# Immersive Access to Amazonian Paleontology: Photorealistic Design and Virtual Deployment at a Public University in Brazil

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***Abstract. Introduction:*** *The closure of a paleontological museum in the Brazilian Amazon disrupted educational activities and access to fossil collections.* ***Objective:*** *To ensure continuity, the UFAC Virtual Museum of Paleontology was developed as an accessible, immersive alternative.* ***Methodology or Steps:*** *Fossils were digitized by photogrammetry, optimized, and integrated into Unity via the Spatial Creator Toolkit, enabling web, mobile, and VR access.* ***Results:*** *The platform supports collaborative exploration, has been adopted in courses with positive engagement, and already surpassed a thousand visits. Future steps include usability testing and expansion of the fossil collection.*
***Keywords:*** *Virtual museum, Photogrammetry, Virtual reality, Human-Computer Interaction, Digital heritage.*

***Resumo. Introdução:*** *O fechamento de um museu paleontológico na Amazônia brasileira interrompeu atividades educativas e o acesso às coleções fossilíferas.* ***Objetivo:*** *Garantir a continuidade por meio do Museu Virtual de Paleontologia da UFAC, como alternativa acessível e imersiva.* ***Metodologia ou Etapas:*** *Os fósseis foram digitalizados por fotogrametria, otimizados e integrados ao Unity pelo Spatial Creator Toolkit, com acesso via web, dispositivos móveis e VR.* ***Resultados:*** *A plataforma já foi adotada em cursos, aumentou o engajamento e superou mil visitas. Próximos passos incluem testes de usabilidade e expansão do acervo.*
***Palavras-chave:*** *Museu virtual, Fotogrametria, Realidade virtual, Interação Humano-Computador, Patrimônio digital.*

## 1. Introduction

Access to scientific and cultural heritage in remote regions is often limited, especially when local institutions face structural renovations. The temporary closure of a paleontological museum in the Brazilian Amazon disrupted educational activities and public access to fossil collections of regional importance. This scenario reflects a broader challenge also observed in other regions, where limited infrastructure and geographic isolation hinder cultural engagement [Anwar et al. 2025].

To address this gap, a Virtual Museum of Paleontology was developed as an immersive, multi-user environment. Photorealistic fossil models — created via photogram-

metry — are integrated into a platform designed for accessibility and multimodal interaction across a range of devices. The system supports learning and outreach by combining accessibility, interactivity, and scientific authenticity in a culturally contextualized experience. Similar XR-based heritage initiatives have demonstrated that immersive environments can enhance user engagement, provide remote access to valuable collections, and promote heritage appreciation when aligned with accessibility and interoperability standards [Anwar et al. 2025].

## 2. Problem and Motivation

The museum's physical closure intensified pre-existing access barriers such as geographic isolation, limited infrastructure, and low digital inclusion. These constraints restricted participation from students, educators, and the broader public, highlighting the need for remote and inclusive alternatives.

In parallel, many Extended Reality (XR) heritage projects struggle with poorly defined educational goals and weak cultural contextualization. The Virtual Museum of Paleontology addresses these issues by enabling collaborative exploration of Amazonian fossils, connecting users to scientific content through a participatory and context-aware virtual space.

## 3. Contribution and Innovation

This project delivers an immersive, multi-user virtual museum where visitors can interact with photorealistic 3D models of Amazonian fossils, access educational content, and collaborate in real time. Key innovations include:

- **High-fidelity 3D fossil models**, produced via photogrammetry, preserving morphological accuracy for educational and scientific purposes [Konstantakis et al. 2023].
- **Place-based educational narratives** that integrate local legends, fieldwork stories, and scientific context.
- **Multimodal interaction** through avatars, spatial navigation, interactive panels, and external links (e.g., Sketchfab).

Unlike virtual museums that prioritize passive visualization or asset aggregation, this system fosters experiential learning through interactive storytelling and embodied exploration. Following arguments by [Aiello et al. 2019], such emotionally resonant environments promote deeper cognitive and affective engagement with science. Moreover, the system emphasizes scalability and sustainability. Its lightweight rendering, asset reuse, and cross-platform compatibility allow deployment in low-resource settings without compromising usability.

## 4. System Description

The UFAC Virtual Museum of Paleontology was developed in Unity and hosted on the Spatial platform. Fossils were digitized with RealityCapture from 250–450 high-resolution photographs under controlled lighting. The use of image-based reconstruction aligns with best practices observed in other virtual museums, such as the Ecomuseu Guide project, which leveraged Unity and EasyAR to generate lightweight and scalable applications [Teixeira et al. 2021].

Optimized models were integrated into Unity (v2021.3.44f) using the Spatial Creator Toolkit, which provided built-in tools for navigation, interaction, and XR deployment. The system is publicly accessible online[1]. The environment was designed with collision-based navigation, contextual information panels, and affordances such as gaze-based selection, spatial audio, and object manipulation [Vieira et al. 2024]. Figure 1 presents a simplified view of this process.

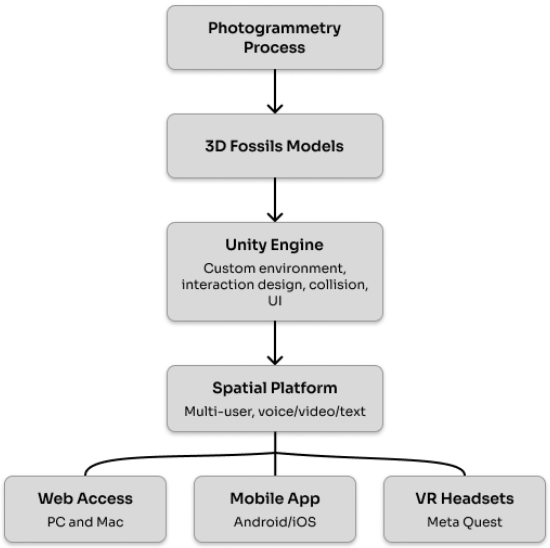


**Figure 1. Simplified architecture diagram of the virtual museum, from the photogrammetry process generating 3D fossil models, which are integrated into the Unity Engine, then deployed to the Spatial platform for access.**

## 5. Relevance to HCI

This demonstration applies key Human-Computer Interaction (HCI) principles to cultural heritage by combining immersive, collaborative, and culturally contextualized experiences. The design addresses usability alongside the emotional, social, and contextual dimensions of interaction — central concerns in HCI research on heritage environments [Chong et al. 2021].

- **Immersive and collaborative interaction**: Users navigate through spatial locomotion, inspect 3D fossils with rotation/zoom, and engage with contextual information panels. Real-time voice, video, and chat channels foster presence, social learning, and co-exploration.
- **Accessible and context-aware design**: The system's multi-platform deployment (VR, desktop, mobile) reduces geographic and economic barriers, enabling access in low-resource contexts. The visual and narrative structure reflects regional identity, avoiding generic museum templates [Chong et al. 2021].

By integrating photogrammetric accuracy, interactive affordances, and inclusive access strategies, the virtual museum serves as a model for HCI-driven approaches to science education and sustainable digital heritage.

[1]https://www.spatial.io/s/Museu-Virtual-de-Paleontologia-da-UFAC-66610d36218833520d23f63c

## 6. Evaluation and Use in Education

The virtual museum has been adopted in secondary and higher education contexts, reaching over 40 students in a VR course conducted in 2024. The activity involved both guided exploration and self-directed navigation. Instructors reported increased engagement and curiosity among students, especially those previously unfamiliar with paleontology.[2]

Although formal usability testing has not yet been conducted, future iterations will incorporate lightweight evaluation tools to assess user experience and learning outcomes.


**Figure 2. Three screenshots from the UFAC Virtual Museum: the first (1) shows a general overview of the immersive space with walls and information panels; the second (2) displays an area with scale models comparing prehistoric animal sizes to a human silhouette; the third (3) presents an interactive fossil visualization accompanied by a floating text description panel.**

## 7. Social Impact

The UFAC Virtual Museum plays a significant role in democratizing access to scientific and cultural heritage from the Amazon, particularly for communities historically excluded from traditional museum spaces due to geographic, infrastructural, or socioeconomic barriers. Using immersive technology, it raises awareness of regional paleontology and highlights underrepresented narratives, following [Shehade and Stylianou-Lambert 2020], VR fosters inclusion and accessibility in museums. This project engages diverse users — students, educators, and the public, benefiting underserved communities and already has over a thousand online visits. By integrating regional cultural and scientific content, the museum offers a contextualized learning experience, serving as an educational space that promotes social good, empathy, and heritage appreciation.

## 8. Demonstration Setup

At IHC 2025, the demonstration will be presented using:

- A VR headset (Meta Quest) with controllers.
- A notebook for web-based access and observation.
- Minimal physical space (user can be seated or standing still).

Participants will be invited to freely explore the environment and interact with digitized fossils, multimedia content, and each other.

[2]This project follows inclusive design practices and aligns with the SIGCHI Accessibility Guidelines and the NAU/UNIRIO recommendations.

## 9. Conclusion

The UFAC Virtual Paleontology Museum illustrates the fusion of technology, education, and cultural heritage to address local needs and global digital trends. Using photorealistic 3D modeling, immersive VR, and HCI principles, it improves accessibility, engagement, and preserves regional assets.

Consistent with [Aiello et al. 2019], the project shows how immersive environments extend museums beyond physical limits, offering dynamic and multisensory experiences. By emphasizing educational equity and heritage preservation, it serves as a model for digital adaptation with contextual sensitivity.

This demonstration invites feedback from the HCI community to enhance design and expand pedagogical and social impact, highlighting virtual museums as tools for inclusive science education and sustainable digital heritage.

## Use of Generative AI

This text was grammatically and orthographically revised with the assistance of the ChatGPT-3.5 language model.

## Ethical Considerations

All demonstrations of the virtual museum were conducted with the awareness of participants, including students and visitors. Participation was entirely voluntary, and no personal or sensitive data were collected, stored, or analyzed.

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