# SKEUOMORPHISM IN EXTENDED REALITY: ENHANCING USER INTERACTION THROUGH FAMILIAR DESIGN IN AR AND VR INTERFACES – INSIGHTS FROM THE HOME INTERSPACE PROJECT

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## ABSTRACT
This study examines skeuomorphism in Extended Reality (XR) interfaces to enhance accessibility. By emulating real-world objects and gestures, skeuomorphic design reduces cognitive load and offers intuitive cues often missing in flat interfaces. Participants sketched metaphors for digital functions, informing the creation of skeuomorphic XR elements integrated with hand tracking and room mapping. User testing showed these designs improved interaction quality, comfort, and usability. Results highlight a gap in XR accessibility for non-digital natives, demonstrating that physical metaphors can bridge this divide. Skeuomorphic principles promise broader XR adoption and more inclusive, user-friendly immersive experiences.

*Keywords: Skeuomorphism, extended reality (XR), user accessibility, Human-Centred Design, cognitive load reduction*

## 1 INTRODUCTION
Extended Reality (XR)—an umbrella term for Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR)—integrates digital and physical spaces in immersive ways [1]. As XR evolves, it holds immense potential to transform user interactions with digital content. This paper explores how skeuomorphism, incorporating real-world metaphors into digital environments, can improve accessibility in XR, particularly for older adults. Such designs may reduce the cognitive burden of navigating novel interfaces by leveraging familiar physical cues and gestures.

### 1.1 Background & Research Gap
Skeuomorphism, transferring real-world textures, forms and actions in digital interfaces, once helped novices feel at ease in early GUIs [2]. In immersive XR, however, users must contend with full body, three dimensional gestures that can be disorienting, especially for older adults, who may face balance or vision changes [1], [3]. While some 2D studies show seniors prefer skeuomorphic icons [4] and even complete tasks more accurately [5], most research still focuses on flat screens. Very little examines how physical metaphors might lower cognitive load in hand tracked XR, where cybersickness and abstract menus remain barriers. *This study therefore probes whether skeuomorphism, embodied as everyday object metaphors, improve usability inside a home environment XR prototype.*

### 1.2 Research Objectives
The primary aim is to determine how skeuomorphic design can enhance accessibility in XR. Specifically, this study seeks to:
- Reduce cognitive effort needed to navigate XR interfaces.
- Improve usability and satisfaction among users with limited digital literacy.

In doing so, the study aims to offer actionable insights for designing XR systems that better serve a broad demographic, including those traditionally underserved by advanced technologies.

### 1.3 Research Questions
This work addresses three key questions:
- How does skeuomorphism in XR interfaces affect the usability and accessibility?

- Which skeuomorphic design elements best reduce cognitive load in XR?
- How do non-digital-natives, such as older adults, perceive and interact with skeuomorphic vs. flat design in XR?

Answering these questions will help define principles that make emerging XR technologies both more accessible and engaging, regardless of prior digital experience.

# 2 CONCEPTUAL FRAMEWORKS: XR, SKEUOMORPHISM, AND METAPHORS

Extended Reality (XR) blends digital and physical space via head-mounted displays, spatial tracking and hand-gesture input [1]. XR devices offer more interaction methods and affordances than prior technological devices, yet they also raise the cognitive bar: users must manage depth, proprioception and unfamiliar motor skills, often without the familiar scaffold of icons or menus.

Skeuomorphism allows designers to leverage existing mental models so that bodily action precedes conscious interpretation [2]. Early GUIs replaced typed commands with folders and trash-cans because a mouse could only point and click; in XR, reach, grasp, twist and proximity replace the cursor. This shift invites **embodied metaphors, analogies and idioms** [6], for example, virtual knobs or levers that leverage users' real-world expectations. This is especially important for technology-averse groups: in Urbano et al., older adults completed tasks faster and reported greater aesthetic satisfaction with skeuomorphic controls resembling physical objects [5].

Building on Norman's "knowledge in the world" principle [7], skeuomorphic controls, by mirroring users' existing motor schemas, significantly reduce cognitive load in unfamiliar XR environments, allowing bodily action to scaffold interpretation. To achieve this, skeuomorphic prototyping is embedded in the research within Kouprie & Sleeswijk Visser's four-phase empathic-design framework [8]:

**Discovery:** Research real users' physical and mental models to identify key metaphors (e.g. objects, knobs, levers).

**Immersion:** Rapidly sketch and build XR prototypes that expose those metaphors as visible affordances, lowering the mental effort required to explore.

**Connection:** Test with target users (e.g. older adults), observe where cognitive friction arises, and gather emotional feedback.

**Detachment:** Reflect on what semantic mappings worked (and which didn't).

This empathy-driven cycle not only helps designers to externalise and validate their design assumptions but also reinforces how skeuomorphism can be used strategically to ease XR onboarding and make interfaces more inclusive for novices and ageing populations alike.

# 3 CREATING A MORE ACCESSIBLE XR ENVIRONMENT

## 3.1 Context and Problem Description

Although XR technologies offer immersive experiences, non-digital natives such as older adults frequently encounter barriers such as physical limitations, reduced cognitive flexibility, and limited familiarity with digital interfaces. These challenges can result in frustration or rejection of potentially beneficial systems. Common design approaches often target younger audiences who are technologically more experienced, potentially increasing fatigue or confusion in other user groups through physically demanding interactions and information overload. Consequently, accessible XR solutions require deliberate strategies that address distinct preferences and constraints of more diverse groups.

## 3.2 User Research and Workshop

Based on Statista's findings, over 3.55 million apps on Google Play and 1.6 million on the Apple App Store [9], and given the scope and limitations of this study, the research focused on the five most common smartphone activities: communicating, mailing, banking, music listening, and video watching. To uncover the physical metaphors people naturally invoke for these tasks, a brief remote workshop was done with 15 volunteers (ages 18–58) drawn from friends, family, and colleagues. Although this sample wasn't statistically specific to a group of people, its mix of ages and cultural backgrounds gave diverse qualitative insights, and its small size kept the process fast and iterative, ideal for the exploratory scope of the research.

Participants joined from home with pen and paper and were **explicitly instructed** *not* to draw existing 2D interfaces (phones, tablets, or apps) but to sketch **objects** that embodied each activity. For each of the five prompts, they had three minutes to draw their imagined object and three minutes to define how they would interact with it. Influenced by the research done by Cila et al. [10], by framing the exercise around "objects" the responses were steered toward tangible, real-world artifacts rather than digital UIs. Although certain artifacts (e.g., letters, TVs) recurred almost universally, the methods of use varied (some sketched DVD decks, others touchscreen controls), illustrating that **no single metaphor** maps cleanly across all users. These findings, rich in both visual form and interaction detail, directly informed the decision to prototype multiple 3D object variants and leverage skeuomorphic interaction patterns in the subsequent XR design stage.

### 3.3 Design Principles and Interaction System

A Meta Quest 3 headset was selected for its high-resolution pass-through cameras, depth projection, room-mapping, and hand-tracking capabilities, features that enable occlusion of virtual elements and truly intuitive, hand-based interactions. Guided by Norman's principle of natural mapping [7], traditional controllers and memorised inputs were avoided, favouring direct manipulation for a more skeuomorphic experience. To leverage these affordances and to provide feedback, a novel interaction system called **Interspace** was introduced to support three-dimensional, proximity-based manipulation of virtual signifiers. Each interactive element, a pull bar, push button, or rotate knob, is surrounded by an invisible "interspace" volume that dynamically adapts as the user's hand approaches. For example, a pull bar will spring outward to signal grasp, while a rotate knob contracts under a two-finger approach for rapid, coarse adjustments and expands under a full-hand approach for slower, more precise control. Because XR lacks traditional haptic feedback, these shape-shifting behaviours are synchronised with subtle auditory cues at the moment of contact, creating a compelling sense of touch. Iterative refinement of the objects incorporated participant sketches and cultural variations, for instance, recognising that a mailbox design can differ between regions. Objects like music players and post-boxes mirror real-world forms to lower cognitive load and provide guidance.

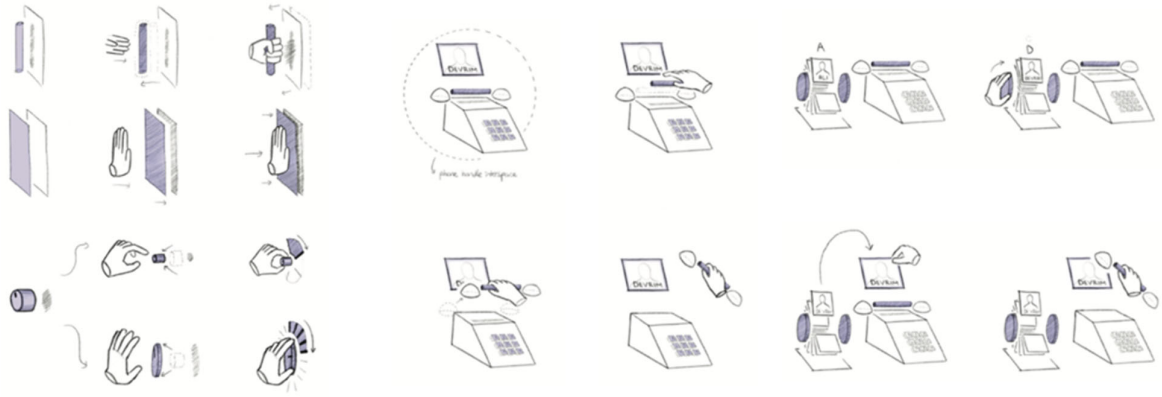

*Figure 1. Interspace interaction elements example sketch*

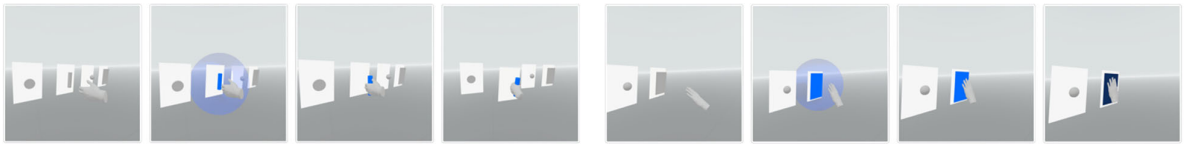

*Figure 2. Interspace prototypes in ShapesXR*

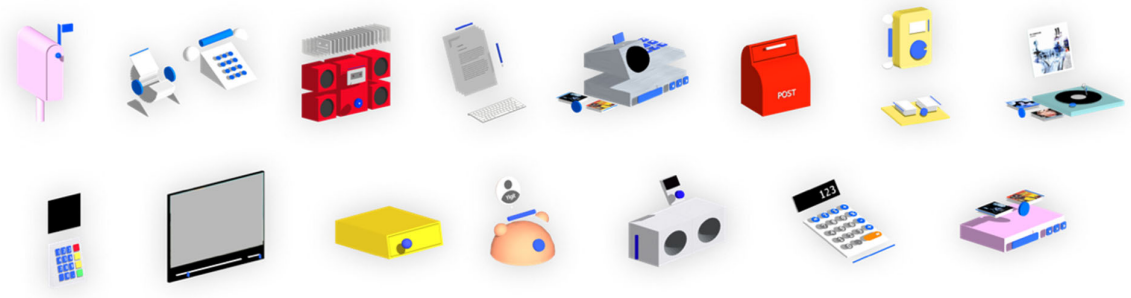

*Figure 3. Example object designs from the Home Interspace project*

### 3.4 Prototyping

For initial testing of object placement in a scanned room environment, 3D-modeled assets were imported into Figmin XR. Although Figmin XR supported basic assessments, it lacked advanced interaction capabilities, prompting the use of ShapesXR for more elaborate, storyboard-based prototypes. A development engine (e.g., Unity or Godot) would be suitable for extended development of the system, however within the current scope, these less-advanced prototypes effectively demonstrate how skeuomorphic elements can integrate with real-world interiors to create an accessible "home interspace."

*Figure 4. Comparison of Meta Quest Stock UI (Left) and Home Interspace Project*

## 4 USER TESTING AND RESULTS

### 4.1 Methodology for User Testing

The final testing phase aimed to evaluate the Skeuomorphic Home Interspace regarding user accessibility and interface intuitiveness. Twelve additional participants (ages 18 to 68), with varying XR experience, were recruited to represent different age groups and technological familiarity.

Testing proceeded in two rounds. In the first round, participants were asked to operate a task (opening a pre-defined application and interacting) via the Meta Quest 3's native flat interface, establishing a baseline for user interaction in a conventional XR setting. In the second round, participants repeated the same task inside the Skeuomorphic Home Interspace, where real-world metaphors (knobs, levers, etc.) guided their interaction. They received no prior briefings and encountered the environment cold, ensuring first-impression reactions. Due to technical constraints, the prototype was largely static, so the attention was focused on which elements users approached first and where they attempted interaction. The attendees were also asked to verbally describe how they could interact the objects. The camera view was mirrored on an external screen and was observed by the reviewer. By comparing these interaction patterns and task success between the native flat interface and the skeuomorphic design, clear insights into each interface's relative intuitiveness and accessibility were gained.

### 4.2 Findings from the User Tests

Round 1 (Flat Interface): Many participants reported confusion and found the interface non-intuitive. Even younger individuals who were generally tech-savvy struggled with navigation, while older users encountered significant barriers and frequently required assistance. These difficulties highlighted potential weaknesses in standard XR interfaces, particularly for newcomers or those with limited XR exposure. The success rate of this round was found out to be 8 percent, with only one out of twelve participants succeeding without requiring assistance.

Round 2 (Skeuomorphic Home Interspace): In contrast, participants of all ages praised the skeuomorphic interface as far more intuitive and user-friendly. The success rate increased to 92 percent in the second round, with only one participant requiring external help to navigate. Direct, tangible actions, such as "opening a mailbox" to check emails, were described as reminiscent of everyday life. One older participant (age 65) commented, "It feels natural to insert (a tape) to play music," while a younger participant (age 22) found it "easier, and more fun than using a smartphone." Some participants suggested adding personalisation options, such as rearranging objects and incorporating fluid interactions.

These experiences significantly altered perceptions of XR. Initially viewed by some as overly complex or niche, XR emerged as a viable tool for daily tasks once skeuomorphic design principles were applied. Three older participants, in particular, mentioned that they began seeing XR as a desirable, user-friendly enhancement which can be beneficial to their routines.

## 5 DISCUSSIONS

Skeuomorphism was found to significantly enhance user engagement and usability in XR environments. Participants across age groups, particularly older adults, reported a more intuitive and enjoyable experience with skeuomorphic designs than with flat interfaces. This improvement appears largely due to familiar physical cues, which reduce cognitive barriers for those less accustomed to digital technologies. Observed benefits included faster adaptation, fewer errors, and positive feedback about user-friendliness.

Another notable result concerns skeuomorphism's potential to broaden XR's appeal beyond younger, technologically experienced demographics. By minimising complexity and intimidation, skeuomorphic interfaces can attract a wider audience, particularly older or technologically hesitant users, to adopt XR more readily. This takeaway is especially relevant for design students, as they learn to address diverse user needs. Through deeper familiarity with skeuomorphism, emerging designers can create XR solutions that are both inclusive and functionally robust.

**Enhanced Accessibility:** Implementing skeuomorphic elements can alleviate steep learning curves, making XR more approachable for individuals with limited digital exposure.

**User-Centred Design:** Regularly collecting and applying user feedback is crucial for accommodating varied demographic needs and ensuring inclusive XR environments.

**Balancing Aesthetics and Functionality:** While skeuomorphism can enrich user experiences, caution is advised to prevent visual clutter and maintain straightforward usability.

**Future Technology Integration:** As XR progresses, features such as advanced haptics, spatial audio, and artificial intelligence can further complement skeuomorphic approaches, reducing cognitive load.

**Educational and Training Applications:** The study's findings suggest strong applicability in instructional contexts, where realistic metaphors can enhance engagement and facilitate skill acquisition.

Overall, integrating skeuomorphic design principles in XR development not only improves user accessibility and satisfaction but also expands the scope of XR's everyday relevance. Continued refinement of these strategies may guide XR technology toward a future that is both highly innovative and broadly inclusive.

## 6 CONCLUSIONS

This study explored how skeuomorphism can enhance usability in XR environments, particularly for users less familiar with digital technologies. By merging real-world metaphors with advanced XR features, interfaces became more intuitive and accessible. The findings also underscore the importance of integrating inclusive, user-centred design principles into XR education.

Results showed that skeuomorphic interfaces often feel more natural and enjoyable than flat designs. Users, particularly older adults, cited greater ease of navigation, reduced cognitive load, and heightened satisfaction when engaging with familiar, physical-like elements. These benefits extend beyond older demographics, suggesting that skeuomorphic principles can foster a more intuitive user experience for many. In reflecting on the research questions, the findings indicate that skeuomorphism substantially improves accessibility in XR by harnessing real-world metaphors, lowering the cognitive hurdles associated with novel digital systems. Critical design elements include visual familiarity, tactile cues, and intuitive interaction models, which allow users to apply existing knowledge when transitioning to digital tasks. A clear preference emerged for skeuomorphic approaches across diverse user groups, largely due to reduced confusion and fewer errors compared to flat designs.

However, it should also be noted that this exploratory study used a small participant pool and focused on brief, task-specific interactions, which limits the generalisability of the findings. In particular, older adults' strong preference for skeuomorphic controls may reflect prior familiarity rather than a universal advantage, and only a narrow set of flat-style interfaces were tested. Future work should implement building a more fully featured more detailed prototype, one that supports dynamic interactions rather than static objects, which also enables more rigorous, quantitative comparisons. Longer-term and cross-cultural studies could reveal how user preferences evolve over time or differ by region. Finally, integrating advanced technologies such as AI-driven adaptive icons and haptic feedback devices may further enhance immersion while preserving the real-world intuitiveness that skeuomorphism provides. Due to the project's scope and time constraints, the prototypes were intentionally kept simple; these extensions offer promising avenues for deeper, more scientifically robust research.
Skeuomorphism demonstrates strong potential to make XR systems more approachable, reducing barriers to adoption among older adults and other non-digital natives. By continuing to refine these Strategies, and embedding them within design education, future XR interfaces can become more equitable, intuitive, and beneficial for all.

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## REFERENCES

[1] Margrett J. A., Ouverson K. M., Gilbert S. B., Phillips L. A. and Charness N. Older Adults' Use of Extended Reality: A Systematic Review. *Frontiers in Virtual Reality*, vol. 2, Jan. 2022, doi:10.3389/frvir.2021.760064.
[2] Interaction Design Foundation. What Is Skeuomorphism? Interaction Design Foundation. [Online]. Available: https://www.interaction-design.org/literature/topics/skeuomorphism. Accessed: 01 Apr. 2024.
[3] Sharit J., Moxley J. and Czaja S. Older Adults' Willingness to Adopt Technologies: An Experimental Study. *Innovation in Aging*, vol. 6, no. Supplement_1, pp. 216–216, Nov. 2022, doi:10.1093/geroni/igac059.859.
[4] Backhaus N., Trapp A. K. and Thüring M. Skeuomorph Versus Flat Design: User Experience and Age-Related Preferences. In *Design, User Experience, and Usability: Designing Interactions – DUXU 2018*, A. Marcus and W. Wang, Eds., vol. 10919. Cham: Springer, 2018, pp. 527–542, doi:10.1007/978-3-319-91803-7_40.
[5] Urbano I. C. V. P., Guerreiro J. P. V. and Nicolau H. M. A. A. From Skeuomorphism to Flat Design: Age-Related Differences in Performance and Aesthetic Perceptions. *Behaviour & Information Technology*, vol. 41, no. 3, pp. 1–16, Sep. 2020, doi:10.1080/0144929X.2020.1814867.
[6] Torgny O. Metaphor – A Working Concept. Semantic Scholar, 1997. [Online]. Available: https://www.semanticscholar.org/paper/...df5d84fe31799e71238b700f087b00f9353f675f. Accessed: 11 Sep. 2024.
[7] Norman D. *The Design of Everyday Things: Revised and Expanded Edition*, Revised edition. New York, NY: Basic Books, 2013.
[8] Kouprie M. and Visser F. S. A framework for empathy in design: stepping into and out of the user's life. *J. Eng. Des.*, vol. 20, no. 5, Art. no. 5, Oct. 2009, doi: 10.1080/09544820902875033.
[9] Statista. Biggest App Stores in the World, 2022. Statista. [Online]. Available: https://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/. Accessed: 01 Apr. 2024.
[10] Cila N., Hekkert P. and Visch V. Source Selection in Product Metaphor Generation: The Effects of Salience and Relatedness. *Int. J. Des.*, vol. 8, pp. 15–28, Apr. 2014.