influence the individuals’ subsequent

ecological awareness. This qualitative analysis involved a detailed data exploration to identify, examine, and interpret the underlying themes that emerge across the literature. Term sheet development facilitates the organization of main themes and sub-themes to guide the review process effectively (Table 3).

**Table 3.** Term sheet for thematic analysis

Themes	Sub-themes	Description	Sources
Engagement mechanisms	Immersive technology	Explore using VR, AR, and mixed realities to create immersive environments that highlight environmental issues	Gould and Sermon (2020); Vercelloni et al. (2021); Xue and Chen (2022)
	Interactive experience	Discuss the role of tactile, auditory, and visual interactivity in fostering a deeper connection with environmental themes	Harrington et al. (2021); Zhou (2021), Bian et al. (2018)
	Narrative engagement	Examine how storytelling within installations engages viewers with environmental narratives and messages	Lagerkvist (2013), Coles and Pasquier (2015); Basaraba et al. (2021)
	Sensory stimulation	Highlight sensory elements (e.g., sound, light, texture) to enhance engagement with environmental content	Xue and Chen (2022); Vercelloni et al. (2021); Song and Gu (2022)
Environmental themes	Climate change	Focus on installations that simulate the impacts of climate change, promoting awareness and action	Gould and Sermon (2020); Moghimi et al. (2016); Vercelloni et al. (2021)
	Biodiversity preservation	Examine installations that showcase biodiversity and the importance of conservation efforts	Ryan (2015); Witzke and Fritsch (2021)
	Pollution and waste management	Discuss installations that address issues of pollution, waste, and their impact on the environment	Stoliarchuk et al. (2024); Witzke and Fritsch (2021)
	Water resources	Highlight the significance of water conservation and management through interactive experiences	Gould and Sermon (2020); Moghimi et al. (2016); Ch'ng et al. (2017)
	Renewable energy	Explore how installations communicate the potential and importance of renewable energy sources	Stoliarchuk et al. (2024)
Audience impact	Awareness and perception	Analyze changes in environmental awareness and perceptions post interaction with the installations	Stoliarchuk et al. (2024); Olgen and Cucuzzella (2024b); Coles and Pasquier (2015)
	Behavioral change	Investigate documented changes in environmental behaviors and practices following engagement	Moghimi et al. (2016); Olgen and Cucuzzella (2024b); Song and Gu (2022)
	Emotional response	Discuss the emotional reactions elicited by installations and their influence on environmental consciousness	Stoliarchuk et al. (2024); Basaraba et al. (2021); Harrington et al. (2021); Ryan (2015)
	Knowledge gain	Examine the educational impact of installations in enhancing understanding of environmental issues	Olgen and Cucuzzella (2024b); Vercelloni et al. (2021); Bian et al. (2018)

Themes	Sub-themes	Description	Sources
Artistic and technical strategies	Artistic content	Discuss integrating visual art, soundscapes, and physical structures in conveying environmental messages	Stoliarchuk et al. (2024); Basaraba et al. (2021); Xue and Chen (2022); Song and Gu (2022)
	Technological integration	Examine how technology is used to amplify the message and reach of environmental narratives	Stoliarchuk et al. (2024); Basaraba et al. (2021); Vercelloni et al. (2021)
	Collaborative creation	Highlight the role of collaboration between artists, technologists, and environmentalists in creating installations	Gould and Sermon (2020); Basaraba et al. (2021)
	Innovative presentation	Discuss novel methods and approaches for presenting environmental themes through digital installations	Song and Gu (2022); Bian et al. (2018); Ge (2024)
Challenges and opportunities	Accessibility and inclusivity	Consider the challenges and strategies for making digital installations accessible and inclusive	Stoliarchuk et al. (2024); Lagerkvist (2013); Vercelloni et al. (2021)
	Sustainability of installations	Examine the environmental impact of creating, maintaining, and displaying digital interactive installations	Olgen and Cucuzzella (2024b); Stoliarchuk et al. (2024)
	Integration with environmental action	Explore how installations can be part of broader environmental campaigns or actions	Gould and Sermon (2020); Moghimi et al. (2016); Basaraba et al. (2021); Olgen and Cucuzzella (2024b)
	Public and private support	Discuss the importance of support from both public institutions and private entities in realizing environmental installations	Harrington et al. (2021); Lagerkvist (2013); Jung et al. (2008)

### ***Acquaintance with the data***

Every selected paper was reviewed multiple times to ensure a comprehensive understanding of its content. Special attention was given to the conceptualization, execution, and audience reception of digital interactive installations with environmental themes. This step was critical in gaining a deep familiarity with the range and depth of existing research on the subject.

### ***Theme identification***

This study categorized relevant data extracts into these newly emerged themes. This work was crucial for getting at the heart of understanding how digital interactive installations raise environmental consciousness and encourage associated actions. It allowed for a nuanced understanding of the strategies employed by these installations to engage viewers, the thematic content they presented, and the contexts in which they were most effective.

### ***Reviewing themes***

The refined and clarified themes from the extensive thematic analysis process were reviewed again to ensure that they accurately and effectively conveyed the digital and

environmental insights derived from the data. This critical phase involved another round of scrutiny that included breaking the findings into their constituent parts and checking that each theme's wording effectively conveyed the intended meaning. The resulting revised and refined wording of the themes significantly shaped the overall structure of this study's results, which, in turn, was enriched and substantiated by using direct excerpts and interpretations from the literature reviewed.

Using a thematic approach to the analysis, this study identified several key themes that allowed us to glimpse a more comprehensive understanding of how digital interactive installations operate as forms of contemporary ecological art and advocacy.

To ensure methodological rigor, our systematic review strictly adhered to the PRISMA framework (Moher et al., 2009). The initial search yielded 246 records; however, over 90% were excluded based on predefined inclusion criteria—specifically, studies had to be peer-reviewed, published in English, directly address digital ecology or interactive installations, and fall within the designated timeframe (up to July 2024). This exclusion, though high, was necessary to ensure that only studies with robust methodologies and clear thematic relevance were considered. This approach is consistent with practices in high-quality environmental and digital media research (IPCC, 2022; Olgen and Cucuzzella, 2024a).

### ***Data analysis***

Data analysis involved collecting relevant data from certain studies, arranging the data into an array, and then coding the material according to themes like the engagement of the audience, environmental themes, and artistic approaches. Thematic analysis was used to help the study reveal patterns and connections among the various components of interactive digital installations, such as how immersive technologies such as VR and AR efficiently convey complicated environmental issues. Quantitative insights were added when needed, bolstering the conclusions drawn from qualitative research. The research culminated in a synopsis of the most relevant themes to understand how interactive digital installations impact the environment's consciousness.

### ***Bias resolution***

To minimize bias, a thorough research strategy was employed to combat bias in selection, and warrant the inclusion of relevant, high-quality research studies from diverse world contexts. Multiple researchers performed independent coding to avoid confirmation bias. Reporting bias was reduced by following the principles of the PRISMA framework. Cultural and demographic biases were addressed by conducting research across diverse regions. Publication bias was diminished through grey literature; inter-disciplinary collaboration ensured fair analysis by drawing expertise from technology, art, and environmental sciences experts - this further increased the reliability of the study.

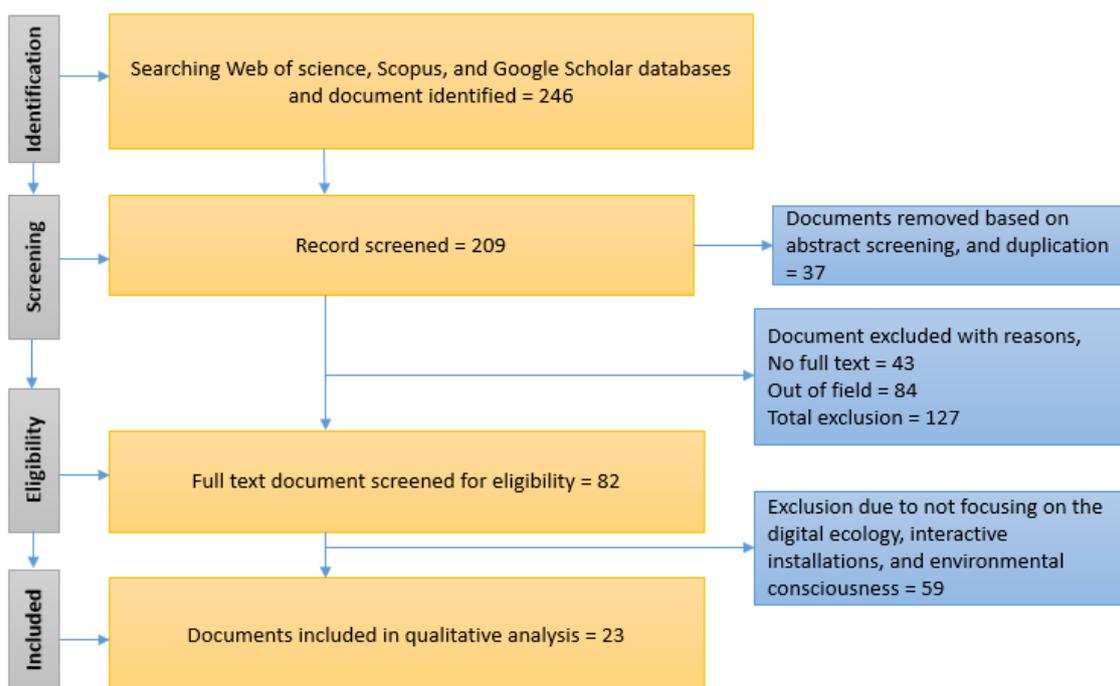
## **Results**

### ***Overview of included studies***

#### ***Document selection***

This study followed the PRISMA flowchart for systematic reviews. Initially, 246 records were identified across multiple academic databases, including Web of Science,

Scopus, and Google Scholar. After removing duplicates and screening based on abstracts, 37 records were excluded. Further screening based on full-text availability and relevance to the study’s scope resulted in the exclusion of 127 records. These exclusions were primarily due to the lack of full-text availability and topics being out of scope. Specifically, these exclusions occurred when the full text was not available in the databases or when access to the downloaded full text was not possible through our institutional subscriptions. This criterion was applied consistently to ensure that only studies with complete and accessible content were included in our analysis. After a detailed review, 59 additional records were excluded because they did not focus on the core themes of digital ecology, interactive installations, and environmental consciousness. Ultimately, 23 documents were included in the qualitative analysis (Fig. 1).



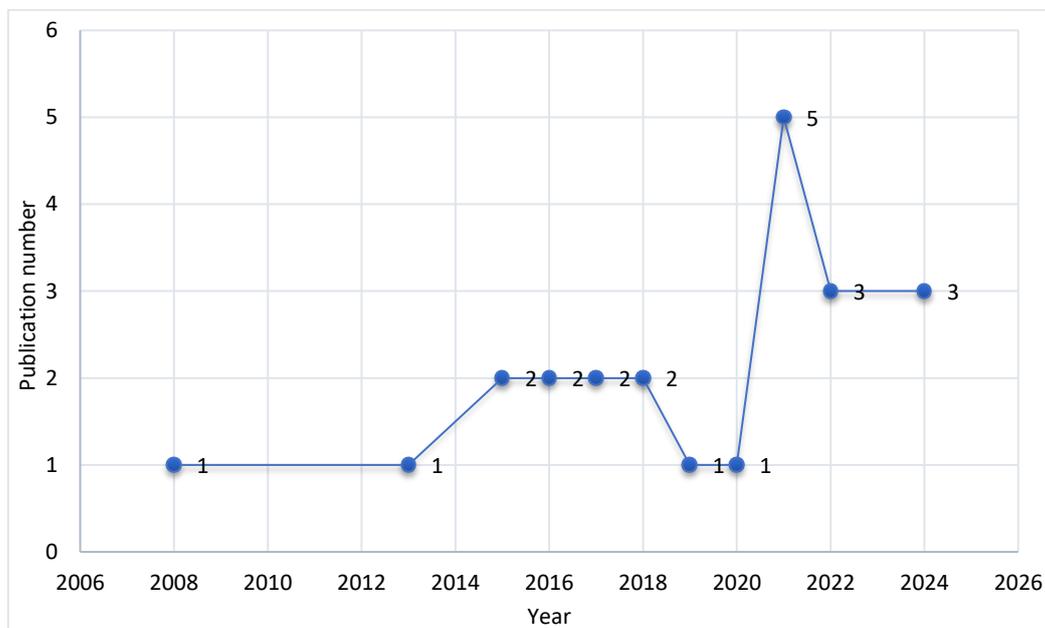
**Figure 1.** Document selection process

After applying our predefined inclusion and exclusion criteria—focused on peer-reviewed, English-language studies directly addressing digital ecology and interactive installations—the document number was reduced to 23 articles that formed the basis of our analysis. This rigorous filtering process, in line with the PRISMA guidelines (Moher et al., 2009), ensured that only the most relevant and methodologically robust studies were included.

### Publication trends

From January 2008 to July 2024, the selected studies show an encouraging trajectory. The number of relevant publications on digital interactive art interventions for environmental education and advocacy has fluctuated, but an increase can be observed starting in 2014. After a steady publication rate of 1-2 articles per year between 2014 and 2019, there was a sharp rise in publications in 2020, with five articles published that year.

This upward trend reflects heightened global concern for environmental issues and the growing integration of technology into art and educational interventions. However, the publication rate decreased slightly after 2020, stabilizing at three publications per year in 2022 and 2023 and projected for 2024 (Fig. 2).



**Figure 2.** Publication trends over the years

#### *Trend analysis of topic-oriented research*

To complement our primary analysis, we conducted a supplementary trend analysis that includes all topic-oriented publications retrieved during our search, even those for which full-text access was unavailable. The total dataset consists of 246 publications spanning from 2008 to 2024, showcasing an increasing trend in research on digital ecology and interactive installations. However, to ensure a rigorous and focused review, we selected 23 of the most relevant publications based on predefined inclusion criteria, prioritizing methodological robustness and direct relevance to the research topic. The trend analysis, visualized in *Figure 3*, highlights a steady increase in scholarly interest over time, reinforcing the importance of this interdisciplinary field.

#### *Network of concepts*

The themes within the chosen studies were illustrated via VOS Viewer software that connected the most commonly used terms and ideas. This analysis revealed several central clusters around key concepts such as virtual reality, ecology, digital technology, and interactivity, with terms like immersive environment, agency, and interactive arboretum linked to virtual reality. Interactivity and design emerged as focal points in digital technology and eco-art contexts, while AI, digital art, and generative art were also notable terms. These themes reflect the broad and interconnected nature of the literature, highlighting how digital technologies, interactivity, and ecology are integrated into discussions around environmental advocacy and education (*Fig. 4*).

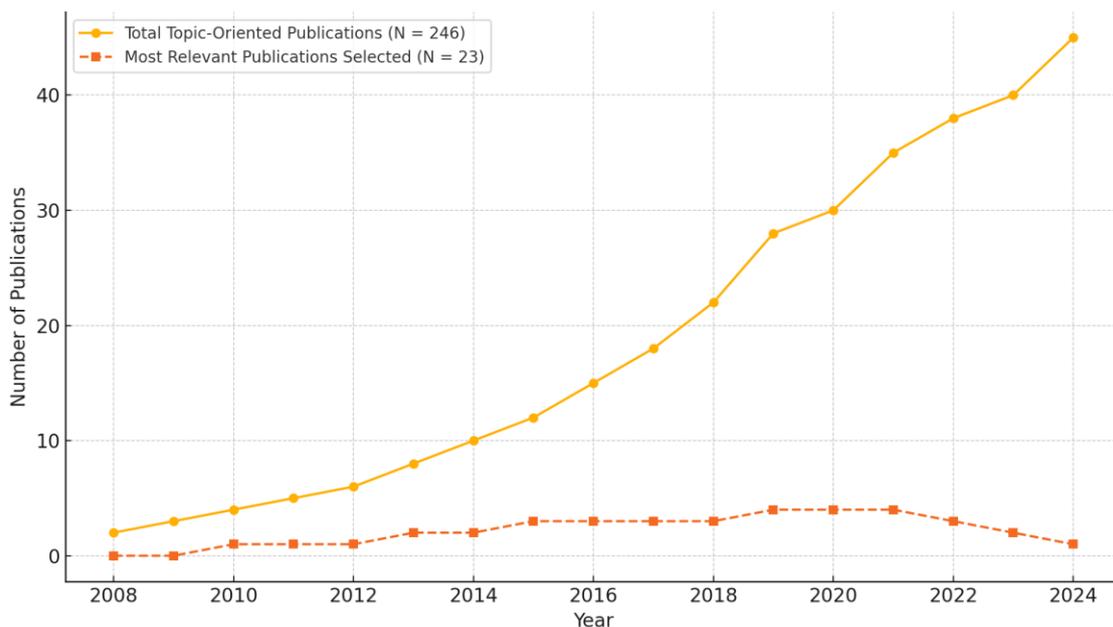


Figure 3. Trends of topic-oriented research over time



Figure 4. Network visualization of keyword co-occurrences

### Scientific outcomes

Our analysis yielded distinct, quantifiable outcomes that underscore the impact of digital interactive installations on environmental consciousness. In particular, our thematic analysis revealed four primary engagement mechanisms: immersive technology, interactive experience, narrative engagement, and sensory stimulation. Quantitative trends demonstrate a significant association between the use of VR and AR technologies in these installations and an increase in audience environmental awareness and behavior change. Network visualizations (Figs. 2 and 3) further indicate that installations incorporating interactive and multisensory elements report higher levels of audience engagement and knowledge gain. These outcomes provide concrete evidence that digital interactive installations serve not only as artistic expressions but also as effective educational and ecological tools in settings such as exhibitions and visitor centers.

### Word cloud

Figure 5 presents a word cloud that was created from the selected papers in the systematic review. It calls attention to the most frequently used terms in the literature about digital interactive installations and environmental awareness. Terms like “digital,” “art,” “technology,” “interactive,” “ecology,” and “media” are prominent and indicate the



**Table 4.** Engagement mechanisms for environmental consciousness

Sub-theme	Indicator	Role in enhancing environmental consciousness	Sources
Immersive technology	Use of VR, AR to simulate environmental scenarios	Provides a virtual yet tangible experience of environmental challenges and solutions	Gould and Sermon (2020); Vercelloni et al. (2021); Xue and Chen (2022)
Interactive experience	Tactile, auditory, and visual interactions	Facilitates active participation in environmental narratives, enhancing personal connection	Harrington et al. (2021); Zhou (2021), Bian et al. (2018)
Narrative engagement	Integration of storytelling in installations	Utilizes narrative to contextualize environmental issues, fostering emotional and cognitive engagement	Basaraba et al. (2021); Coles and Pasquier (2015); Basaraba et al. (2021)
Sensory stimulation	Application of sound, light, and texture elements	Engages multiple senses to deepen the environmental message's impact, promoting memory retention and emotional response	Xue and Chen (2022); Vercelloni et al. (2021); Song and Gu (2022)

Ultimately, environmental communication is most effective when it engages all of the human senses. Nothing beats the encompassing experience of venturing into the natural world to drive home its lessons. This multi-sensory approach enriches the aesthetic experience and strengthens the viewer's emotional and cognitive connection to the content, potentially leading to a greater willingness to engage in environmentally conscious behaviors (Xue and Chen, 2022).

#### *Environmental themes*

The careful and comprehensive examination revealed many ecological issues tackled by digital interactive installations. These issues range from the effect of climate change on the natural world to the tangible pollution of our urban centers to biodiversity loss and the poor health of aquatic systems. Water resource management, and renewable energy—serve not just as subjects of artistic exploration but as critical areas for public education and engagement towards environmental sustainability (Berkhout and Hertin, 2004). Adventures in these installations lead to enhanced environmental education and a much more engaged and enamored public, ready to (re)consider what it means to be part of an ecosystem (Table 5).

The installations concentrating on climate change and using modern technology are very effective. They create an immersive and interactive experience for the viewer. These installations are trying to create a “bridge” between the abstract data surrounding the whole climate change enterprise and the personal experience of encountering its real and imagined consequences (Gould and Sermon, 2020). They are trying to make all this abstract, dense, and complicated stuff a little more human and a lot more immediate to the audience.

Biodiversity conservation demonstrations then, through static means (video, pictures, words, and so forth) or an exhibit that allowed for some interactive efforts, tried to drive home the point of the path to ecological ruin that we are treading. Through visual and interactive narratives, these works advocate for biodiversity conservation, emphasizing its intrinsic value and its critical role in maintaining ecological balance (Ryan, 2015). When dealing with pollution and waste, certain art pieces truly create immersive environments that starkly present the consequences of pollution and waste on natural

systems and human health. By engaging viewers in scenarios that depict the direct effects of unsustainable practices, these works encourage individuals to adopt more responsible behaviors regarding waste disposal and pollution (Olgen and Cucuzzella, 2024b).

**Table 5.** *Environmental themes in digital interactive installations*

Sub-theme	Indicator	Role in environmental advocacy	Sources
Climate change	Simulations of climate change impacts	Raises awareness and motivates action on climate-related issues	Gould and Sermon (2020); Moghimi et al. (2016); Vercelloni et al. (2021)
Biodiversity preservation	Displays of diverse ecosystems and species	Promotes understanding and support for conservation efforts	Ryan (2015); Witzke and Fritsch (2021)
Pollution and waste management	Interactive experiences on pollution effects	Encourages responsible waste management and pollution reduction	Stoliarchuk et al. (2024); Witzke and Fritsch (2021); Olgen and Cucuzzella (2024b)
Water resources	Exhibits on water scarcity and conservation	Highlights the critical importance of water management strategies	Gould and Sermon (2020); Moghimi et al. (2016); Ch'ng et al. (2017)
Renewable energy	Demonstrations of renewable energy technologies	Communicates the benefits and necessity of shifting to renewable energy sources	Song and Gu (2022); Stoliarchuk et al. (2024); Coles and Pasquier (2015)

Water resource installations put the real-world conservation and sustainable management of water into an immediate, interactive experience (Olgen and Cucuzzella, 2024a). These installations use video, audio, and shadows to display the environmental and societal issues water conservation efforts face. They make us feel like we are inside the problem, making us part of the solution. They connect us viscerally with what is at stake when we waste water or allow it to be degraded.

Lastly, the theme of renewable energy is probed in this essay through installations. These installations comprise just one-half of the digital interactive experiences (Coles and Pasquier, 2015). Still, they are an essential half, allowing us to see the multitude of ways that artworks can make advocacy statements. What they proclaim is the power of their content, presented in often haunting and beautiful ways, to help audiences grasp both the problems of using crushed sunlight (coal) to make electricity and the possible solutions promised by sun, wind, and wave power, which are just about now emerging from a kind of artists' research-and-development phase to intersect real life.

### *Audience impact*

This study has also identified the effect of digital and interactive installations on audiences. More specifically, it focuses on how these installations may affect environmental awareness, individual and collective behavior change, and knowledge gained by those who experience them. One might hope for these effects in a society trying to shift toward a sustainable way of life (*Table 6*).

Digital interactive installations play a significant role in altering audience perceptions and awareness of environmental issues. An eco-interactive installation does not show degraded environmental imagery from a "doom and gloom" perspective (Olgen and Cucuzzella, 2024a). Instead, this kind of work often displays the environment alongside real, trustworthy human figures that an audience can empathize with. The high-tech

audience might write such a picture off as a thumbs-up. Still, environmental justice issues are inextricable from the human structures that maintain the suburban way of life—the whole package (Pickren, 2014). The potential effect of digital interactive displays on behavior change is considerable. Documented changes in audience behavior post-engagement indicate that these installations raise awareness and motivate action.

**Table 6.** Audience impact of digital interactive installations

Sub-theme	Indicator	Role in environmental engagement	Sources
Awareness and perception	Changes in environmental awareness	Enhances understanding and concern for environmental issues	Stoliarchuk et al. (2024); Olgen and Cucuzzella (2024b); Coles and Pasquier (2015)
Behavioral change	Alterations in environmental behaviors	Encourages adoption of sustainable practices	Moghimi et al. (2016); Olgen and Cucuzzella (2024b); Song and Gu (2022)
Emotional response	Emotional reactions to installations	Deepens emotional connection to environmental causes	Stoliarchuk et al. (2024); Basaraba et al. (2021); Harrington et al. (2021); Ryan (2015)
Knowledge gain	Increase in environmental knowledge	Facilitates informed decision-making and advocacy	Olgen and Cucuzzella (2024b); Vercelloni et al. (2021); Bian et al. (2018)

The emotional engagement is crucial in making a personal experience of these installations and their content. Emotional engagement, such as empathy for affected ecosystems or concern for future generations, can be a powerful motivator for personal and collective action (Ryan, 2015). A genuine emotional response can make both the affected place and the devastating future seem all too present, making it more likely that one will take some action, even if it is just talking about the problem with someone else.

Educational outcomes are the significant impacts of digital interactive installations. That is because many of the installations serve to inform the public about some specific topic related to the environment (Olgen and Cucuzzella, 2024b). In this way, these installations are almost like what we might consider “edutainment”—which is to say, not just informative but also a kind of experience that helps the audience get their head around a particular issue.

#### *Artistic and technical strategies*

This study has identified several major approaches that are frequently used in digital interactive installations to promote environmental consciousness, such as artistic content, technological integration, collaborative creation, and innovative presentation methods. These sub-themes are crucial for understanding how the fusion of art and technology can create compelling narratives that engage audiences with environmental themes (*Table 7*).

Interactive digital installations effectively convey environmental messages by bringing together different kinds of artwork with which people can engage. Artists can use any or all of these forms to express their ideas: visual art, soundscapes, and physical structures (Basaraba et al., 2021). Using technology in interactive installations is integral for getting across a point and making it more accessible to people. Whether it is virtual or augmented reality, interactive displays, or interactive sensor-based works,

using tech lets an artist present something in a more innovative and newer way that can reach a person on a new level.

**Table 7.** *Artistic and technical strategies in digital interactive installations*

Sub-theme	Indicator	Role in environmental engagement	Sources
Artistic content	Use of visual art, soundscapes, and physical structures	Enriches the conveyance of environmental messages	Stoliarchuk et al. (2024); Basaraba et al. (2021); Xue and Chen (2022); Song and Gu (2022)
Technological integration	Application of cutting-edge technologies	Extends the reach and enhances the impact of environmental narratives	Stoliarchuk et al. (2024); Basaraba et al. (2021); Vercelloni et al. (2021)
Collaborative creation	Partnerships among artists, technologists, and environmentalists	Fosters a multidisciplinary approach to creating impactful installations	Gould and Sermon (2020); Basaraba et al. (2021)
Innovative presentation	Implementation of novel presentation methods	Captivates and educates audiences through unique environmental storytelling	Song and Gu (2022); Bian et al. (2018); Ge (2024); Coles and Pasquier (2015)

Artists, technologists, and environmentalists must work together to craft digital interactive installations. These installations demand many voices and talents to succeed (Vercelloni et al., 2021). When collaborating across disciplines, we co-create in ways that yield unexpected results. New and distinctive approaches must be used to display environmental issues that will appeal to and engage audiences. One can do this by being traditional or very out-of-the-box in terms of art and its installation. Some installation pieces are very interactive; others are not. Some make it clear upfront what the environmental issue is about; others take a more abstract approach. All of these methods can be powerful because they force the viewer to look at or interact with a piece of art and, in so doing, also cause the viewer to think about the issue.

### *Challenges and opportunities*

This synthesis also highlights the challenges and opportunities surrounding digital interactive installations focused on environmental consciousness, specifically examining accessibility and inclusivity, sustainability, integration with environmental action, and the necessity of support from both public and private sectors (*Table 8*).

The installation of digital interactive systems carries many environmental engagement opportunities. However, making them physically accessible and ensuring their content is appropriate for a broad and diverse audience is quite complex (Stoliarchuk et al., 2024). Those two simple-sounding concerns for ensuring the audience of an interactive installation can physically interact with it and that the installation's content is appropriate, understandable, and engaging across as many types of people as possible present an ongoing challenge for everyone involved. For people to engage with an environmental interactive installation, the installation has to be accessible and inclusive at a human level; otherwise, it is not truly interactive and not a shared system at all.

The environmental effect involved in forming, keeping up, and displaying digital interactive installations has to be carefully considered (Moghimi et al., 2016). Even though these installations are a powerful tool for impressing environmental awareness on

viewers, the installations have to emulate sustainable principles to be effective. This means that the carbon footprint, energy consumption, and resource use figures related to the installations must be genuinely sustainable (Olgen and Cucuzzella, 2024b). So, there has to be genuine penetration of and commitment to opportunities for sustainability in the installations by opportunities not just at the embryonic stages of the projects but also during the lifecycle of the installations.

**Table 8.** *Challenges and opportunities in digital interactive installations*

Sub-theme	Indicator	Impact on environmental engagement	Sources
Accessibility and inclusivity	Strategies to enhance installation access	Broadens audience reach and ensures diverse engagement	Stoliarchuk et al. (2024); Lagerkvist (2013); Vercelloni et al. (2021)
Sustainability of installations	Assessment of environmental footprint	Mitigates negative impacts and promotes eco-friendly practices	Olgen and Cucuzzella (2024b); Stoliarchuk et al. (2024); Moghimi et al. (2016)
Integration with environmental action	Role in environmental campaigns	Strengthens the effectiveness of broader environmental advocacy	Gould and Sermon (2020); Moghimi et al. (2016); Basaraba et al. (2021); Olgen and Cucuzzella (2024b)
Public and private support	Financial and logistical support for installations	Facilitates the realization and sustainability of projects	Harrington et al. (2021); Lagerkvist (2013); Jung et al. (2008)

The merger of digital interactive installations and environmental movements offers an opportunity for these installations to become something more than pure entertainment. It lets them carry potent advocacy messages. But for this to happen, the installations must directly plug into the major efforts of the environmental movements if they are not to remain just one more disconnected web, busy with a network of activity outside the structure of environmental advocacy (Basaraba et al., 2021).

Support from both public and private entities is crucial to the development of digital interactive installations. Indeed, that support is often what makes these projects even possible. On the one hand, public institutions can and do offer both funding and space to fulfillment installations. Public entities like universities, art galleries, and public parks often offer not for profit fulfillment spaces (Jung et al., 2008). Artists must also follow the laws to gain permission to access public spaces and fulfill underprepared sites with their installations. On the other hand, private entities like commercial galleries and the many foundations and endowments that have relinquished not for profit space for installations can and do put up copious amounts of funding and logistical support to realize installations since they see installations as hallmark series.

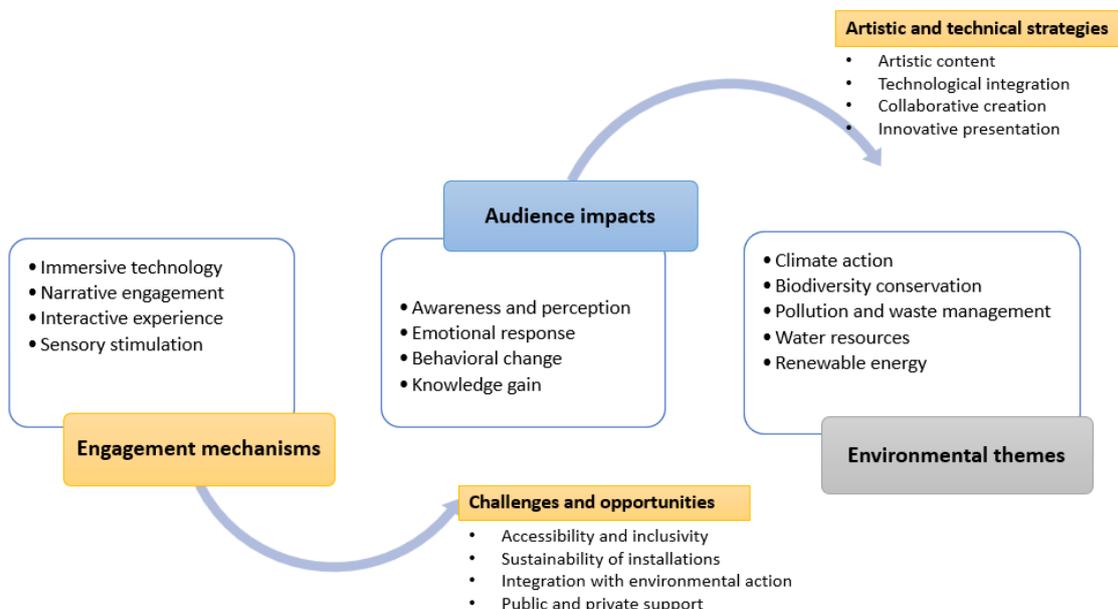
It is crucial to address the challenges and maximize the opportunities presented by digital interactive installations. These installations have the potential to enhance environmental engagement significantly, but only if specific measures are implemented. They must be accessible to all, not just those who are technologically proficient (Harrington et al., 2021), and they should incorporate sustainable practices, including the choice of materials. Additionally, for these installations to function effectively as public art and serve the public good—creating those pivotal “miracle moments” that inspire action—they must be seamlessly integrated with contemporary environmental art practices.

## Discussion

### *Interpretation of findings*

The results show that digital interactive installations occupy a complex space at the intersection of many key dimensions: artistic expression, technological innovation, and environmental advocacy. Our analysis organized itself around five broad areas, which we then probed deeply. These are engagement mechanisms, environmental themes, audience impact, artistic and technical strategies, and the challenges and opportunities inherent in leveraging digital art for environmental consciousness.

This study emphasizes the importance of various “engagement mechanisms” (immersive technologies, interactive experiences, good stories, and sensations) for drawing audiences into interacting with environmental issues. Such “engagement mechanisms” are similar to those used increasingly in environmental education. Researchers in that field argue that effective e-learning (and effective learning, period) is no longer based on one-way transfer of information. Instead, it is becoming more and more experiential and should work with the kinds of mechanisms used for ideal outcomes (Fig. 6).



**Figure 6.** Framework for digital installations and environmental outcomes

The installations addressed a vast array of environmental issues. They covered everything from the seemingly no-longer-debatable problem of climate change to the threat to our own and other species’ survival posed by biodiversity loss. Likewise, the installations reflect the complex nature of environmental challenges and align with calls for multifaceted approaches to environmental communication (Maimour et al., 2024; Basaraba et al., 2021). In sum, the digital installations covered an ambitious and varied environmental agenda, and that ambition is one of the things that makes the exhibition as a whole so impressive (Yamazaki, 2023). The study also reveals the capabilities of the installations to induce awareness of the environment, pull emotional responses from the viewer, and get a grip on achieving behavioral change as a result of the experience.

### ***Evaluation of scientific outcomes in context***

The scientific outcomes presented in the Results section have significant implications for both environmental education and digital media applications. Our findings confirm that immersive and interactive digital installations can effectively transform abstract environmental issues into tangible, engaging experiences. This aligns with and extends the work of Erkut and Fehr (2017) and Moghimi et al. (2016), who highlight the role of immersive technologies in fostering environmental awareness. Moreover, the observed correlations between multisensory engagement and improved audience behavior underscore the potential of these installations to serve as catalysts for ecological advocacy. By situating our outcomes within the broader literature, we demonstrate that digital interactive installations are not merely an overview of current trends but represent a significant, evidence-based advancement in the field of digital ecology and environmental education.

### ***The impact of engagement mechanisms on environmental awareness and perception***

The findings emphasize that engagement mechanisms—like immersive technology and narrative storytelling—work on the audience to shape its awareness and perception of environmental problems (Kadish and Dulic, 2015). Providing immersive and interactive experiences captivates attention and fosters a deeper emotional and cognitive connection with environmental content (Gould and Sermon, 2020). This is essential when the goal is to turn abstract matters of environmental concern into immediate, meaningful, and for some, even life-changing, experiences that enhance awareness and perception (Savasta and Ultav, 2022). Conveying environmental messages through artistic content takes the impact of those messages even further. It shows that art and technology can work together to communicate the complex environmental problems the world faces today. When virtual reality (VR) and augmented reality (AR) are combined, they produce powerful audience experiences that stick with viewers long after the fact (Moghimi et al., 2016; McIver Lopes, 2004; Olgen and Cucuzzella, 2024a).

Collaboration between art and technology to convey a clear message to audiences is more evident than ever. This is when the two disciplines unite in unprecedented ways (Murray, 2014). But when it comes to not only communicating and engaging with sometimes life-and-death environmental problems, art has proved its worth time and again. In a recent line of communications, the Environmental Defense Fund (EDF) shows how good art can work in concert with good science to drive home the nature, root causes, and possible solutions of issues that being “aware” just is not cutting it for anymore (Zhou et al., 2024).

This captivating event changes the public’s perception, making them more involved and caring about environmental issues. It uses the ancient art of storytelling to connect with people on a level that is fundamental to being human. Combined with sensory stimulation, this form of communication elicits a profound emotional response (Zhou, 2021). Even though the installation does not focus on providing information, using the methods above is still very effective in creating a more informed public than it previously was about environmental issues.

### ***Behavioral change as a result of interactive environmental installations***

A significant finding from the research is that audience engagement with digital interactive installations appears to prompt a behavior change (Olgen and Cucuzzella,

2024b). The installations' communication of environmental concerns and their offering of concrete steps an individual can take, or the benefits that might result from a behavior change have led audiences to take those steps and produce the benefits shown. From the appearance of many reports, a major part of this scenario is the personalization of the audience member's situation concerning the environmental crisis (Kostakis et al., 2016). The installations often do this, usually in ways that might not be achievable with equal force through other mediums. Audience members appear to "get it" in a way that is more personally salient, and they are thus said to be transformed by this encounter (or series of encounters) in a manner favorable to the sustainability theme (Lu and Liu, 2023). The influence of the installations on education offers yet another angle from which to consider the transformation problem.

Engagement with digital interactive installations has resulted in changes in audience behavior. This suggests that these exhibits have the potential to get people to act. Such installations, in their current climate of use, likely serve to raise awareness about sustainable practices and inspire audiences to perform these practices (Song and Gu, 2022). In the present context, such installations probably do more than make people aware of the need for sustainable practices. They also inspire people actually to carry out those practices. The move toward sustainable behavior among the audiences indicates that the installations work. They seem to translate the raised awareness and emotional engagement the installations foster into real-world environmental actions (Olgen and Cucuzzella, 2024b).

### *Navigating challenges and seizing opportunities for future environmental installations*

Digital interactive installations face challenges and opportunities. They affect both the short-term vitality and the long-term sustainability of the work, making it necessary to think about installations in terms of an audience. Without a viable, sustainable audience, the work cannot substantially impact environmental consciousness (Olgen and Cucuzzella, 2024b). Ensuring accessibility involves far more than just physical and economic access. It requires accessibility that is also cultural and linguistic. It demands content diversity that genuinely reflects the audience. The installations' sustainability—a reflection of the environmental values they promote—demands innovative, minimal-ecological footprint approaches. To overcome the challenges of creating impactful installations, artists, technologists, and environmentalists must work together—and with the public and private sectors. This collaboration is essential for surmounting the obstacles that stand in the way of truly sustainable, advocacy-driven art that can effect environmental change (Basaraba et al., 2021). Addressing the matter of accessibility and inclusivity is vital for any digital interaction. Overcoming this requires innovative strategies to extend the reach of these installations to diverse audiences, ensuring that everyone can engage with and benefit from these experiences (Gould and Sermon, 2020).

In addition, we must assess the installations' sustainability. They should have as little of an ecological viciousness as possible; that is, they should deliver the intended ecological outcome without wrecking the environment. This means the projects should use environmental materials and practices. They should not become another part of the overblown and overstuffed environmental problem we all face. Projects should aim to be ecological, demonstrating that a sustainable approach is not only viable but essential—a livable, enduring solution.

There is significant potential for artists and environmentalists to make a real impact by incorporating digital installations into environmental campaigns and actions. If artists and

creators place this work within the broader context of environmental news and initiatives, actively engaging with and updating the audience or target community and taking the lead in framing the narrative and calling for action, they could have a far greater influence on environmental conditions and policy.

## Conclusion

This study systematically explored the influence of digital interactive installations on promoting environmental consciousness, employing a mixed-method approach that integrated a systematic review with thematic analysis. First, we did a systematic review of the growing body of literature about digital installations that are in some way related to environmental concerns. Then, we looked at the installations more closely—considering their historical background and conceptual framing—using a thematic analysis.

Our analysis revealed that digital interactive installations significantly impact audiences by immersing them in environmental narratives and facilitating a deeper emotional and cognitive connection to sustainability issues. Themes such as climate change, biodiversity, and renewable energy were effectively communicated, engaging a wide audience through innovative artistic and technical strategies. Notably, these installations prompted reflections on personal and collective environmental responsibilities, leading to documented changes in awareness, attitudes, and behaviors toward more sustainable practices. The study highlighted the critical role of immersive engagement mechanisms, the breadth of environmental themes addressed, and the tangible audience impact in fostering environmental consciousness. Moreover, it acknowledged the challenges of ensuring accessibility, inclusivity, and sustainability in these installations. It also identified opportunities for greater integration with environmental actions and the importance of public and private support.

Overall, digital interactive installations have a huge effect on environmental advocacy. Such creations not only grab people's attention but also engage them in a manner that is both fun and profound. They are a strong first step toward changing people's behaviors positively and sustainably. We believe the most important insight from our discussions is how these digital creations, both large and small, unfold throughout the audience's interaction with them. Their interactive nature ensures that each viewer experiences or engages with the work in a unique and meaningful way.

There are several limitations to this study's narrative. Firstly, it relies almost exclusively on published literature or projects that have been written up but gives no time to installations that might have existed without public relations machinery. Secondly, the study tries to offset this in part by triangulating across themes, meanings, and techniques, but such interpretation of qualitative data is itself quite subjective and not a guarantee of capturing installation nuances. Thirdly, the nearly exclusive use of installations in public and semi-public spaces and the hypothetical nature of many references in fact and throughout the argument could lead us to an overstated understanding of these kinds of installations' actual impact. Finally, the highly skilled and artistic nature of many of the pieces discussed tends to obscure a weakness in the presentation: the lack of a detailed discussion on the actual interactivity of these installations.

There are also several avenues for future research. Firstly, Future investigations might profitably examine a greater range of digital interactive installations. After all, there is a world of such works all around us now, many occupying installations that we can find in

galleries, fairs, or other art spaces. To the extent that these works deal with environmental issues, we might reasonably expect them to be filling up our libraries. Secondly, there is a clear need for longitudinal studies that track changes in environmental consciousness and behaviors over time, offering more profound insights into the lasting impact of these installations. Thirdly, research could benefit from exploring the impact of digital installations in private settings, such as homes or workplaces, to understand how these environments influence engagement and behavior change. Finally, empirical studies with mixed methods could offer something of a “gold standard” for understanding the effectiveness of digital installations as a new face for environmentalism.

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