

Exploring Public Engagement with Paleontological Visualisations: A Survey at Design and Heritage Exhibitions

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Abstract

This study investigates how different audience groups, including design professionals, students, and the general public, engage with and interpret paleontological visualisation works. Using survey data collected from visitors at a visualisation exhibition and a heritage museum, the analysis focuses on levels of comprehension, interest, and preferred visual features. The findings indicate that design-trained respondents place greater value on visual aesthetics and stylistic expression, whereas general public participants prioritise clarity, accessibility, and narrative context to support understanding. Visual features associated with stronger comprehension include layered information structures, the use of metaphors to explain complex concepts, and the presence of bilingual labels. These results offer insights for improving exhibition design strategies and enhancing public communication of scientific content.

Keywords: Palaeontology Communication, Information Visualisation, Public Engagement, Museum Exhibitions, Survey Study

Introduction

Communicating complex scientific knowledge to public audiences remains a central challenge in contemporary science communication. Paleontological heritage, which concerns deep-time evolution and prehistoric life, poses particular difficulties due to the temporal and conceptual distance between audiences and the subject matter. To bridge this gap, information visualisation has become an important strategy for translating abstract data—such as evolutionary lineages and fossil morphology—into accessible and engaging forms (Yaqoob et al., 2025). Yet, despite growing adoption of visualisation technologies in museums and exhibitions, it remains unclear how effectively these representations support understanding among audiences with diverse backgrounds and levels of visual literacy (Jensen et al., 2022). This gap highlights the need for empirical investigation into the

communicative performance of paleontological visualisations across different public contexts.

Museums and design exhibitions increasingly adopt digital visualisation, AR, and narrative-driven displays to enhance visitor engagement (Adewojo, 2024). However, research shows that audience responses to these strategies vary according to prior knowledge, cognitive preferences, and educational background (Falchetti et al., 2022). Heritage institutions such as the Chengjiang Fossil Site Museum often prioritise scientific accuracy, which may overwhelm non-expert visitors, whereas visually spectacular design displays may favour aesthetics at the expense of conceptual clarity (Zhu, 2024). These contrasting tendencies underscore a central challenge in InfoVis for heritage communication: balancing scientific fidelity with cognitive accessibility. Understanding how different audiences interpret such displays is therefore essential for developing visualisations that effectively communicate complex paleontological knowledge (Jensen et al., 2022).

This study addresses this challenge by comparing audience responses to paleontological visualisations across two contrasting exhibition contexts: the 2024 CHINAVIS Information Visualisation Design Exhibition, attended largely by design-trained visitors, and the Chengjiang Fossil Site Museum, which attracts a broader public audience. The study asks: (1) How do visitors with different backgrounds interpret paleontological visualisations? (2) Which visual and informational features support or hinder comprehension and engagement? and (3) How can the findings inform exhibition design strategies?

A structured questionnaire survey conducted between December 2024 and February 2025 yielded 464 valid responses across the two venues. The analysis examines perceptions of visual clarity, information structure, engagement level, and emotional response in relation to demographic and educational variables, enabling systematic comparison of professional and non-professional interpretive patterns.

By foregrounding the audience as an active interpreter, this study makes two key contributions to social science research on public engagement and visual communication. First, it provides the first comparative empirical analysis of how design-trained and general public audiences interpret paleontological visualisations across different exhibition environments. Second, it offers evidence-based guidelines for balancing scientific rigour, cognitive accessibility, and aesthetic appeal in heritage communication. The findings therefore advance audience-centred approaches in science communication and support more inclusive public understanding of paleontological heritage.

Literature Review

Communicating complex scientific knowledge to diverse audiences remains a central challenge in contemporary science communication. Paleontological content, in particular, poses unique difficulties due to its temporal and conceptual distance from everyday experience (Mirza, 2024). Effective mediation often requires visual and narrative strategies that translate abstract information—such as evolutionary lineages, fossil morphologies, and ecological interactions—into accessible representations (Reyes & Villanueva, 2024). Information visualisation (InfoVis) has emerged as a critical tool for this purpose, allowing the

integration of layered data, interactive elements, and multimodal cues to support comprehension and engagement.

Research suggests that audience characteristics, including prior knowledge, cognitive style, education, and visual literacy, significantly shape engagement with scientific visualisations (Walsh et al., 2021). Design professionals, for instance, may prioritise aesthetics, innovation, and usability, whereas general public audiences often value clarity, narrative context, and interpretive scaffolding (Matthews et al., 2022). Museums and heritage sites increasingly adopt digital and interactive displays, including AR and immersive visualisations, to enhance learning and emotional resonance. However, evaluations of these tools have often focused on expert perspectives, leaving the experiences of non-specialist audiences underexplored (Dong & Zhang, 2026).

Audience-centred research highlights the importance of comparative analyses across professional and public populations to understand differential cognitive and affective responses (Perry et al., 2024). Studies indicate that visual features such as layered information, metaphor use, bilingual labels, and clear narrative structures can improve comprehension and engagement across diverse groups. Nevertheless, few investigations have systematically examined how these attributes function in contrasting exhibition contexts, such as design-focused exhibitions versus heritage museums.

Overall, the literature underscores a dual challenge: balancing scientific fidelity with cognitive accessibility while addressing the diverse needs of audiences with differing expertise and expectations. Bridging this gap requires empirical studies that foreground audience experience and evaluate the interplay of visual, cognitive, and affective factors in the design of paleontological visualisations.

Materials and Methods

This study employed a comparative survey design to examine how audiences with different professional and educational backgrounds perceive and interpret paleontological visualisations. Two research contexts were selected to represent contrasting audience profiles: the 2024 CHINAVIS Information Visualisation Design Exhibition, attended largely by design-trained participants, and the Chengjiang Fossil Site Museum, which attracts a broader public audience including families, students, and tourists. This comparison enabled analysis of how visual literacy, disciplinary knowledge, and prior exposure to scientific content influence comprehension and engagement.

A mixed-methods approach was adopted to integrate quantitative and qualitative insights. Structured questionnaire data provided measurable indicators of cognitive clarity, aesthetic appreciation, and emotional engagement, while open-ended responses offered nuanced reflections on viewing experiences. This approach aligns with recommendations in science and visualisation research that emphasise combining numerical and interpretive evidence to strengthen contextual understanding.

A total of 617 questionnaires were distributed across both sites, yielding 464 valid responses (response rate: 75.2%). Purposive sampling ensured that only participants who had engaged with the visualisations for at least ten minutes were included. Of these, 254 valid

responses came from CHINAVIS and 210 from the museum. Respondents ranged from 18 to 65 years old and represented varied educational backgrounds, providing diversity in cognitive and cultural perspectives.

The survey instrument consisted of four parts: demographic questions; items evaluating perceived clarity and structure of information; items assessing affective engagement and aesthetic response; and an open-ended prompt for additional comments. Closed-ended items used a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). Survey items were adapted from established research on visual cognition and museum communication, including constructs related to comprehension, attention, and emotional resonance.

A pilot test conducted in November 2024 led to refinements in wording and layout. Cronbach's alpha values exceeded 0.85 across major dimensions, indicating high internal reliability. Expert review by specialists in visual communication, psychology, and museum education further supported content validity.

Data collection occurred between December 2024 and February 2025. Surveys were administered onsite at both venues, with informed consent obtained before participation. Quantitative data were analysed using SPSS 27.0, employing descriptive statistics and independent-samples t-tests to identify group differences. Open-ended responses were analysed thematically to interpret underlying cognitive and affective patterns.

Ethical approval for the study was obtained from the affiliated research institution. Participation was voluntary and anonymous, and no incentives were provided. Data were securely stored and handled in accordance with standard human-subject research guidelines.

Results and Discussion

A total of 464 valid responses were collected from the CHINAVIS 2024 Information Visualisation Design Exhibition and the Chengjiang Fossil Site Museum, enabling a comparative analysis of professional and public engagement with paleontological visualisations. Quantitative measures of comprehension, aesthetic appeal, emotional engagement, and accessibility were supplemented with qualitative insights from open-ended responses, revealing distinct patterns across the two audiences. Design-trained participants demonstrated high visual literacy, emphasising hierarchical organisation, colour coding, and metaphorical representations, which facilitated cognitive mapping and analytical engagement (Yang et al., 2025). In contrast, public visitors valued clarity, narrative context, and immersive realism, though comprehension was occasionally hindered by scientific terminology and dense text, highlighting the importance of linguistic and contextual scaffolding.

Both groups rated the visual appeal of exhibits highly, but for different reasons. Professionals evaluated aesthetic intentionality, innovation, and visual coherence, linking design quality to cognitive function. Public visitors associated beauty with legibility, realism, and narrative immersion. Emotional engagement mirrored these differences: CHINAVIS respondents reported reflective curiosity and admiration for design, while museum visitors expressed wonder, empathy for ancient species, and connections to contemporary environmental concerns. Sensory elements, including ambient sound, lighting, and motion,

enhanced affective resonance, supporting dual-coding principles in which verbal and visual stimuli jointly facilitate learning and retention (Davis et al., 2024).

Accessibility challenges were observed in both contexts. Interface complexity affected professional users navigating interactive layers, whereas textual density, unfamiliar terminology, and contrast issues limited comprehension among the general public. These findings highlight the need for layered visualisation strategies that combine a universal core, interactive exploratory modules, and reflective narrative elements to accommodate diverse cognitive and experiential capacities. Such schema-informed design aligns visual structure with users' existing cognitive frameworks, reducing cognitive load and enhancing interpretability (Chivukula & Gray, 2024).

Expert consultations reinforced these insights, advocating modular hierarchical visualisations, interactive timelines, and spatiotemporal maps to convey ecological evolution effectively. Experts emphasised integrating multimodal and narrative features to balance scientific accuracy with audience engagement. These recommendations align closely with public preferences for immersive and temporally coherent representations, confirming that iterative feedback from multiple stakeholders strengthens design outcomes (Han et al., 2022).

The combined findings suggest that effective paleontological visualisation relies on balancing cognitive scaffolding, visual metaphorisation, and multimodal communication. Professionals benefit from analytical clarity and design coherence, while public audiences require intuitive visual hierarchies, accessible language, and narrative context. Schema-informed co-design, which integrates cognitive, affective, and accessibility considerations, emerges as a powerful framework for bridging knowledge gaps. By structuring information into hierarchical modules, employing culturally resonant metaphors, and incorporating iterative stakeholder feedback, visualisations can transform static displays into interactive learning experiences (Wijayawardena et al., 2023).

Overall, this study demonstrates that paleontological InfoVis can support both comprehension and emotional engagement, fostering scientific understanding and ethical reflection. Tailoring visualisation strategies to audience diversity—while maintaining scientific fidelity and aesthetic quality—enables heritage institutions and exhibition designers to enhance inclusivity, interpretive depth, and public science literacy. These findings extend schema theory into practical design methodology and underscore the potential of information visualisation as a cognitive bridge between expert knowledge and public understanding.

Conclusion and Implications

This study addressed the persistent challenge of communicating complex scientific knowledge to diverse audiences by developing and validating a schema-informed co-design framework for information visualisation (InfoVis), using the Chengjiang ancient biota as a case study. Drawing on literature review, longitudinal field observation, comparative surveys at CHINAVIS 2024 and the Chengjiang Fossil Site Museum, and expert consultations, the research demonstrates that aligning visualisation with cognitive schemas enhances comprehension, emotional engagement, and inclusivity. Design-trained participants benefited from hierarchical structuring, visual metaphors, and interactive layers. At the same

time, public audiences responded positively to clarity, narrative context, and immersive realism, highlighting the need for layered, multimodal approaches.

Theoretically, the study extends schema theory into visual design practice, showing that hierarchical sequencing, scaffolding, and narrative mapping can transform static displays into cognitively navigable systems that facilitate progressive meaning-making. It also advances design-based research in heritage communication by adapting iterative cycles of diagnosis, design, implementation, and evaluation to co-create materials with public audiences, experts, and designers. The resulting framework integrates cognitive schema alignment, participatory design, and multimodal communication, bridging debates around scientific fidelity and communicative empathy.

Methodologically, the research illustrates the value of mixed-method, triangulated approaches that combine quantitative surveys, qualitative feedback, and expert validation. Cross-contextual comparison between professional and public audiences reveals how differing cognitive schemas shape interpretation, offering a template for future comparative studies. Using visualisation as both object and instrument of research demonstrated its potential to elicit cognitive and affective responses, highlighting the methodological synergy between design practice and empirical evaluation.

Practically, the findings provide actionable strategies for designers, museum professionals, and science communicators. Schema-informed structuring, layered communication, and multimodal interaction improve comprehension, engagement, and inclusivity. Iterative co-design strengthens collaboration among scientists, educators, and designers, while digital tools—such as interactive timelines, AR/VR, and phylogenetic visualisations—support adaptive, user-centred storytelling. Policy and institutional implications are equally significant: the framework can reinforce UNESCO mandates for accessible heritage communication, inform science literacy initiatives, embed co-design in museum practice, and promote equitable digital access, while supporting educational curricula that cultivate visual literacy and critical thinking.

Limitations include the study's focus on two sites, the need for longitudinal assessment of engagement effects, and geographically concentrated expert input. Future research could expand to additional heritage domains, incorporate international expert perspectives, and employ neurocognitive or eye-tracking measures to validate comprehension and emotional engagement empirically.

In conclusion, effective scientific communication relies not solely on aesthetic design but on cognitive alignment, participatory co-creation, and emotional resonance. The schema-informed co-design framework provides both a conceptual and practical model for transforming InfoVis from a technical or aesthetic exercise into an interactive, inclusive process of shared meaning-making. Beyond palaeontology or museum contexts, the findings demonstrate how thoughtful design can democratise access to complex knowledge, connect interdisciplinary expertise, and humanise scientific understanding.

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