ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P239

A Study on Data Visualization Design of Marine Biodiversity Based on Empathy Theory

Xi Deng [a] *, Youfang Zhang [b]

School of International Communication and Arts, Hainan University, Haikou, Hainan, China.

[a] dengxi@hainanu.edu.cn, [b] 23221351080041@hainanu.edu.cn

Abstract. As the crisis of marine ecological degradation intensifies, public awareness and concern for marine biodiversity have grown significantly. Data visualization, as a critical tool for communicating scientific knowledge, not only enables intuitive dissemination of complex information but also serves as a bridge between rational analysis and emotional engagement. This study investigates the integration of empathy theory into the design of marine biodiversity data visualizations, aiming to foster deeper emotional resonance and environmental consciousness among users. By examining the unique characteristics of marine biodiversity and synthesizing key principles of empathy theory, the study proposes a design framework that incorporates emotional storytelling, multisensory interaction, and visual metaphor. A prototype project was developed to evaluate the practical application of this framework. The findings suggest that empathy-driven visualization design can substantially enhance user engagement and comprehension of biodiversity data. This research contributes innovative design strategies for environmental data communication and provides both theoretical insights and practical guidance for advancing marine ecological protection.

Keywords: Empathy theory; marine biodiversity; data visualization

1. Introduction

As global climate change and intensified human activities continue to reshape the natural world, marine biodiversity is facing unprecedented threats. The fragility of marine ecosystems is becoming increasingly evident, with habitat destruction, accelerated species extinction, and the functional degradation of ecosystems posing serious challenges to ecological balance. In this context, there is an urgent need for innovative communication strategies that can transform complex and abstract scientific data into intuitive and engaging visual forms, making marine biodiversity and its vulnerabilities more accessible to scientists, policymakers, and the general public.

Data visualization plays a pivotal role in this transformation. By translating intricate ecological information into visual narratives, it bridges the gap between data and understanding. However, beyond visual clarity, there is a growing need for emotionally resonant design that can engage audiences on a deeper level. This is where empathy theory offers a valuable framework—shifting focus from purely cognitive interpretation to fostering emotional and multisensory connections with marine life and ecosystems. Incorporating principles of empathic design into data visualization facilitates a shift from static presentations to immersive, interactive, and multisensory experiences. These experiences not only attract attention through visuals, but also engage audiences through sound, touch, and emotional presence, creating a more holistic and memorable encounter with the data. When guided by principles of data aesthetics and scientific rigor, such visualizations communicate both the urgency and beauty of marine biodiversity in ways that are intellectually compelling and emotionally evocative. The integration of art and science thus becomes a powerful vehicle for raising awareness, stimulating emotional engagement, and encouraging pro-environmental behavior.

This study proposes a visualization model grounded in empathy theory to enhance the coherence of immersive storytelling and improve the readability and communicative efficacy of biodiversity data. Through a case study analysis of marine biodiversity data visualization, the paper identifies current limitations and explores potential avenues for innovation. Furthermore, it outlines a science communication strategy informed by empathy, encompassing affective storytelling, interactive

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P239
engagement, and multisensory stimulation. These design strategies aim to foster emotional resonance, deepen public understanding, and cultivate a stronger sense of responsibility for marine conservation. Ultimately, this research offers a new perspective on how data visualization can transform science popularization in art and design, contributing to both ecological awareness and sustainable design practices.

2. Theoretical Foundations and Related Research

2.1 Overview of Empathy Theory

The term “empathy” originates from the German word “Einfühlung”, first introduced by German philosophers Hermann Lotze and Robert Vischer. In its earliest usage, the term referred to the projection of one's feelings into natural objects or phenomena within artworks during aesthetic appreciation[1]. Dutch psychologist Frans de Waal once remarked, “We are not living in an age of reason, but in an age of empathy”[2]. A growing academic consensus suggests that the future trajectory of societal development will be increasingly guided by empathy as a core competency. As a discipline grounded in practice, design is no exception to this trend[3]. In the field of design, empathy emphasizes the principle of human-centeredness. It encourages designers to creatively respond to challenges in daily life and the environment by combining empathetic insight with aesthetic perception. This approach not only addresses practical needs but also reawakens emotional awareness in users.

2.2 Empowering Data Visualization through Empathy

Data visualization, grounded in computer graphics and image processing technologies, refers to the theoretical systems, methodological pathways, and technical tools that transform various forms of data into intuitive visual representations—often interactive in nature[4]. The primary goal of data visualization is to present analyzed datasets in a manner that is efficient, accurate, and aesthetically engaging, thereby enhancing users’ access to information and improving their viewing experience[5].

Empathy-driven design empowers data visualization by transforming cold digital imagery into emotionally resonant visual language. By integrating psychological experience with design strategy, it reconstructs the communicative mode of technological information. A notable example is the “Haibao Map”, launched on June 8, 2020, in celebration of the 12th World Oceans Day (Fig. 1). This project employed data visualization to depict 35 representative rare and endangered marine species native to Chinese waters—such as the Chinese white dolphin, hawksbill turtle, and large yellow croaker—alongside three typical marine habitats. The design not only conveyed scientific data but also fostered emotional connection through vivid imagery and interactive elements. For instance, in the “WWF Haibao Map” mini program, users could collect virtual puzzle pieces to unlock corresponding species, while simultaneously learning about their ecological characteristics and the threats they face. This empathy-oriented design strategy significantly improved the effectiveness of data communication, making it easier for the public to engage with the narratives behind the data. The shift from emotional resonance to behavioral motivation highlights the value of empathy theory in data visualization. By enabling alternative narrative approaches, empathy provides effective means of communicating complex information, offering valuable insights for science communication and the visual design of marine biodiversity data.

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P239

Fig. 1 WWF Haibao Map

3. Building a Marine Ecological Empathy Design Model

3.1 Analysis of the Current Status of Marine Biodiversity Data Visualization

3.1.1 Lack of depth of content and narrative

In recent years, increasing attention has been given to marine biodiversity and the protection of endangered marine species. However, current science communication and popularization efforts in this area tend to rely primarily on unidirectional presentations of data and information, lacking depth in narrative structure. For instance, many science platforms simply list the classification, distribution, and conservation status of marine species without integrating these elements into a coherent storyline.

The content is often fragmented, with individual knowledge points presented in isolation and little organic connection between them. This makes it difficult to sustain public interest. When showcasing different marine organisms, many designs fail to establish ecological relationships or contextualize their habitats, resulting in a limited understanding of the marine ecosystem as a whole.

3.1.2 Lack of interaction and immersion

Current marine biodiversity data visualization designs predominantly rely on visual graphics to convey information, with insufficient integration of multisensory modalities such as auditory and tactile perception. For instance, in the presentation of marine life, elements like underwater acoustics or the tactile sensation of water currents are often overlooked, limiting users' ability to fully immerse themselves in the marine environment. Although technologies such as virtual reality (VR) and augmented reality (AR) have been widely adopted, many applications rely solely on projection or basic visual rendering, which fails to create a truly immersive experience. Some VR experiences, for example, remain superficial in their visual stimulation and lack meaningful interaction with users. As a result, user engagement in science communication experiences remains low, offering few opportunities for active exploration.

3.1.3 Lack of emotional resonance and conceptual communication

In the era of rapid technological advancement, the deep integration of experience design and virtual reality technologies has opened up broad possibilities for science communication and popular science experiences. However, when designers rely solely on technological tools and overly pursue sensory stimulation, it becomes difficult to genuinely move audiences or evoke profound emotional resonance[6].Many science communication projects fail to deeply embed the concept of marine biodiversity conservation into the experience. For instance, some popular science activities

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P239
remain on the surface level of visual display without guiding users to reflect on the impact of human activities on marine ecosystems.

3.2 Directions for Improvement and Expected Results

Current marine biodiversity data visualization often lacks an ecologically holistic perspective, resulting in insufficient narrative depth and content coherence. To address this, biological data should be structured through knowledge graph–driven dynamic narrative engines that enable contextual storytelling. The limitations in multisensory experiences stem from outdated interaction technologies, leading to uncoordinated sensory modalities. Enhancing real-time biofeedback mechanisms can significantly improve immersion and user engagement. Empathy failure is often caused by the inability to open emotional pathways in users, leading to a lack of resonance. Therefore, digital technologies must be transformed into emotional carriers capable of evoking genuine affective responses. Empowering marine biodiversity data visualization with empathy theory can drive ecological communication from immersive experiences toward behavioral transformation, and shift from mere data presentation to shared emotional and value resonance. The table below summarizes the key directions for improvement and the expected outcomes.

Table 1. Directions for improvement and expected results

Dimension of the problem	Root causes of the problem	Directions for improvement	intended effect
Lack of depth of content and narrative	Predominantly one-way presentation of data and information, lacking depth of narrative	Building Immersive Marine Ecospaces with Biological Mapping to Drive Narrative	37% improvement in user experience smoothness
Lack of interaction and immersion	Lack of immersive experience and lagging interactive technology	Enhanced somatic interactions and improved real-time interactive eco-feedback to enhance immersion	48% increase in immersion
Lack of emotional resonance and conceptual communication	Empathic arousal fails to lead people to think	Enhance the emotional interaction between marine life and users to improve emotional engagement	75% Increase in Conversion Rate for Eco-Friendly Behavior

3.3 Marine Ecological Empathy Design Modeling

Empathy theory emphasizes an individual's capacity to understand and resonate with the emotions of others. Ecological empathy extends this capacity to the relationship between humans and the natural environment, highlighting emotional resonance and a sense of responsibility toward nature. In The Design of Everyday Things, Donald A. Norman[7] proposed a three-tiered emotional design framework consisting of the visceral, behavioral, and reflective levels. These dimensions operate both independently and interactively, collectively shaping how humans perceive and emotionally experience the world.

In response to current challenges in marine biodiversity data visualization, it is essential to enhance real-time biofeedback to improve immersion and to strengthen the emotional transformation capabilities of digital technologies. This study deconstructs these needs into a tripartite framework: sensory empathy, cognitive empathy, and behavioral empathy, forming a closed-loop system of "perception–understanding–action." Within the context of marine biodiversity data visualization, this framework can be translated into a design path of "data narrative—aesthetic encoding—ecological awakening," as illustrated in the conceptual model (Fig. 2). By leveraging the metaphorical power of visual symbols, the affective warmth of data schemes, and the ecological dimension of interaction design, this approach aims to transcend the limitations of traditional unidirectional science communication.

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P239

The metaphorical nature of visual symbols refers to the use of imagery, color, and form to translate abstract scientific data into intuitive and emotionally expressive representations. Metaphorical design disrupts the "cold" presentation style typical of conventional science popularization, enabling emotional resonance at the perceptual level. The affective warmth of data visualization refers to the capacity of design to imbue data with emotional temperature, allowing viewers to sense the interconnectedness between humans and the natural world. While traditional data visualization often relies on charts and graphs that are direct but emotionally neutral, the affective approach incorporates aesthetic encoding and narrative expression to humanize data.

The ecological dimension of interactive behavior transforms the audience from passive recipients of information into active participants. Conventional science communication is typically unidirectional, offering limited engagement. In contrast, ecologically driven interactive design fosters immersive experiences that enable audiences to feel their embeddedness within the ecological system, thereby motivating protective behaviors. By integrating metaphorical visual symbols, emotionally resonant data schemes, and ecologically meaningful interactions, ecological empathy design establishes a closed-loop system that moves from perception to understanding to action. This design paradigm breaks through the limitations of traditional science outreach and achieves a holistic transformation from information transmission to emotional resonance and behavioral change.

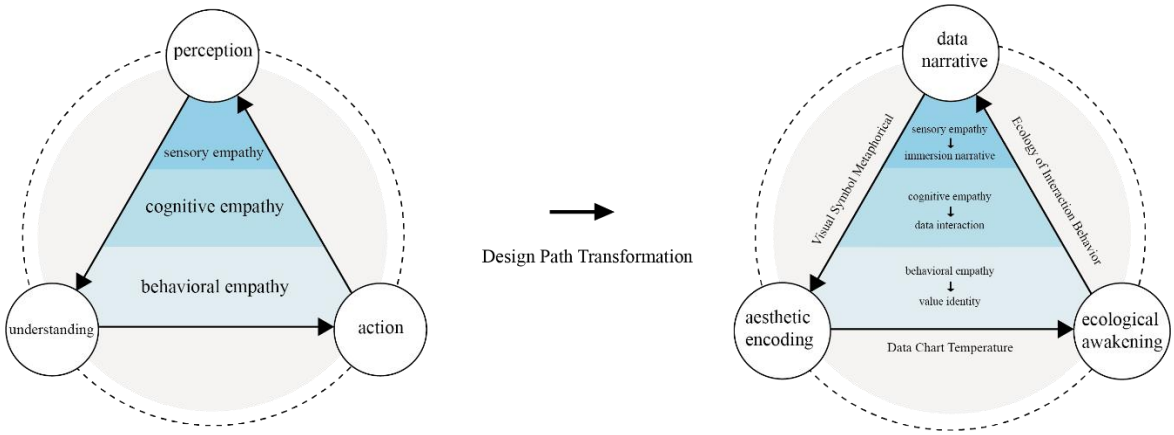


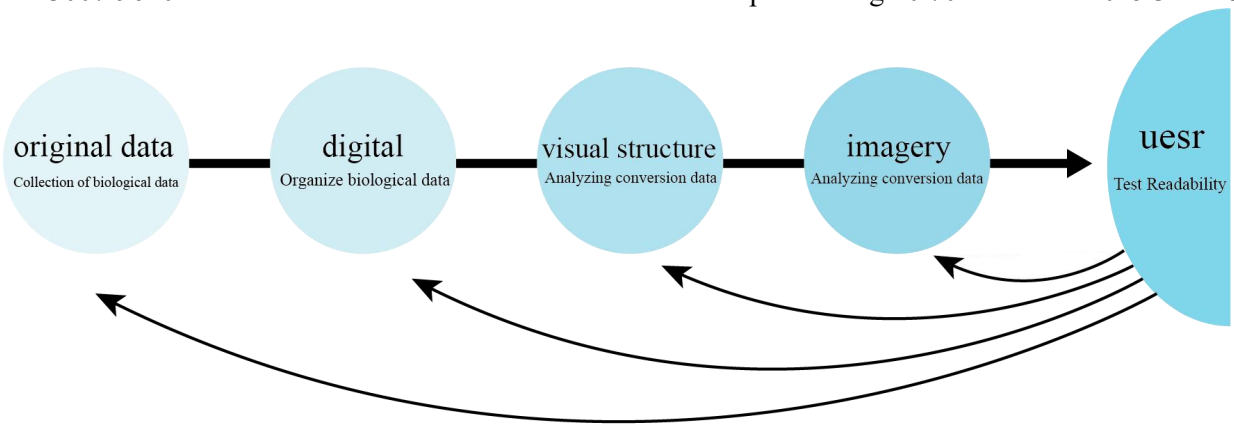
Fig. 2 Ecological empathy design model

4. Design of a Data Visualization Framework Driven by the Ecological Empathy Design Model

4.1 Data Narratives: Multidimensional Data to Enhance Data Aesthetic Performance

The primary goal of marine biodiversity data visualization is to process ecological data in a way that conveys complex information clearly and effectively. This facilitates a deeper understanding of the intrinsic relationships within marine ecosystems and creates an engaging narrative context. The workflow of data visualization is shown below (Fig. 3). It involves the selection and collection of marine ecological data, followed by data interpretation and analysis, and the visual presentation of this information using appropriate formats. To enhance clarity and readability, the selected charts and visual elements must adhere to the principles of data aesthetics. Furthermore, each functional interface should be designed in accordance with multi-dimensional and multi-layered perspectives, allowing for the most suitable chart types to be applied in each scenario.

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P239



When a problem is detected, go back to the problem step to modify and loop.

Fig. 3 Flowchart for visualizing marine biodiversity data

Foreign chart expert Andrew Abela once summarized a guideline for categorizing chart dimensions (Fig. 4), in which he classified the types of relationships that charts are intended to convey into four categories: comparison, distribution, relationship, and composition[8]. Based on the characteristics of each dataset, he analyzed the appropriate types of charts that correspond to different variables. For example, scatter plots and bubble charts can be used to display relationships between variables, while pie charts, waterfall charts, and bar charts are more suitable for illustrating composition. In addition, dynamic data visualization—such as animated charts and real-time updates—can intuitively present changing trends and enhance user engagement and interest. Lastly, the process of data refinement requires continual feedback loops: by collecting user feedback and usage data, designers can iteratively optimize the interface to improve both user satisfaction and readability.

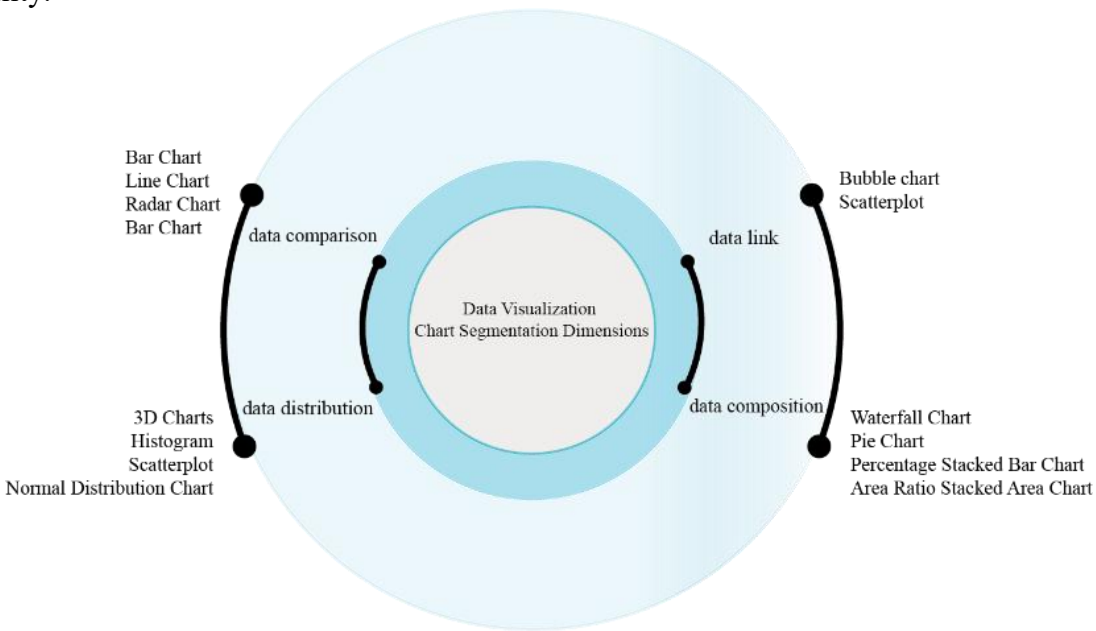


Fig. 4 Chart Dimensioning Guide (Source: Author's own drawing)

4.2 Aesthetic Encoding: Integrating Design Elements to Optimize Data Visualization Layout

Aesthetic encoding serves as a bridge between data and emotion, with its core function being to engage audiences emotionally and foster awareness and concern for marine biodiversity through carefully crafted visual elements. By leveraging design components such as color, shape, layout, animation, and interactivity, marine biodiversity data is transformed into aesthetically pleasing visual forms that not only convey information but also evoke empathy.

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P239

In terms of color usage, hues aligned with marine environments or the living habits of species are selected—deep blues symbolize the mystery and depth of the ocean, while bright accents highlight key data points. Color psychology further enhances emotional resonance: warm tones convey vitality and abundance, while cool tones suggest fragility and tranquility, helping to stir empathy. For example, when visualizing coral reef ecosystems, a deep blue background can evoke the profoundness of the ocean, while the vibrant colors of coral rendered in warm tones highlight their vitality. Conversely, cool colors are suited for illustrating endangered species, eliciting viewers' compassion.

Shape design grounded in biological forms makes complex data more intuitive. Regular shapes such as circles or squares can represent stable populations, while irregular forms—such as wave-like patterns—depict dynamic processes like species migration. The composition of these shapes reflects complex ecological relationships, aiding the audience in understanding the deeper environmental context behind the data.

Layout design adheres to visual aesthetics, emphasizing key data while maintaining spatial hierarchy and appropriate whitespace for an optimal viewing experience. For instance, when visualizing global marine biodiversity, the number of endangered species can be placed at the center, with supplementary information presented around it through minimalistic lines and icons, creating a clear visual structure. This enhances both readability and emotional engagement. Interactive functionality fulfills users' exploratory needs—zooming in to view detailed species information or filtering key datasets empowers user agency. Meanwhile, animated effects—such as simulations of swimming, growth, or migration—immerse viewers in a marine environment. This immersive approach prolongs users' interaction with the data, deepening their understanding and emotional resonance with marine biodiversity.

Through these aesthetic encoding strategies, data is not only communicated with precision but also emotionally connected to the audience. This elevates data visualization from mere "presentation" to meaningful "resonance."

4.3 Ecological Awakening: Immersive Interaction to Enhance Users' Emotional Resonance

Under a design thinking–oriented framework for information communication strategies, enhancing interactivity and audience engagement requires designers to proactively create opportunities for users to become active participants in the communication process[9]. In science communication surrounding marine biodiversity, interactive design serves as a crucial medium that bridges audience cognition and ecological emotion.

Virtual reality (VR) technology is employed to construct immersive panoramic marine ecosystems, enabling users to engage in lifelike interactions with marine organisms through natural gestures. By creating and rendering oceanic environments grounded in multi-sensory storytelling, both biological data and sound data can be visualized in a virtual setting. The spatial layout can be divided into multiple zones, each representing a different marine ecosystem—such as coral reefs, mangroves, the deep sea, and polar regions. Each area leverages unique visual, auditory, and tactile design elements to communicate the ecosystem's distinctive environment and biodiversity. For instance, VR art installations can visualize the genetic diversity of key species like corals or sharks, where interactive data nodes light up in response to user engagement within the virtual marine space.

Auditory design is an essential component of immersive experience. By collecting real ocean sounds—such as waves crashing, fish swimming, and whale songs—a three-dimensional soundscape is created that places users in a believable underwater environment. These sounds dynamically respond to spatial transitions and the movement of marine organisms in the virtual space. For example, in the coral reef zone, users may hear the rustling of swimming fish and flowing water among the reefs, while in the deep-sea zone, they may encounter low-frequency whale calls and subtle sounds made by abyssal creatures. This dynamic sound design not only enriches sensory engagement but also triggers emotional resonance through the expressive qualities

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P239
of sound. The fading calls of endangered species, for instance, can subtly convey the urgency of extinction.

Tactile experience represents one of the most innovative aspects of immersive design. Through interactive devices, users can feel the textures of virtual marine life or simulate the temperature and humidity of seawater. Users might experience the rough surface of coral via a touchscreen or the rhythm of waves through haptic feedback. This tactile dimension intensifies the sense of immersion and allows users to comprehend the living conditions of marine organisms through embodied experience. Tactile feedback can also be integrated with data visualization—for instance, when users "touch" an endangered species, the device may emit a vibration or a temperature shift, delivering a tangible sense of crisis and thereby enhancing conservation awareness. This design transforms abstract data into concrete sensory experiences, fostering deeper emotional connections with the marine ecosystem.

The essence of interactive design lies in making the audience an active participant in the exchange of information. For example, users can zoom in with gestures to explore detailed biological data or filter key datasets to suit their curiosity. This not only empowers exploration but also offers real-time feedback—when a user "rescues" an endangered species, ecological data nodes within the virtual environment may gradually light up, delivering positive emotional reinforcement. The ultimate goal of multi-sensory immersive storytelling is to foster emotional resonance that motivates action. By integrating visual, auditory, and tactile stimuli, users not only gain extensive scientific knowledge but also develop a profound emotional connection to marine ecosystems.

5. Demonstration of a Visualization Framework for Marine Ecological Data Based on Empathy Theory

Based on the ecological empathy design model, this study proposes a framework that integrates a VR narrative engine with immersive storytelling to visualize marine biodiversity data. This approach realizes the dynamic aesthetic encoding of marine species diversity and constructs a science communication blueprint for marine biodiversity through a multi-sensory immersive narrative, incorporating visual, auditory, and tactile modalities. By translating marine species behavior data into narrative language, an immersive marine ecological space is created where real-time interaction facilitates the expression of visual storytelling. These three processes—data transformation, spatial construction, and interactive narration—continually stimulate users' emotional resonance through multi-sensory engagement.

The following figure shows the design of the marine ecological diversity data visualization framework based on empathy theory (Fig. 5). Data construction forms the foundation of this framework, requiring the collection and presentation of the richness, uniqueness, and survival threats of marine species. This includes, but is not limited to, species variety, distribution ranges, conservation status, life habits, global ocean temperatures, and species extinction rates. Such data can be sourced from the Chinese Biological Species Database, which contains comprehensive records of marine organisms in Chinese waters, as well as from other reputable marine research institutions, databases, and academic literature. Once collected, the data must be categorized and structured according to content type. To present marine biodiversity information more intuitively and clearly, various visualization techniques such as scatter plots and line graphs may be employed. Scatter plots are effective for illustrating relationships and distributions among species, while line graphs highlight trends over time. These visual methods improve both the comprehensibility and communicative power of biodiversity data. Tools like Flourish and Adobe Illustrator can be used to produce precise and aesthetically appropriate data visualizations.

Complex biological data is clarified through principles of data aesthetics, ensuring that visual forms remain concise and accessible. The addition of dynamic interactive modules further strengthens the emotional connection between users and the data. These interactive elements encompass ocean environmental simulations, marine species data interaction, and multisensory

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P239

audiovisual responses. Users are able not only to engage with the virtual marine environment in real time but also to interact with marine organisms through tactile and auditory means. This multi-sensory interaction offers a sense of immersion that encourages users to develop a deeper understanding of ocean ecosystems and a heightened awareness of biodiversity conservation.

On the narrative level, marine behavioral data is transformed into compelling storytelling, creating an immersive marine ecological space where each organism possesses a unique story and each ecological phenomenon conveys metaphorical significance. Through real-time interactivity, users can explore this virtual ocean world at their own pace—following migration paths, observing life patterns, and witnessing the survival challenges marine creatures face. This narrative-based approach makes abstract data vivid and emotionally engaging, planting the seed of ecological awareness in users' minds. As users navigate this space, their emotional investment grows, fostering a powerful sense of empathetic resonance. Such emotional connections are critical in motivating the transition from awareness to action.

By combining virtual reality narrative engines with immersive storytelling, this framework transcends the limitations of traditional one-way science communication. Through multi-sensory integration—visual, auditory, and tactile—it transforms complex ecological data into emotionally compelling experiences. This approach not only facilitates public understanding of current marine biodiversity issues but also stimulates protective awareness and a desire for action through emotional arousal and resonance. It represents a deep integration of technology and art, offering both theoretical and practical support for ecological advocacy and the promotion of harmonious coexistence between humans and nature.

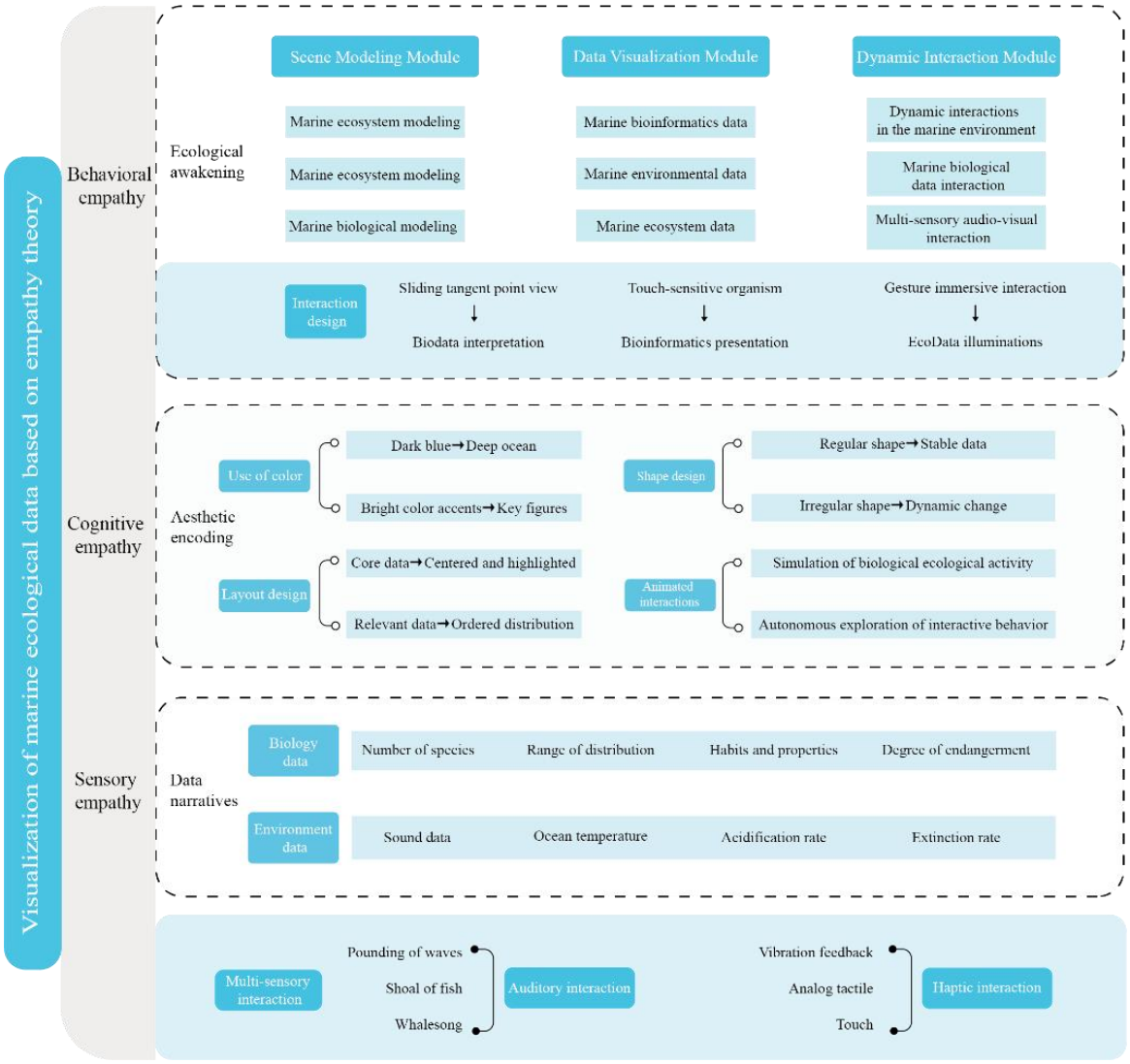


Fig. 5 System Architecture Chart

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P239

6. Summary

This study introduces empathy theory into the field of marine biodiversity data visualization. Through carefully constructed narratives and the application of data aesthetics, it significantly enhances both the effectiveness of data communication and the user experience. By incorporating immersive interaction and multisensory integration, researchers are able to gain deeper insights into the complexity of marine ecosystems and transform these insights into forms that are perceptible and understandable to the public. The research adopts immersive interaction and digital technology strategies to evoke ecological empathy, enabling the design of more expressive visual representations of marine biodiversity data. This approach not only enriches the expressive forms of visual discourse but also deepens the application of empathy theory within the field of design. Through data visualization, the study provides scientific support for the protection, management, and decision-making related to marine biodiversity, while also offering new perspectives and tools for its research.

Building on this foundation, the study further explores the value and methodologies of emotional design in ecological data visualization, aiming to integrate users' emotional experiences with ecological narratives to enhance engagement and comprehension. For example, by constructing emotionally charged visual symbols, dynamic presentations, and sound design, the visualization fosters emotional resonance in users, transforming abstract data into *story-driven, tangible experiences* that enable deeper emotional communication. At the same time, the study emphasizes the importance of interdisciplinary integration in design practice, combining art, technology, and ecological knowledge to offer a more creative and critical approach to data visualization. This research not only expands the expressive boundaries of design language but also propels ecological visualization toward a more tangible, human-centered, and emotionally engaging direction, further encouraging public awareness and action regarding marine ecological issues.

Acknowledgements

This work was supported in part by the Hainan Science and Technology Special Project "Research on the Design of Digital Twin VR Platform for Eman Sea Ranch, Danzhou, Hainan".

(No. ZDYF2024GXTS013)

References

[1] Ma Chunmei. Identity and Resonance: Exploration of the Red Culture Communication Model Based on Empathy Theory[J]. Media Forum, 2024, 7(23): 25-28.

[2] Zhang Zongdeng, Zhang Huayu. A Review of Design Research Based on Empathy Theory[J]. Shanghai Packaging, 2024, (05): 168-172.

[3] Tang Runhua. Promoting Mutual Understanding through Empathy Communication[J]. Journalism and Writing, 2019(7): 1-1.

[4] Li Xiguang, Zhao Pu. Data Visualization: The Application of Data Journalism in Health Reporting[J]. News Frontline, 2014, 11: 53.

[5] Xu Shaolin, Fang Ruohong. More Than Beauty: Teaching Innovation and Practice in Data Visualization Courses[J]. Decoration, 2021, (12): 136-138.

[6] Tang Bixia, Zheng Zhong. Design of an Immersive Science Popularization Experience for the Yangtze River Dolphin in Dongting Lake Based on Biological Data Visualization[J]. Hunan Packaging, 2024, 39(04): 169-172+183.

[7] Norman, Donald A. The Design of Everyday Things: Emotional Design[M]. He Xiaomei, Ou Qiuxing, Trans. Beijing: CITIC Press, 2012.

[8] Lee C J, Tran G, Tabalba R, et al. Macro-Queries: An Exploration into Guided Chart Generation from High Level Prompts[J]. arXiv preprint arXiv:2408.12726, 2024.

[9] Zhou Xiaoxue, Ma Danli. Research on Data Visualization and Information Communication Strategies Driven by Design Thinking[J]. Footwear Technology and Design, 2025, 5(02): 54-56.