Design of a Marine Conservation-Themed Digital Interactive Picture Book Based on Augmented Reality (AR) Technology

CHEN Mengran
Jiangsu Maritime Institute, Nanjing, 211170, China
Hanyang University, Seoul, 04763, Republic of Korea

ABSTRACT

[Background] Worsening marine ecological degradation highlights the urgency of enhancing children's marine conservation awareness. Traditional picture books, constrained by linear narration and passive reading, are insufficient for conveying complex environmental issues, while Augmented Reality (AR) technology enables immersive and interactive learning for environmental education.
[Objective] This study explores how AR-enhanced picture book design improves children's engagement with marine conservation themes and proposes an interactive design framework for AR digital picture books.
[Method] A print-AR dual-medium model was adopted, with first-person baby sea turtle narration contrasting healthy and crisis marine scenarios. Multimodal elements and task-based interaction were integrated; AR prototypes were built via Kivicube image recognition and refined through iterative usability testing.
[Results] The AR picture book converts static ecological information into vivid, participatory experiences, boosting immersion, attention and emotional resonance. It improves children's understanding of marine issues and is applicable to parent–child reading and public education.
[Conclusion] AR-based picture books provide an effective environmental education approach via immersive storytelling and intuitive interaction, offering practical design strategies for marine conservation communication.

Keywords: Augmented Reality; Digital Interactive Picture Book; Marine Conservation; Public Science Education

ORCID: 0009-0000-1302-4464
Corresponding Author: CHEN Mengran; mengranchen39@gmail.com
Funding: 2024 Jiangsu Province Vocational College Student Innovation and Entrepreneurship Training Program (Institutional-level) (Project NUmber: GX-2024-042), Project Title: Design of a Marine Conservation-Themed Digital Interactive Picture Book Based on Augmented Reality (AR) Technology in the Context of the Metaverse.
DOI: 10.23112/jgas25123101

Received: 15. Oct. 2025 **Reviewed:** 05. Nov. 2025 **Accepted:** 31. Dec. 2025

1 Introduction

Digital interactive picture books based on Augmented Reality (AR) technology have emerged in recent years as a new form of reading that integrates the achievements of multiple disciplines, including computer graphics, human–computer interaction, education, and digital media art. AR technology employs cameras, sensors, and image recognition to superimpose virtual images, sounds, animations, and other digital information onto the real world, thereby constructing an interactive environment that blends virtual and physical realities (Zhang, 2019). In reading contexts, AR technology can recognize specific images or page elements in picture books and trigger corresponding multimedia content such as 3D animations, voice narration, or interactive games, thereby revitalizing traditional print media on digital platforms.

Digital interactive picture books are defined as books that achieve dynamic interaction between text–image content and users through mobile devices, touchscreens, or AR/VR equipment (Wan, 2024). They transcend the limitations of traditional picture books characterized by "passive reading and linear browsing," emphasizing instead operability, feedback, and contextual immersion. Particularly in educational and reading settings, interactive picture books not only enhance the fun and immersion of learning but also strengthen users' comprehension and memory of knowledge. For instance, Helen Papagiannis created the world's first true AR picture book, *Who's Afraid of Bugs?*, which uses image recognition to trigger interactive animations and sound effects. Touching a spider activates an "attack" animation; triggering an ant links to explanatory scientific text and images; and activating a butterfly simulates the flapping of wings in a flower field. These features help children learn about insects and reconstruct their perception and curiosity by overcoming fear through virtual interaction.

Similarly, the AR picture book adapted from the renowned Chinese science fiction film *The Wandering Earth* was developed with contributions from scientists at the Institute of High Energy Physics (Zhou, 2020), Chinese Academy of Sciences. Using multimedia, 3D modeling, and intelligent interaction technologies, the book virtually reconstructs the vast cosmos, space stations, futuristic underground cities, and the "Wandering Earth Project." It also provides comprehensive explanations of the solar system, the history and structure of space stations, the design principles of underground cities, and the scientific foundations of the project—such as the gravitational slingshot effect (as shown in Figure 1).

Fig 1: The AR picture book adapted from the science-fiction film *The Wandering Earth*

Image source: *The Wandering Earth* AR picture book

At present, AR-based digital interactive picture books are becoming important expressive forms across diverse domains, including museum exhibitions, science popularization, intangible cultural heritage transmission, social issue advocacy, and public communication. With their multisensory integration and fusion of virtuality and reality, they are gradually reshaping users' perceptions of book media and transforming reading behaviors.

2 Analysis of the Background of the Research

2.1 Global Marine Ecological Crisis and Weak Public Awareness

In recent years, marine ecosystems have faced unprecedented crises due to escalating ecological degradation, including plastic debris pollution, coral reef bleaching caused by rising sea temperatures, acidification, and contaminant erosion, as well as the depletion of fishery resources. International organizations such as the United Nations Environment Programme (UNEP) have repeatedly issued reports calling on the global community to strengthen marine conservation efforts. However, in practice, public awareness of marine pollution—particularly among children, remains vague, and systematic channels for environmental education are lacking. Traditional approaches to environmental publicity largely rely on text, static images, and offline lectures. These methods are often overly didactic and abstract, lacking effective educational media and behavioral guidance mechanisms. As a result, they fail to evoke emotional resonance, foster active participation, or generate meaningful behavioral transformation. Consequently, the development of educational media that integrates contextual awareness and interactive guidance has become an important entry point for enhancing public environmental consciousness.

2.2 Potential of AR in Digital Publishing and Science Education

Augmented Reality (AR) technology, by overlaying virtual content onto real-world environments, provides users with immersive, interactive, and multisensory experiences. In recent years, this technology has demonstrated broad application potential in digital publishing, science communication, and cultural dissemination. He Siqian, in From VR/AR to the Metaverse: Research on Immersive Interactive Picture Books for the Alpha Generation, points out that with the integration of emerging technologies such as the metaverse and VR/AR, picture books have evolved from a mode of “passive reading” to one of “immersive participation” in interactive learning (He & Qin, 2022). AR technology not only expands the expressive possibilities of digital picture books by transforming static text and images into tangible 3D animations, audio narration, and gamified mechanisms, but also stimulates curiosity and exploratory motivation. This significantly enhances user engagement and immersion, while improving knowledge comprehension and memory retention. Similarly, the AR picture books bring traditional cultural content “to life” through 3D animation, interactive design, and dynamic presentation, thereby enhancing both communication effectiveness and experiential appeal. By leveraging interaction modes such as clicking, dragging, and voice triggering, users can even simulate the processes of intangible cultural heritage practices. The unique advantages of AR interactive technology—including immersive content, vivid and lively forms, and immediate feedback—provide effective support in areas such as public exhibitions, cultural identity formation, and value-oriented education (Miao et al., 2022).This technological empowerment not only creates new opportunities for the in-depth dissemination of scientific knowledge but also reshapes the logic of content presentation within the field of digital publishing.

2.3 Integration of AR with Marine Conservation Themes

The application of Augmented Reality (AR) technology to marine environmental protection picture books not only reflects technological innovation but also carries significant value in public communication and moral education. By constructing contextual narratives and triggering visual feedback through interactive

character-based tasks, users are able to comprehend the seriousness of marine ecological issues while simultaneously cultivating a sense of responsibility and willingness to act through virtual participation. Compared with the unidirectional transmission of traditional science education, AR picture books employ a model of "storytelling + interactive participation + multisensory presentation and feedback," thereby creating an environmental education pathway that is more immersive, empathetic, and memorable.

3 Project Innovations

3.1 Advantages of AR in Marine Conservation Picture Books

3.1.1 Innovation in Experiential Education

By embedding AR technology into traditional picture book design, it becomes possible to achieve real-time overlay and presentation of multidimensional information—such as virtual marine organisms and dynamic ecological systems—under the influence of temporal, spatial, and environmental factors through image recognition and spatial positioning. AR interactive picture books can significantly visualize abstract marine ecological crises. For example, from a temporal perspective, the dynamic visualization can demonstrate the gradual degradation of vibrant, colorful coral reefs into bleached and ultimately dead corals. From a spatial dimension, AR can illustrate ecological interactions such as floating marine plastic pollution, sea turtles suffocating or becoming entangled in fishing nets after ingesting plastic bags, and other endangered conditions. Through 3D animations and interactive feedback, children and readers are immersed in these scenarios, fostering a deeper understanding of environmental issues. Compared with traditional text or illustrations, the multisensory stimulation of AR (visual, auditory, and interactive operation) enhances memory retention and learning interest, providing an innovative medium for marine environmental education.

3.1.2 Significance for Science Communication

Picture books are important media for both parent–child reading and mass readership. When combined with AR interactive functions, they can extend into offline AR application experiences that complement printed books (Chiang et al., 2014). By supporting multi-terminal access via mobile phones, tablets, or public touchscreens, AR picture books enable mobile sharing, social dissemination, and immersive experiences that amplify the spread of environmental information. This approach is particularly effective in contexts such as museum exhibitions, public libraries, and classroom teaching, where it can establish a multilayered communication chain of "children–parents–social networks." Such a structure broadens the reach of marine protection themes and expands their social impact.

3.2 Constructing a Dual-Medium Narrative Model of "Print + AR" Based on Interactive Augmented Reality

This project transcends the expressive limitations of a single medium by innovatively integrating the static reading advantages of printed picture books with the dynamic presentation capabilities of AR interactive content, thereby forming a dual narrative structure of "parallel and complementary lines." While the printed picture book carries the core storyline and establishes the visual tone, the AR medium extends narrative details, overcoming the constraints of two-dimensional static media and providing a three-dimensional, interactive, and immersive reading experience (Cheng et al., 2016). The two forms complement one another: readers can experience both the warmth of traditional print reading and the sense of immersion and participation afforded by digital

technology. This integration not only enhances users' sensory engagement and comprehension of information but also significantly strengthens the persuasive power and memorability of science communication related to marine conservation.

4. Design Strategies

4.1 User Needs Analysis and Thematic Positioning

In this study, the primary target users are clearly defined as children aged 6–12, while also considering parent–child co-reading as well as applications in public educational and science communication settings such as marine museums and theme parks. By identifying and analyzing user characteristics and needs, this project provides both theoretical support and practical guidance for content planning, interaction mechanisms, and visual design of AR-based picture books. This ensures a balance between entertainment and education, thereby achieving the dual objectives of knowledge dissemination and value shaping.The user needs analysis and thematic positioning of this study mainly encompass three dimensions:

At the functional level, the picture book is expected to overcome the static limitations of print reading by employing AR technology to realize information overlay and immersive interaction. At the experiential level, users anticipate a reading mode that integrates playfulness, interactivity, and immersion, thereby enhancing learning motivation and engagement. At the educational level, the picture book is expected, with the support of digital technologies, to effectively convey knowledge about marine conservation, strengthen social responsibility for environmental protection, and promote the dissemination of environmental values aligned with the principle of "technology for good," ultimately fostering greater public awareness and social advocacy.

4.2 Content Planning and Narrative Framework

At the level of content planning, this design project adopts the perspective of a small turtle living in an aquarium as the first-person narrator, unfolding an immersive storytelling framework. The turtle, who has never seen the real ocean, constructs an imaginative vision of a "beautiful sea" through the vivid accounts of other marine characters, including a jellyfish, a tropical fish, a ray, and an anglerfish. However, when the turtle is eventually released into the actual ocean, it encounters shocking scenes: floating marine plastics everywhere, once-vibrant coral reefs bleached and decayed, oil leakage from human drilling platforms, and marine creatures suffering from overfishing. This stark contrast between "beautiful memories and harsh realities" creates a powerful emotional impact, representing a typical framework of contrastive narration. Through the turtle's process of "growth and cognition," the narrative metaphorically reflects the real-world marine environmental crisis, reinforcing readers' emotional resonance and ecological awareness, and ultimately achieving an allegorical educational effect.

4.3 Visual Design

4.3.1 Layout and Composition Design

In terms of layout, this project draws on the cross-page arrangements of classic picture books such as *Where the Wild Things Are* (Sendak, 1963), adopting a flexible structure that integrates text, illustrations, and blank space to ensure both narrative rhythm and visual hierarchy (as shown in Figure 2). The compositional approach emphasizes multiple perspectives—including eye-level, low-angle, bird's-eye view, and long shots，to

enhance spatial depth and immersion. For example, in the scene where the little turtle is released into the sea, a bird's-eye perspective is used to depict the vast and complex marine environment, generating a strong sense of presence for the reader.

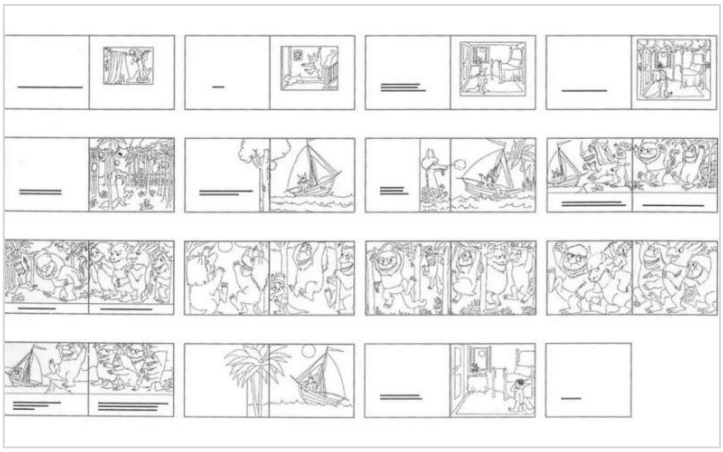

Fig 2: Layout Design Illustration of the Classic Picture Book *Where the Wild Things Are*

Image source: Illustrations from *Where the Wild Things Are* by Maurice Sendak

4.3.2 Illustration Style and Color Language

The overall visual style employs hand-drawn textured illustrations, combined with cartoonish and anthropomorphic character designs to align with children's aesthetic and cognitive preferences. In terms of color usage, the first half of the book adopts highly saturated blues, oranges, and yellows to convey vitality and hope, while the second half shifts to lower-saturation, cooler hues such as gray-blue, dark green, and brown, creating a somber atmosphere of ecological destruction. This stark color contrast serves as an implicit educational cue.

4.3.3 Typography and Text Design

Categorized typography not only helps readers distinguish narrative layers but also enhances visual diversity. This design distinguishes three styles of text corresponding to the title, narration, and character dialogue. For the book title, a lively, hand-drawn cartoon font is used to emphasize approachability and recognition. Standardized serif or sans-serif fonts (e.g., Songti or Heiti equivalents) are applied for narration to ensure clarity and professionalism. Character dialogues are expressed in anthropomorphic handwritten fonts, reinforcing individual personality traits and emotional resonance.

4.3.4 Binding and Media Adaptation

The book adopts a hardcover flat-binding format to ensure stability and reliable recognition when combined with AR technology. The cover features a group portrait of the little turtle and various marine animals, set against a blue gradient background with a prominent title to highlight the thematic focus. To accommodate AR integration, all illustrations are produced in vector or high-resolution formats to guarantee visual clarity and accurate recognition during scanning.

4.4 Interactive Design and Implementation

4.4.1 Trigger Design

Users activate interactive content by scanning picture book pages with the camera of a mobile device. Once the system recognizes the designated image markers within the book, it automatically retrieves the pre-set virtual

scene. Following on-screen guidance, users can click navigation buttons or virtual triggers to initiate video playback, 3D animations, narration, or sound effects. This trigger mechanism ensures intuitive operation and immersive engagement.

4.4.2 Animation Effects

To enhance the sense of immersion, the design team incorporated contextual animation effects into the picture book. For example, when users scan the page, the AR system initially presents a simple underwater background with only basic terrain elements. As recognition progresses, marine plants such as seaweed and coral gradually emerge and populate the scene. Subsequently, various tropical fish enter the frame, their vivid colors and fluid motions enriching the visual composition. The sequence culminates in a dynamic multi-species environment that evokes the gradual restoration of an underwater ecosystem (as shown in Figure 3).This layered animation process surpasses the visual limitations of static illustrations by enabling children to experience discovery and participation through continuous scene changes. As a result, the effect more effectively captures attention, strengthens emotional engagement, and enhances children's interest and cognitive connection to marine ecological themes.

Fig 3: Animation effects design illustrating marine ecosystem scenes

Image source: Original illustration created by the author

4.4.3 Sound Design

The audio system consists of background music, character narration, and interactive sound effects. Background music establishes the overall atmosphere and conveys the emotional tone of the story. Character dialogues and narration are adjusted through audio software to match character traits in tone and rhythm, ensuring alignment with visual imagery. Interactive sound effects are synchronized with user actions—for example, after successfully cleaning ocean debris, a celebratory confetti animation is accompanied by a "pop" sound, enhancing immersion and a sense of achievement.

4.4.4 Implementation of Interactive Functions

On the Kivicube platform, scanned pages of the picture book are uploaded to the backend as recognition markers. When users scan the corresponding pages with a mobile device, the system triggers pre-set 3D models, audio, or video content (as shown in Figure 4). Unlike Unity-based code development, Kivicube provides a visual configuration of "trigger conditions + response actions," making the process more intuitive. After completing the interaction design, the platform supports one-click generation of QR codes or links, which can be accessed directly via mobile browsers without requiring additional app installation.

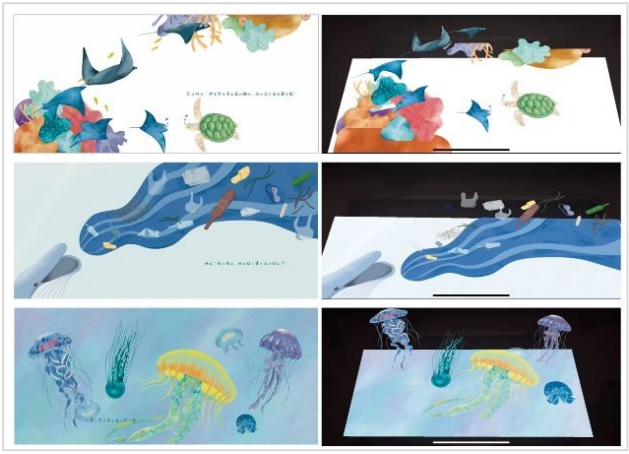

Fig 4: Interactive AR scene triggered by scanning the printed picture book page

Image source: Original illustration created by the author

After completing the interaction design, the Kivicube platform supports one-click generation of QR codes or web links, enabling users to access the AR experience directly through a mobile browser without installing additional applications. During the testing phase, the research team evaluated whether the interactions functioned as intended by scanning the QR codes corresponding to each picture book page, examining factors such as recognition speed, animation loading, and audio–video synchronization. If any issues were identified, the team could modify model parameters or interaction logic directly in the platform backend and republish the updated version.

5. Conclusion

This study, centered on AR technology, explores the design pathways and practical methods of digital interactive picture books on the theme of marine conservation. By adopting a dual-medium narrative model of "print + AR" and incorporating an immersive storytelling framework, the project overcomes the two-dimensional limitations of traditional reading while effectively enhancing children's engagement and emotional resonance during the learning process. In terms of application, the design is not only suitable for parent–child reading at home but also demonstrates considerable potential for dissemination in museum exhibitions, public educational spaces, and social advocacy contexts, offering new practices for both digital publishing and public communication. Furthermore, this study verifies the potential of AR technology in science education and social value dissemination, providing theoretical reference and methodological insights for subsequent research.

Future studies may further investigate multi-platform adaptability, cross-cultural communication, and the integration of artificial intelligence into interactive picture books, thereby promoting the long-term impact of AR-based digital interactive picture books across broader contexts of social education.

References

Bacca, J., Baldiris, S., Fabregat, R., Graf, S., & Kinshuk. (2014). Augmented reality trends in education: A systematic review of research and applications. Educational Technology & Society, 17(4), 133 − 149.
URL: https://hdl.handle.net/20.500.12799/5029

Billinghurst, M., & Duenser, A. (2012). Augmented reality in the classroom. Computer, 45(7), 56 − 63.
DOI: https://doi.org/10.1109/MC.2012.111

Cheng, K. H., & Tsai, C. C. (2016). The interaction of child − parent shared reading with an augmented reality picture book and parents' conceptions of AR learning. British Journal of Educational Technology, 47(1), 203 − 222.
DOI: https://doi.org/10.1111/bjet.12228

Chiang, T. H., Yang, S. J., & Hwang, G. J. (2014). Students' online interactive learning activities by using an augmented reality-based game. Computers & Education, 77, 49 − 58.
DOI: https://doi.org/10.1016/j.compedu.2014.04.015

He, S., & Qin, J. (2022). From VR/AR to metaverse: Immersive picture book interaction design for the Alpha generation. Library Development, 5, 66 − 67.
DOI: https://doi.org/10.19764/j.cnki.tsgjs.20220169

Huang, P. C., & Chen, C. C. (2024). Exploring the experience of augmented reality applied to children's book-finding app. Proceedings of the 11th IEEE International Conference on Consumer Electronics − Taiwan (ICCE − Taiwan 2024), 743 − 744.
DOI: https://doi.org/ 10.1109/ICCE-Taiwan62264.2024.10674259

Jones, S., Hall, L., & Hilton, J. (2012). Exploring children's "indexical encounter" with real and digitised archive photographs using tablet and large flat screen technologies. Proceedings of the 11th International Conference on Interaction Design and Children (IDC' 12), 30 − 39.
DOI: https://doi.org/10.1145/2307096.2307101

Miao, Y., Xu, A., & Cao, Y. (2022). Design strategy research on AR picture books of Changsha nursery rhymes from the perspective of situated cognition. Furniture and Interior Design, 29, 7.

Naradika, R., Masood, M. B., Hafizah, N., & Baharudin, N. S. B. M. (2024). An integrated AR application with creative dental health illustration book as a learning media for children. Proceedings of the 14th IEEE Symposium on Computer Applications and Industrial Electronics (ISCAIE 2024), 283 − 288.
DOI: https://doi.org/10.1109/ISCAIE61308.2024.10576447

Sendak, M. (1963). Where the wild things are [Picture book]. Harper & Row.

Wan, X. (2024). Research on AR children's picture book design based on user experience (Master's thesis). Changchun University of Technology.

Wang, J., Zhang, S., Wang, Z., Wang, J., & Fang, X. (2024). Picture book design based on AR technology and

immersive digital platforms. Design Art Research, 14, 6.

Wang, S., Kim, S. P., & Hong, D. S. (2023). A study on the characteristics of children's picture book design using AR: Focused on popular books published in the last five years. Illustration Forum, 24(77), 51 − 66.

Yilmaz, R. M. (2016). Educational magic toys developed with augmented reality technology for early childhood education. Computers in Human Behavior, 54, 240 − 248.
DOI: https://doi.org/10.1016/j.chb.2015.07.040

Zhang, Y. (2019). Research and practice on AR children's picture book design based on mobile terminals (Master's thesi). Nanjing University of the Arts.

Zhou, B. (Adapter). (2020). The Wandering Earth: Film adaptation picture book (Illustrated by A. Krylov). Jieli Publishing House.

Disclaimer: The statements, views, and data included in all publications represent only those of the individual authors and contributors and not those of JGAS and/or the editors. JGAS and/or the editors bear no responsibility for any personal injury or property damage arising from the use of any ideas, methods, instructions, or products mentioned in the content.