# Material Exploratory

## A Hand-Tracked Mixed Reality Interface for Phygital Material Archives

Annapaola Vacanti*
Iuav University of Venice
Venezia, Italy
avacanti@iuav.it

Raffaella Fagnoni
Iuav University of Venice
Venezia, Italy
rfagnoni@iuav.it

Pietro Costa
Iuav University of Venice
Venezia, Italy
pcosta@iuav.it

Martin Romeo
Iuav University of Venice
Venezia, Italy
info@martinromeo.com

Marco Pizzini
The Metagate Srl
Milano, Italy
marco.pizzini@themetagate.it

## Abstract

Material Exploratory is a mixed reality installation that investigates how spatial interaction can transform the consultation of material archives. The system combines four physical samples of circular materials with a hand-tracked application for Meta Quest 3. By picking up and manipulating virtual representations associated with the samples, visitors explore their origins, production processes, industrial relationships, applications, and possible future transformations. Rather than reproducing the structure of a conventional catalogue, Material Exploratory presents each material as a narrative object situated within a spatial and temporal network. Information is organized across three interconnected dimensions (i.e. past, present, and future) corresponding respectively to material biographies and documentation, immersive narratives of current production systems, and possible applications in education and design research. The installation demonstrates a phygital interaction model in which physical material samples act as anchors for layered digital content. Interaction is performed entirely through natural hand gestures, without controllers. The mixed reality environment preserves awareness of the surrounding exhibition space while extending the physical samples with spatialized visualizations, three-dimensional objects, text, voice, and sound. Material Exploratory was developed from research conducted by Università Iuav di Venezia in collaboration with Metagate. The application has been deployed in public exhibition settings and is publicly available for Meta Quest devices.

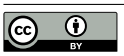
## CCS Concepts

• **Human-centered computing**; • **Human Computer Interaction (HCI)**; • **Interactive Systems and Tools**;

## Keywords

Mixed Reality, Material Archive, Phygital Interaction, Hand-tracking

*Corresponding author



This work is licensed under a Creative Commons Attribution 4.0 International License.
*SUI '26, Bari, Italy*
© 2026 Copyright held by the owner/author(s).
ACM ISBN 979-8-4007-2812-9/2026/10
https://doi.org/10.1145/3822518.3839329

**ACM Reference Format:**
Annapaola Vacanti, Raffaella Fagnoni, Pietro Costa, Martin Romeo, and Marco Pizzini. 2026. Material Exploratory: A Hand-Tracked Mixed Reality Interface for Phygital Material Archives. In *ACM Symposium on Spatial User Interaction (SUI '26), October 10, 11, 2026, Bari, Italy*. ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3822518.3839329

## 1 Introduction

Material understanding is both embodied and relational. Designers, researchers, and students evaluate materials through direct sensory engagement, but they also rely on information concerning origins, transformation processes, environmental implications, production actors, and possible applications. Conventional material libraries often separate these forms of knowledge: physical samples communicate perceptual and tactile qualities, while catalogues, labels, and databases provide contextual and technical information [1]. This separation is particularly limiting for circular and second-generation materials. Their significance cannot be inferred from appearance or mechanical properties alone but also depends on the waste or by-product streams from which they originate, the processes used to transform them, and the industrial and territorial networks involved in their production. Understanding these materials therefore requires moving beyond the isolated sample toward the exploration of distributed processes, actors, temporalities, and relations.

Material Exploratory investigates how a spatial user interface can connect these layers of knowledge while preserving direct engagement with physical materials [2]. The mixed reality installation combines four circular material samples produced in North-East Italy by Alisea, Favini, Rehub, and Tecnica Group with a hand-tracked application for Meta Quest 3. Each sample acts as the entry point to a material biography [3]: a structured account of its origins, transformations, production context, current applications, and possible future trajectories. The project addresses the following design question: how can mixed reality extend the informational depth of a material archive without replacing the embodied qualities of its physical samples? The demonstration contributes (1) a deployable mixed reality interface for circular material archives; (2) a tangible-digital interaction model based on physical samples and spatial content; and (3) a temporal narrative structure for representing material biographies as explorable knowledge environments.

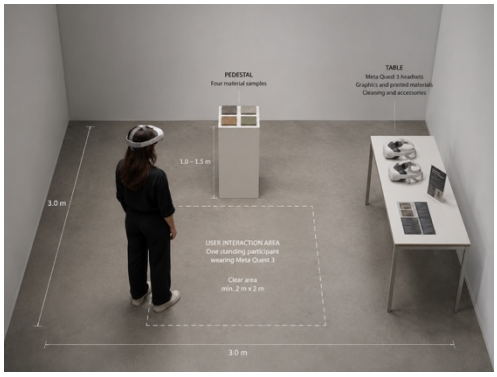



**Figure 1: 2026 Setting of the Material Exploratory archive installation, courtesy of the authors.**

## 2 System overview

The installation consists of four physical samples displayed on a pedestal and a mixed reality application running locally on Meta Quest 3 (fig. 1). Color passthrough preserves visual awareness of the samples, the visitor's hands, facilitators, and the surrounding exhibition space. The physical setup is extended through three-dimensional objects, text, images, animation, voice, and spatialized sound. The system does not simulate or replace the materials. Physical samples communicate properties that remain difficult to reproduce digitally, including texture, temperature, flexibility, weight, and surface irregularities. The mixed reality layer instead reveals information that is not materially present in the sample, such as production sequences, waste flows, territorial connections, organizational relationships, and possible transformations.

The material biography provides the main unit of organization. It connects the current sample to the resources, actors, decisions, and processes that produced it, while leaving its trajectory open to subsequent uses. Circular materials are consequently presented not as static outcomes or isolated records, but as nodes within evolving industrial and territorial ecosystems.

## 3 Spacial and narrative interaction

The experience is organized through three interconnected temporal dimensions: Past, Present, and Future. Rather than reproducing the categories of a conventional database, this structure reflects the lifecycle-oriented character of circular materials and provides a coherent way to navigate heterogeneous information. Past reconstructs the material biography, including the source waste stream or by-product, the original industrial sector, transformation stages, and documentary evidence. Present provides an immersive interpretation of the material's current production ecosystem, using spatial compositions, animation, voice, and sound to communicate processes and relationships that would remain abstract in a label or database entry. Future frames the material as an open resource for design experimentation, education, and research, presenting possible applications and further circular connections without proposing a fixed prediction.

Visitors access these dimensions by acting on spatial objects associated with the samples rather than navigating menus or document hierarchies. They can select, pick up, rotate, inspect, move, and reposition virtual representations through optical hand tracking. The archive is therefore experienced as a spatial environment to be explored rather than as a collection of records to be searched.

Hand tracking reduces the discontinuity between touching a material and manipulating its digital counterpart. The same hands used to inspect the physical samples are used to activate and organize related information, avoiding the need to alternate between direct examination and controller-based input. The resulting tangible-digital coupling is complementary rather than representational: the sample communicates perceptual qualities, while the spatial interface communicates contextual, temporal, and relational information.

Unobtrusive physical reference elements support calibration and alignment without visible QR codes. Passthrough mixed reality maintains the spatial coherence of the installation and supports direct contact with the samples, interaction with facilitators, and co-located observation by other visitors. Sound further differentiates materials and narrative phases through text-to-speech narration and material-specific audio elements.

## 4 Implementation and deployment

The application runs autonomously on Meta Quest 3 and uses color passthrough, environmental tracking, spatial positioning, and optical hand tracking. It does not require an external computer or continuous internet connection during operation, enabling deployment in museums, universities, exhibitions, and public-engagement settings without a dedicated immersive room. Material Exploratory was developed by Università Iuav di Venezia in collaboration with Metagate [4]. The authors thank Alisea, Favini, Rehub, and Tecnica Group for providing materials, information, and project content. The project has been presented at Università Iuav di Venezia and within the New Atlas of Digital Art at MEET Digital Culture Center in Milan [5]. The application is also publicly distributed for Meta Quest devices [6]. These deployments informed the design of a compact installation requiring only a pedestal, a clear standing area, standard electrical power, and a surface for headset management. The project is presented as a research-through-design artifact rather than as a controlled evaluation of individual interface variables. Its contribution lies in the integration of physical material consultation, spatial information, and narrative interaction within a publicly deployable system.

## References

[1] Annapaola Vacanti, Michele De Chirico, Martin Romeo, Carlo Turri, Pietro Costa, and Raffaella Fagnoni. 2025. From Library to Exploratory: Rethinking the Narrative of Materials through Interaction Design. In *Design Plurale: Cases and Alternative Models for Innovation: Proceedings of the Annual Conference of the Italian Design Society*, June 26–27, 2025, Naples, Italy, Alfonso Morone, Ed. FedOAPress, Naples, Italy, 663–672. https://doi.org/10.6093/978-88-6887-385-1.

[2] Pietro Costa, Michele De Chirico, Raffaella Fagnoni, and Annapaola Vacanti. 2025. Storie di materiali: interazioni e riusi nei sistemi produttivi locali. In *Design and Research: Sources and Resources / Design e ricerca: Fonti e Risorse: Proceedings of the Annual Conference of the Italian Design Society*, July 4–5, 2024, Venice, Italy, Alessandra Bosco, Lucilla Calogero, Luca Casarotto, and Saul Marcadent, Eds. Società Italiana di Design, 678–687. https://hdl.handle.net/11578/361529.

[3] Raffaella Fagnoni, Pietro Costa, and Annapaola Vacanti, Eds. 2025. *Ecosistemi materiali: Narrazioni e tecnologie per la circolarità nei sistemi produttivi locali.* Anteferma Edizioni, Conegliano, Italy. https://doi.org/10.57623/979-12-5953-231-2.

[4] Marco Pizzini. 2025. Material Exploratory: la materioteca in Mixed Reality sviluppata da Metagate con lo IUAV. *Metagate* (June 18, 2025). Retrieved August

3, 2026 from https://discover.themetagate.it/blogs/news/material_exploratory-materioteca-mixed_reality-metagate.
[5] Marco Pizzini. 2025. Metagate torna al MEET con "Immersive Frontiers": due anni di innovazione in Realtà Mista. *Metagate* (June 23, 2025). Retrieved August 3, 2026 from https://discover.themetagate.it/blogs/news/metagate-atlas-meet-mixed_reality-2025.
[6] Meta. 2026. *Material Exploratory*. Meta Horizon Store. Retrieved August 3, 2026 from https://www.meta.com/it-it/experiences/material-exploratory/9711900195508418/.