IMPULSE

IMmersive digitisation: uPcycling cULtural heritage towards new reviving StratEgies

Deliverable 1.2:

User Research Report: UX Evaluation of IMPULSE VR Prototype

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2 Executive summary

This deliverable, D1.2 – *Report on qualitative and quantitative UX research*, presents the results of a multi-method user study conducted within Work Package 1 (WP1) – Extended Storytelling Towards Vivid User Experiences - of the IMPULSE project (GAP-101132704). The research was carried out in Task 1.1.3, coordinated by the Jagiellonian University, and aimed at identifying how diverse user groups perceive, interpret, and interact with immersive cultural heritage content.

The study employed a triangulated methodology, integrating participatory UX workshops, structured surveys, and semi-structured interviews. These methods were applied across three key user groups defined in Deliverable D1.1 (Krakowska, Zych, Deja, 2024, p. 13-18):

- G1: students and academic teachers and researchers
- G2: artists and art school educators,
- G3: professionals from the Cultural and Creative Industries (CCI).

Group 1 (G1): Students, University Educators, and Researchers.

This group includes undergraduate and graduate students, as well as university educators and researchers, primarily from the partner institutions involved in the project (e.g., Jagiellonian University). The focus of this group is on the educational and didactic potential of immersive environments and digital cultural heritage, particularly the application of immersive prototypes in educational settings. The primary exploration will be around how immersive environments can be integrated into curricula, facilitating deeper engagement with digital cultural assets and enhancing learning experiences in academic contexts.

Group 2 (G2): Artists and Creative Practitioners.

This group consists of artists and creative practitioners, such as art school educators and professional artists, who engage with cultural content through creative and interpretive practices. The investigation will focus on the potential of the prototype in an artistic context, with an emphasis on creative exploration, artistic re-imagining, and speculative methodologies. Members of G2 will use the prototype for artistic research and will explore its potential to stimulate creative re-interpretation and re-engagement with cultural heritage in immersive digital formats, encouraging new forms of expression and narrative.

Group 3 (G3): Cultural and Creative Industries (CCI) Professionals.

This group includes professionals from the cultural and creative industries (CCI), such as curators, designers, multimedia developers, and cultural heritage professionals, who work with digital heritage tools and immersive technologies. The research within this

group will explore the professional use of the prototype, focusing on aspects like technical stability, scalability, and integration into professional workflows. G3 participants will assess the potential of the prototype for professional curation, exhibition development, and the creation of digital assets for the cultural heritage sector, focusing on practical applications in real-world contexts.

A two-day co-creative workshop held in Leuven enabled in-situ testing of early-stage VR prototypes and collaborative narrative design. Remote surveys allowed for broader validation of user preferences, while interviews deepened understanding of affective and interpretative experiences.

Findings reveal that each user group demonstrates distinct expectations regarding usability, content structure, emotional engagement, and technical functionality. These insights informed the construction of provisional user personas and form the basis for the design recommendations presented in Section 7.

D1.2 contributes empirical evidence to support the user-centred and inclusive development of the IMPULSE platform in WP2 and provides strategic guidance for interaction and narrative design in WP3. It also builds upon the conceptual foundations set in D1.1 and prepares the ground for further persona refinement and behavioural diagnostics in D1.3.

Key words:

user experience, immersive environments, cultural heritage, extended reality, UX research, participatory design, co-creation, user groups, XR, virtual reality, prototype evaluation, interaction design, persona construction, narrative strategies, education and the arts.

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4 Abbreviations and Acronyms

Abbreviation / acronym	Description
AI	Artificial Intelligence
AR	Augmented Reality
CCI	Cultural and Creative Industries
CH	Cultural Heritage
D1.2	Deliverable number 1.1 / 1.2
EC	European Commission
FIG.	Figure
G1	Group 1
G2	Group 2
G3	Group 3
HCI	Human-Computer Interaction
IMCo	IMPULSE Community of Practice
JPG	Joint Photographic Experts Group
MUVE	Multi-User Virtual Environment
PNG	Portable Network Graphics
SVG	Scalable Vector Graphics
UEQ	User Experience Questionnaire
UX	User Experience
VR	Virtual Reality
WP	Work Package
WP1	Work Package 1: Extended Storytelling Towards Vivid User Experiences
XR	Extended Reality

5 Introduction

5.1 IMPULSE Project

The IMPULSE project (*IMmersive digitisation: uPcycling cULtural heritage towards new reviving StratEgies*) addresses key challenges in the digitisation, accessibility, and re-use of digital cultural heritage collections across Europe. It aims to develop inclusive, sustainable, and innovative strategies for presenting and transforming cultural content through immersive technologies such as XR, VR and MUVE (Multi-User Virtual Environments), with particular attention to educational, artistic, and creative applications.

The project integrates methodologies and perspectives from multiple disciplines—including information science, heritage studies, arts, digital design, and social sciences—into a common framework for immersive storytelling. It responds to the increasing need for:

- improving the interoperability of heritage platforms,
- expanding the meaningful re-use of existing digitised collections,
- developing standardisation procedures,
- and adapting legal and ethical frameworks to contemporary digital transformation.

IMPULSE places a strong emphasis on the diversification of narratives and audiences, particularly by addressing underrepresented communities, engaging artists and creatives in content reinterpretation, and enabling the co-creation of hybrid digital experiences. Through a Community of Practice, hackathons, and mentoring hubs, the project fosters dynamic exchange between academia, cultural institutions, artists, and the Cultural and Creative Industries (CCI). These interactions are instrumental in building robust, human-centred ecosystems for immersive digitisation.

The project adopts an iterative and participatory approach to the design of immersive experiences. The development of prototypes proceeds through successive cycles of conceptual exploration, user research, testing, and refinement, rooted in agile, design-based and future-oriented methods. At the heart of this process lies Work Package 1, which provides the empirical and methodological foundation for the creation of impactful, accessible, and multi-layered digital narratives.

5.2 Objectives of the Work Package 1

Work Package 1 (WP1), entitled *Extended Storytelling Towards Vivid User Experiences*, is one of the foundational modules of the IMPULSE project. Its overarching goal is to conceptualise, develop, and empirically validate new modes of storytelling in immersive environments based on user needs, narrative diversity, and technological affordances.

WP1 seeks to:

- identify and define the information needs and behaviours of selected user groups interacting with immersive cultural content,
- investigate affective, cognitive, and social dimensions of XR-based user experiences,
- support the design of educational and artistic applications using extended reality (XR),
- and produce guidance for narrative structures and interaction strategies that are accessible, inclusive, and adaptable to different audiences and contexts.

To achieve these goals, WP1 includes the design of a comprehensive research methodology (developed in D1.1), followed by empirical UX research (documented in D1.2), and culminating in behavioural diagnostics and persona construction (in D1.3 and beyond). The findings from WP1 are directly integrated into the technical development of the prototype platform in WP2, ensuring continuity between conceptual design, user engagement, and implementation.

5.3 Objectives of the Task 1.1

Task 1.1 (*UX Research*) is the core empirical component of WP1 and is led by the Jagiellonian University in collaboration with project partners from Belgium, Italy, Greece, Germany and Malta. It consists of seven interrelated subtasks (1.1.1–1.1.7), spanning the entire duration of the project (months 1–36). These include literature review and methodological design (1.1.1–1.1.2), empirical user research (1.1.3–1.1.5), final usability testing (1.1.6), and educational dissemination activities (1.1.7).

Deliverable D1.2 corresponds directly to **Task 1.1.3** – User study: preliminary research before developing prototypes. This subtask is focused on identifying:

- users' information requirements, expectations, and behavioural patterns.
- digital and cultural competencies (e.g., knowledge of software, instruments, interpretative frameworks).
- motivational and emotional factors involved in immersive engagement.

According to the Grant Agreement and WP1 roadmap, Task 1.1.3 is scheduled for months 7–15 of the project, serving as a bridge between conceptual methodology development (1.1.1–1.1.2) and prototype refinement (1.1.4–1.1.5). Its function is to collect and analyse empirical data from key user groups before the first complete version of the prototype is finalised.

The research includes both quantitative (survey-based) and qualitative (interview, observation, workshop) components, and is conducted among the three primary user groups identified in WP1 and D1.1:

- Group 1 (G1) – This group comprises students, university educators, and researchers, representing a broad range of expertise with immersive technologies, including VR. It encompasses both novice and expert users who engage with XR technologies primarily in academic settings, for research purposes, and in educational contexts. Members of G1 are key in testing the educational potential of the VR system and exploring its application in both teaching and academic research across various disciplines.

- Group 2 (G2) – This group consists of artists, art educators, and creative practitioners, with varying levels of engagement with digital tools. G2 members are primarily focused on exploring the creative possibilities of VR, using the platform for artistic expression, innovative narrative forms, and experimental applications in the visual and performing arts.

- Group 3 (G3) – This group includes professionals from the Cultural and Creative Industries (CCI), such as curators, game designers, multimedia developers, and cultural heritage specialists. G3 participants engage with immersive technologies from a professional perspective, aiming to integrate VR into real-world workflows for content creation, curation, and cultural heritage management.

The results of Task 1.1.3 feed directly into the design, content curation, and functional development of the immersive prototype in WP2. By mapping user needs and practices, the task helps ensure that future technological solutions are inclusive, responsive, and grounded in real-world contexts of digital heritage interaction.

5.4 Background and Objectives

This deliverable, D1.2 – Report on qualitative and quantitative UX research, presents the results of a multi-method user study conducted as part of Task 1.1.3 – User study: preliminary research before developing prototypes, within the framework of Work Package 1 (WP1) – Extended Storytelling Towards Vivid User Experiences. The research was led by the Jagiellonian University (JU) and carried out between project months 7 and 15, prior to the release of the first functional prototype.

WP1 plays a foundational role in the IMPULSE project. It aims to conceptualise, develop, and validate new immersive narrative strategies and interaction models based on real user needs, behaviours, and expectations. By investigating how different audiences interact with XR-mediated cultural heritage content, WP1 provides a human-centred and inclusive framework for the design of emotionally engaging and socially responsive digital solutions. It also builds the basis for prototyping (WP2) and subsequent validation, legal, and dissemination activities.

Within this framework, Task 1.1.3 serves as the first empirical investigation focused on identifying:

- user information needs, behavioural patterns, and digital competences,
- motivational and affective dimensions of immersion,
- and the experiential quality of user interaction with early-stage prototypes.

The study was implemented using a triangulated research strategy, including:

- a participatory UX workshop with an interactive prototype during a co-creation session in Leuven,
- quantitative online surveys conducted with selected participants from G1 and G2,
- and semi-structured qualitative interviews with users and experts across all three groups.

The user research was conducted across three target groups, as defined in WP1 and further elaborated in Deliverable D1.1:

- **Group 1 (G1)**: students, academic teachers, and researchers, representing a range of educational contexts and levels of digital literacy. It is important to note that within this group, research may focus on specific subgroups, such as students, without necessarily involving academic teachers or researchers at all times.
- **Group 2 (G2)**: artists and art school educators, who engage with cultural content through creative and interpretive practices. Similar to G1, specific studies may focus on subsets of this group, such as art school educators, while not including artists in a given period of research.
- **Group 3 (G3)**: professionals from the Cultural and Creative Industries (CCI), including curators, designers, and developers of digital heritage tools. Within this group, the research may target particular subgroups (e.g., curators), depending on the focus of the study at a specific point in time.

Given the diversity within each of these groups, not all members will be involved in every phase of the research. Depending on the specific objectives and time frame, studies may focus on selected subgroups within G1, G2, and G3.

By capturing perspectives from these distinct but complementary communities, the research offers critical insight into how immersive cultural experiences can be shaped to support education, creativity, innovation, and participation. Specifically, G1 (students and

academic teachers in general educational fields) focuses on the application of immersive technologies within broader educational contexts, while G2 (artists and art school educators) explores the intersection of immersive environments and creative practices. This distinction ensures that the needs of both academic and artistic communities are addressed separately. The evidence gathered will feed directly into the development of the IMPULSE platform (WP2), inform user validation and behavioural diagnostics in WP1, Task 1.1, and underpin inclusive design and narrative adaptation across the entire project.

5.5 Scope and purpose of this Deliverable

Deliverable D1.2 provides the first large-scale empirical dataset on user interaction with early-stage immersive digital heritage prototypes in the IMPULSE framework. While D1.1 established the conceptual and methodological foundations of UX research in WP1, D1.2 translates them into applied research practice, yielding evidence-based insight into users' needs, practices, and challenges.

The scope of this deliverable includes:

- the description of research methods, instruments, sampling and implementation settings;
- the analysis of user responses, behaviours and attitudes across user groups and methods;
- the comparative synthesis of qualitative and quantitative data;
- and the development of user-driven recommendations for immersive interaction design, content curation, and system functionalities.

The aim of the research was to understand how different user groups perceive, interpret, and interact with immersive cultural heritage content. The integration of methods allowed for both group-specific and cross-cutting insight generation, informing both immediate design implications and strategic directions for future work packages.

The report is structured as follows:

- Section 3 – User Groups and Personas: profiles and characteristics of the three user groups and provisional persona construction;
- Section 4 – Methodology: research design, instruments, and ethical considerations;
- Section 5 – UX Research Activities and Results: results of the Leuven workshop, surveys and interviews;
- Section 6 – Synthesis and Cross-case Analysis: integration of insights across user groups and methods;

- Section 7 – Recommendations: actionable guidance for design, narrative adaptation, strategic development and inclusivity;
- Section 8 – Conclusions: main takeaways and implications for further development;
- Section 9 – References and Section 10 – Annexes: supporting materials and documentation.

This structure follows a logic of progression from user characterisation through research execution to results, synthesis and application. It ensures transparency, traceability, and usability of findings for both internal project development and external evaluation.

6 User Groups and Personas

6.1 Definition and Justification of User Groups

The user research conducted within Task 1.1.3 of the IMPULSE project builds on a structured segmentation of user groups established in WP1 and elaborated in Deliverable D1.1. The rationale for this segmentation is to ensure that the development of immersive digital heritage prototypes is informed by the diverse experiences, needs, and expectations of real users, representing a wide range of educational, artistic, and professional contexts (D1.1, pp. 9–11).

Three main user groups were defined and selected for focused empirical investigation:

- **Group 1 (G1): Students, Academic Teachers, and Researchers.**

This group includes university students, academic teachers, and researchers, representing a range of digital literacy levels and familiarity with immersive technologies. They were selected to test educational use cases and explore user needs in both formal and informal learning environments.

- **Group 2 (G2): Artists and Art School Teachers.**

This group comprises practitioners and educators engaged in the arts, with particular attention to those who work with visual, performative, and interpretive approaches. Their perspective is crucial for validating the artistic relevance and expressive affordances of immersive cultural narratives.

- **Group 3 (G3): Cultural and Creative Industries (CCI) Professionals.**

This group includes curators, digital designers, developers, and other professionals operating at the intersection of heritage, technology, and innovation. Their feedback

is key for ensuring that the prototype can be adapted to real-world production environments and creative workflows (D1.1, pp. 9–12).

This tripartite segmentation reflects the project's commitment to inclusivity, sectoral relevance, and co-creation, and enables comparative analysis across user types.

6.2 Key Characteristics

The three user groups identified for the UX research in WP1 differ substantially in terms of their digital competences, usage contexts, and experiential expectations. These differences were initially hypothesised during the preparatory work in WP1 and elaborated in Deliverable D1.1, which provided both the theoretical rationale and the methodological structure for their exploration (Krakowska et al., 2024, pp. 9–12). They guided the development of research instruments and the interpretation of findings across tasks in WP1.

6.2.1 Information and Digital Literacy.

- G1 (Students and Educators) shows a heterogeneous profile with respect to digital fluency. While some students—especially those in creative disciplines—are digitally competent and curious about immersive technologies, others require clear structure and conceptual scaffolding. Academic teachers tend to emphasise usability and educational transparency in immersive content design (Krakowska et al., 2024, pp. 13, 17).
- G2 (Artists and Art School Teachers) generally exhibits high visual and aesthetic literacy, yet their familiarity with immersive and interactive digital systems varies. Many are open to exploratory and speculative approaches, favouring experimentation with content and format. However, for some members of this group, immersive systems represent novel and potentially challenging environments (Krakowska et al., 2024, pp. 13–14, 19).
- G3 (CCI Professionals) is typically characterised by high functional digital literacy. Members of this group—including curators, designers, and developers—are often well-versed in XR, 3D environments, or digital platforms used in heritage and creative sectors. Their expectations are strongly shaped by professional standards, productivity demands, and integration with existing workflows (Krakowska et al., 2024, pp. 19–21).

6.2.2 Expectations for Digital Heritage.

- G1 values immersive content that is clearly structured, contextualised, and educationally meaningful. Navigation ease and access to supporting information

are seen as essential for effective learning engagement (Krakowska et al., 2024, pp. 17, 20).
- G2 expects openness to interpretation, symbolic richness, and opportunities for reappropriation and aesthetic expression. Multimodality and creative affordances are key to maintaining engagement (Krakowska et al., 2024, pp. 14, 21).
- G3 prioritises technical robustness, modularity, and adaptability. Systems must enable efficient content manipulation, exportability, and usability in applied creative contexts (Krakowska et al., 2024, pp. 21–22).

6.2.3 Narrative, Affective, Aesthetic Preferences.

- G1 favours immersive experiences that combine clear narrative trajectories with affective resonance, especially where the content addresses social, historical, or ethical dimensions in culturally situated ways (Krakowska et al., 2024, p. 28).
- G2 engages more easily with open-ended, ambiguous, and affectively rich storytelling formats. Artistic users prefer interfaces and content structures that stimulate the senses, allow freedom of interpretation, and support embodied interaction (Krakowska et al., 2024, pp. 28–29).
- G3 is generally drawn to task-oriented, customisable, and scalable narratives. The emphasis is placed on clarity, control, and alignment with user goals such as exhibition development, audience outreach, or commercial production (Krakowska et al., 2024, p. 29).

These insights formed the conceptual backdrop for the design of surveys, interview guides, and co-creation workshop scenarios. They also support the synthesis of results across user groups, discussed in Section 6.

6.3 Provisional Personas

As part of the interpretative synthesis of user characteristics and early empirical insights, a series of provisional user personas was constructed to represent salient behavioural patterns, motivational profiles, and experiential expectations within each of the three main user groups identified in WP1. These personas are integral to supporting the iterative design process, enhancing the understanding of user needs, and guiding the adaptation of immersive narratives and interaction models throughout the project. By embedding user personas into the design workflow, the project can better align with user preferences and requirements, ultimately leading to a more user-centred approach to immersive technology development. These personas are crucial not only for visualising user characteristics but also for facilitating the targeted development of the immersive environment. They allow designers to make informed decisions about the customisation and personalisation features, as well as to optimise user engagement and interaction quality within the immersive platform. This process enables the creation of a more tailored immersive environment that directly addresses the needs and preferences of

different user groups. For instance, G1 may require more structured, pedagogical features; G2 may seek more freedom for expressive interaction and narrative development; and G3 may prioritise tools for curation, metadata integration, and interpretive frameworks. The iterative refinement of personas based on ongoing data collection allows the platform to evolve and be better prepared for future testing phases, ensuring that the system remains flexible and responsive to users' changing needs. Therefore, the continuous development of personas, combined with empirical data, ensures that the immersive environment is dynamic and adaptable, and that the platform can meet both current and future user demands.

While the personas presented here are based on a combination of desk research, literature analysis, and early-stage empirical data (as described in Sections 5 and 6.2), they remain provisional and will undergo further refinement as more qualitative interviews and behavioural diagnostics are integrated during Task 1.1.5. This refinement ensures that the personas evolve in alignment with actual user feedback and performance metrics. Each persona reflects core attributes observed across user profiles: digital and information literacy, experiential orientation, content and interaction preferences, and attitudinal dispositions toward immersive technologies and digital cultural heritage. This multi-dimensional approach ensures that the personas are holistic and contextually grounded, serving as a practical tool for guiding the development of meaningful and inclusive user experiences in the immersive environment.

Persona 1: "Curious Synthesiser" (G1 – Student, Academic Teacher, or Researcher).

- Background: undergraduate student in humanities with some prior exposure to digital museums and AR/VR in education. Can also represent academic teachers or researchers in the same field.
- Digital competence: moderate. Comfortable using digital platforms but lacks experience with immersive systems.
- Motivations: Seeking engaging, accessible, and personally meaningful content that bridges academic learning with contemporary cultural concerns.
- Behavioural traits: needs structured navigation and clear guidance; responds positively to emotionally resonant content and contextual explanation.
- Pain points: overwhelmed by unstructured interfaces; unsure how to "read" immersive spaces.

Persona 2: "Structured Facilitator" (G1 – Educator)

- Background: senior lecturer with strong interest in integrating cultural heritage into course material.
- Digital competence: high in instructional platforms, low in immersive media.
- Motivations: needs content to be pedagogically grounded, adaptable to learning objectives, and accessible to students with varied backgrounds.
- Behavioural traits: analytical, outcome-oriented, values interpretative clarity and credibility.

- Pain points: distrusts over-stylised interfaces; concerned about student disorientation or cognitive overload.

Persona 3: "Reflective Performer" (G2 – Artist or Educator, Art Teacher).

- Background: independent performance artist and part-time art school instructor. While this persona combines both artists and educators, it is based on the premise that many art school educators also actively engage in creative practices, merging both roles within the same professional identity.
- Digital competence: variable; high aesthetic literacy but limited experience with XR tools.
- Motivations: seeks inspiration, emotional depth, and symbolic openness in immersive environments; views heritage as a medium for artistic transformation.
- Behavioural traits: embraces ambiguity; prefers poetic and non-linear experiences.
- Pain points: frustrated by didactic content; prefers exploration to instruction.

Persona 4: "Strategic Integrator" (G3 – CCI Professional).

- Background: digital curator at a mid-sized design studio developing museum installations and AR applications.
- Digital competence: very high; works daily with interactive platforms and immersive media.
- Motivations: looking for tools that allow creative re-use of content, technical stability, and integration into production pipelines.
- Behavioural traits: pragmatic, efficiency-driven, interested in functionality and scalability.
- Pain points: limited tolerance for experimentation if not aligned with project goals; seeks granular control and reliability.

These personas serve as conceptual bridges between raw user data and actionable design requirements. They offer a humanised synthesis of the user landscape explored in WP1 and will be further refined during the upcoming work in Task 1.1.5 and usability validation in WP2 and WP3.

6.3.1 Comparative Overview of Provisional Personas (G1–G3).

The following table presents a structured comparison of four provisional personas, corresponding to their respective user group as defined in WP1. It synthesises key behavioural traits, digital competencies, narrative preferences, and interaction expectations observed during the early research phase. This overview may serve as a practical design tool to support iterative development processes, prioritisation of functional features, and inclusive narrative strategies in the subsequent stages of the project (notably WP2 and WP3).

Table 1. Comparative overview of provisional user personas representing G1–G3.

Persona	Group	Digital competence	Motivations	Narrative preferences	Functional requirements	Sensitivities / Challenges
Curious Synthesiser	G1	Moderate	Engagement, understanding, personal relevance	Emotional, contextual, partially guided storytelling	Clear navigation, logical structure, contextual framing	Prone to disorientation; difficulty interpreting immersive spaces
Structured Facilitator	G1	Medium (low in immersive tech)	Pedagogical value, clarity, adaptability for learning	Coherent, structured, didactic narrative	Intuitive interface, educational alignment, interpretative control	Concern about cognitive overload; aversion to ambiguity
Reflective Performer	G2	Varied (aesthetic literacy high)	Inspiration, emotional depth, interpretative openness	Non-linear, symbolic, performative, emotionally layered	Freedom to explore, aesthetic richness, minimal constraints	Dislikes overly prescriptive formats; prefers expressive openness
Strategic Integrator	G3	Very high	Functionality, reusability, technical integration	Modular, goal-driven, customisable content	Technical reliability, flexible control, exportability	Low tolerance for inconsistency; demands production-readiness

This Table 1 summarises the defining characteristics of four provisional personas developed during Task 1.1.3. Each persona reflects typical behavioural patterns, digital competences, motivational profiles, narrative preferences, and functional expectations observed among users belonging to the three primary groups defined in WP1: G1 (students and educators), G2 (artists and art school teachers), and G3 (professionals from the Cultural and Creative Industries). The matrix offers a condensed visual reference to support user-centred design decisions and alignment with diverse experiential contexts.

This comparative matrix builds upon the user segmentation and characterisation framework developed in *Deliverable D1.1 – Methodological Framework and User Groups Definition* (Krakowska et al., 2024). The construction of provisional personas is explicitly foreseen in Task 1.1.5, where personas are defined as synthesised user archetypes reflecting observed needs, practices, and expectations across user groups (Krakowska et

al., 2024, pp. 22–23). According to the methodology outlined in WP1, provisional personas are derived from:

- the initial desk-based profiling and segmentation of user groups (G1–G3) presented in D1.1;
- thematic insights obtained from interviews, surveys, and participatory observation conducted in Task 1.1.3;
- established UX research practices based on the ISO 9241-210 framework for human-centred design, in which personas are recognised as design tools bridging empirical user data and system development decisions.

The personas presented here serve as intermediate conceptual models, guiding the ongoing development of narrative strategies, user journeys, and interface structures. They will be subject to further validation and refinement in subsequent empirical activities within Task 1.1.5, and in co-design sessions planned under WP2 and WP3.

7 Methodology

The empirical UX research presented in this deliverable was grounded in a user-centred and iterative design approach, as defined in *Deliverable D1.1* (Krakowska et al., 2024) and aligned with the ISO 9241-210 standard for human-centred interactive systems. The overarching goal was to generate actionable insights into how diverse user groups engage with immersive digital heritage experiences.

A triangulation of methods was employed to ensure both depth and breadth of insight:

- Participatory workshops enabled live observation and co-creation in controlled immersive settings;
- Structured surveys captured attitudinal and experiential data across larger respondent samples;
- Semi-structured interviews elicited detailed individual perspectives, interpretative frames, and usage contexts.

This multi-method strategy was designed to accommodate the complexity of immersive experience design, balancing exploratory openness with comparative consistency across user groups and cultural content types.

7.1 Methodological Framework

The UX research conducted within Task 1.1.3 of the IMPULSE project was grounded in a user-centred, iterative and exploratory methodology, designed to capture diverse user perspectives on immersive digital cultural heritage experiences. This approach builds

directly on the framework laid out in *Deliverable D1.1 – Methodological Framework and User Groups Definition* (Krakowska et al., 2024), and is aligned with the principles of the ISO 9241-210 standard for human-centred design of interactive systems (ISO, 2019).

7.1.1 User-centred and Iterative Approach.

In accordance with the overall vision of WP1, the study placed real users—students, educators, researchers, artists and CCI professionals—at the centre of the design and evaluation process. Rather than testing predefined assumptions or fixed functionalities, the aim was to engage users in dynamic, creative and reflexive interactions with the prototype and with each other. The research was iterative, allowing feedback to inform not only interpretation but also the redesign of survey instruments and the evolution of prototype components.

The study recognised that immersive user experience is shaped not only by usability, but also by emotional resonance, cognitive framing, social background, and contextual expectations. Therefore, the methodology sought to account for these multidimensional aspects of user engagement through a careful combination of qualitative and quantitative tools.

User participation occurred at several levels:

- as co-creators of spatial narratives during the Leuven workshop;
- as evaluators of interface and content coherence via structured questionnaires;
- as informants and interpreters through individual and expert interviews.

This layered engagement was crucial for understanding not just what users do within immersive environments, but how they make sense of them, what values they assign, and what barriers they encounter.

7.1.2 Triangulation of Methods.

To ensure the robustness, depth and credibility of the findings, the research adopted a triangulation strategy combining three complementary methods:

1. **Participatory UX Workshop (Leuven).** Designed as a co-creative and exploratory environment, the workshop enabled real-time observation of user interaction with the prototype, spontaneous feedback, and collaborative scenario development. It produced data in the form of group observations, design sketches, materials shared via Miro and Discord, field notes, and post-task survey responses.

2. **Quantitative Surveys (G1 & G2).** Online surveys provided a structured means to collect data from broader samples of target users, enabling statistical comparison of perceived usability, immersion, clarity, and narrative relevance. The survey design was informed by pilot observations and refined between iterations.
3. **Semi-structured Interviews (G1–G3 + Experts).** Interviews captured individual reflections, interpretative logics, affective responses, and broader professional or educational expectations. They provided insight into long-term familiarity with XR systems, narrative interpretation, and context-specific needs.

This triangulated framework allowed for:

- cross-verification of insights across data types;
- contextual anchoring of quantitative results in user narratives;
- synthesis of shared themes and identification of group-specific variations.

The integrated methodological design also reflects the ambition of WP1 to combine theoretical innovation (in narrative and interaction design) with empirical grounding in the lived experiences of cultural heritage users.

7.2 Tools and Instruments

The empirical study conducted within Task 1.1.3 required the development and application of research tools capable of capturing nuanced, multidimensional aspects of user experience across different contexts of interaction. Instruments were designed to reflect both the diversity of user profiles (G1–G3) and the multimodal nature of immersive cultural heritage engagement. Each tool addressed a different dimension of the UX landscape: experiential immersion, usability, affective response, cognitive interpretation, and narrative preference. Their complementary application allowed for cross-validation of findings and the integration of both quantitative and qualitative user perspectives.

The key instruments included: (1) scenario-based UX testing protocols, (2) structured questionnaires for on-site and remote data collection, and (3) tailored semi-structured interview guides.

7.2.1 UX test scenarios.

To structure user interaction with the early-stage IMPULSE prototype and to probe how users interpret, navigate, and emotionally engage with cultural heritage content in immersive environments, a set of UX test scenarios was developed and implemented by the KU Leuven team specifically for the two-day participatory workshop in Leuven (February 2025). These scenarios, which reflect the preparatory work and creative

ideation carried out by KU Leuven in advance, guided participants through narrative ideation, spatial storytelling design, and live testing in the VR platform, enabling structured observations and post-task evaluations.

7.2.1.1 Scenario Architecture and Purpose.

The test scenarios were not abstract tasks but were rooted in curated historical themes and artefact sets, assigned to each team. Each group worked with different content types (e.g. Palmyra, Vesalius, mythological reliefs) to develop immersive story experiences. The scenario process unfolded in three interdependent phases:

1. Ideation and Narrative Development (Day 1):
    a. Participants explored a curated collection of digital heritage artefacts and assigned themes.
    b. Through guided exercises using story prompt cards, they brainstormed possible narrative angles, emotional framings, and learning outcomes.
    c. Teams discussed key storytelling questions: What message should the visitor take away? What affective response do we want to trigger?
2. Spatial Storyboarding and Scenario Structuring (Day 1–2):
    a. Using sketching tools, Miro boards, and the principles of Juxtaposition, Sequence, and Perspective, teams developed spatial layouts and interaction flows.
    b. They mapped story arcs through object arrangement, spatial pacing, and user movement expectations, simulating museum-like or exploratory narrative journeys.
3. Immersive Scenario Testing (Day 2):
    a. Participants reconstructed their story layouts in the actual VR environment and walked through the scenarios as both creators and test users.
    b. Teams tested: Does the artefact placement support the story? Are transitions between themes legible? Is the visitor's attention guided meaningfully?
    c. After internal walkthroughs, cross-team feedback sessions allowed fresh perspectives and evaluative insights.

Each test scenario thus functioned as a full-stack experiential unit, from ideation to prototype instantiation, simulating future visitor experiences and surfacing design constraints.

7.2.1.2 Roles in Scenario Facilitation.

The scenarios were facilitated through a dual role structure, as defined in the facilitation script:

- The Team Lead ensured the progression of tasks, team dynamics, and structural consistency. They supported group synthesis and maintained documentation of design decisions.
- The Storytelling Expert introduced theoretical concepts (e.g. spatial narrative techniques) and mentored teams in aligning emotional, educational, and curatorial goals. Their role was particularly crucial in enabling participants to shift from linear storytelling to immersive, interactive modes of representation.

This combination enabled participants to co-create immersive narratives while remaining critically aware of interaction logic and affective design.

7.2.1.3 Scenario Objectives and Observational Strategy.

The UX test scenarios were designed to fulfil several concurrent aims:

- Stimulate co-creative exploration of immersive narrative forms;
- Surface experiential challenges related to navigation, content interpretation, and sequencing;
- Evaluate users' intuitive engagement with cultural material in VR;
- Generate actionable feedback on interface design, cognitive load, and affective resonance;
- Support the creation of personas and user journeys, as further elaborated in Section 6.

Structured observation protocols were used during scenario execution, alongside post-task surveys and live annotations by researchers. These materials formed a critical dataset for the triangulation of insights across groups and methods.

7.2.2 Survey Questionnaires.

Two distinct survey instruments were employed during Task 1.1.3, both developed collaboratively by JU and KU Leuven to address the needs of the UX study. While both shared a common structure, they were applied in different contexts and served complementary research purposes.

1. **Workshop Evaluation Questionnaire (JU).** The first questionnaire was designed specifically for the participatory UX workshop conducted in Leuven in February 2025. This two-day event, hosted at the Agora Learning Centre of KU Leuven, served as a co-creative exploration of how immersive technologies—particularly VR—can transform engagement with cultural heritage and educational content. Participants engaged with early-stage IMPULSE prototypes developed using authentic digital cultural assets (e.g. Vesalius manuscript, Palmyra reconstructions, hybrid mural simulations), and were invited to test, reflect and

co-design immersive storytelling strategies. Questionnaire for Leuven workshop is available in **Appendix 11.1** and all materials for partners and participants of Leuven workshop is available on MS Team WP IMPULSE General Group, available at:
https://teams.microsoft.com/l/team/19%3A9mNtT4kob1TQolvDLWRi6KWOsSHQPRVIK1QQKwjLHxo1%40thread.tacv2/conversations?groupId=39f4586f-e918-473a-8b46-e27f90217b45&tenantId=eb0e26eb-bfbe-47d2-9e90-ebd2426dbceb).

The workshop was conceived as an open, interdisciplinary environment welcoming educators, artists, cultural mediators and curious participants from diverse backgrounds. No prior technical experience was required. The emphasis was placed on collaboration, imagination and critical reflection. Participants experimented with prototype scenarios, interacted with content, and engaged in structured and informal feedback sessions.

To evaluate user reactions and gather structured insights, JU administered an on-site post-interaction questionnaire that captured:

a. initial emotional and sensory reactions to immersive interaction;
b. perceived clarity and usability of the interface;
c. preferences regarding content structure, aesthetic qualities, and accessibility;
d. self-assessed digital literacy and creative background.

Jagiellonian University (JU) was responsible for creating the anonymous UX questionnaire in collaboration with WP2. Once it was confirmed that no personal data would be processed, the KU Leuven ethics committee advised that ethical review was not necessary. KU Leuven's obtained participants' consent for GDPR purposes specifically related to the use of images and videos taken during the workshop.

2. **Formalised Survey for Remote Study (Jagiellonian University)**. Building on the design and insights of the Leuven questionnaire, a revised and extended survey was developed by the Jagiellonian University for remote deployment. This instrument reflected improvements outlined in *Deliverable D1.1*, including enhanced granularity of usability metrics and additional open-ended prompts for interpretative feedback (Krakowska et al., 2024, pp. 25–27).

This version targeted broader segments of G1 (students and educators) and G2 (artists and art teachers). It was distributed online using a GDPR-compliant platform and collected both quantitative data (via Likert-scale items) and qualitative reflections. Items assessed immersion, accessibility, narrative coherence, perceived educational or expressive value, and user confidence with XR tools.

The structured comparison between workshop-based and remote data allowed for cross-validation of thematic findings and provided a basis for developing differentiated design recommendations across user groups.

7.3 Ethical and Logistical Considerations.

All research activities conducted as part of Task 1.1.3 complied with the ethical standards of the IMPULSE project, as defined in the Data Management Plan (D5.1) and in line with the European Code of Conduct for Research Integrity (ALLEA, 2023). Specific ethical procedures varied depending on the nature of the data collection method and the institution responsible for implementation.

For the participatory UX workshop in Leuven, KU Leuven—being the hosting and organising partner — was responsible for ensuring ethical oversight and procedural compliance related to its specific role. This included:

- informing participants about the use of images and videos taken during the workshop;
- obtaining signed consent forms specifically for GDPR purposes concerning those materials;
- safeguarding participants' rights to withdraw at any point;

The anonymous UX questionnaire used during the session was created by Jagiellonian University (JU) in collaboration with WP2. Since the questionnaire did not involve the processing of personal data, KU Leuven's ethics committee determined that formal ethical approval was not required. The Microsoft Form used to collect the anonymous responses contained information about consent, ensuring that participants were informed about the voluntary nature of their participation and the anonymous handling of their data.

For the surveys and interviews conducted under the leadership of the Jagiellonian University (JU), the following safeguards were implemented:

- Informed consent was collected digitally prior to survey access or interview scheduling;
- Survey responses were fully anonymised, and transcripts were pseudonymised during processing;
- Data were stored on secure, GDPR-compliant institutional servers;
- Only members of the authorised research team had access to raw data;
- The instruments were reviewed internally by JU's ethics liaison for compliance with both institutional and Horizon Europe standards.

All activities followed the principles of voluntary participation, non-intrusiveness, and data minimisation, and were conducted in accordance with the FAIR principles to ensure the findability, accessibility, interoperability and reusability of research data in subsequent tasks (notably D1.3 and WP2 user testing protocols).

8 UX Research Activities and Results

8.1 Participatory UX Workshop (Leuven)

As part of the participatory design strategy adopted in the IMPULSE project, a co-creative UX workshop was conducted at KU Leuven, involving participants from three defined user groups: G1, G2 and G3. Organised by the entire KU Leuven team, including Digit GLAM as part of WP1 and KU Leuven Libraries as the WP3 leader, the workshop constituted a structured and adaptive research intervention designed to explore the narrative, pedagogical, and experiential dimensions of immersive technologies in the context of cultural heritage.

Originally, the session was expected to facilitate direct, scenario-based interaction with the IMPULSE VR prototype. However, due to critical technical malfunctions (described in detail in Section 8.1.2), the workshop was restructured as a hybrid methodological activity, combining speculative co-design, storyboard-based prototyping, affective narrative ideation, and reflective user feedback. This adaptation transformed the session into a valuable dual-purpose exercise, yielding both grounded experiential insights and aspirational design inputs.

8.1.1 Objectives and Structure.

The workshop pursued several interlinked objectives:

- To investigate how digitised 2D historical materials can be creatively recontextualised in a 3D immersive environment;
- To identify opportunities for implementing cross-temporal storytelling and collaborative narration within immersive systems;
- To elicit reflective feedback on user expectations, perceived limitations, and desired affordances;
- To formulate detailed design-oriented recommendations in light of prototype constraints.

Participants were divided into four interdisciplinary teams, each working with selected digital assets from KU Leuven Libraries, including:

- Digitised folios from the Vesalius' annotated Fabrica,
- Glass slides depicting archaeological artefacts, mural fragments, and scientific visualisations,

Each team followed a structured design sequence, including:

- Collaborative scenario building on shared Miro boards;
- Flowchart development and storyboard creation to illustrate potential user pathways and narrative logic;
- Conceptual design discussions focused on user emotion, spatial immersion, and cultural relevance.

Despite the absence of direct system interaction, the participants demonstrated high levels of creative engagement and conceptual immersion. Key outcomes included the emergence of speculative metaphors and interaction motifs such as:

- "Vesalius meets the Egyptian embalmer": suggesting historical cross-temporal dialogue scenarios;
- "From floor plans to embodied rituals": reflecting embodied memory and spatial practice;
- "Personal curation of fragments": foregrounding agency, personalisation, and user-defined meaning-making.

8.1.2 Preliminary Design Recommendations.

Synthesised from group outputs, participant discussions, and facilitator observations, the following initial design recommendations were communicated to the WP2 development team:

- Integrate narrative affordances allowing for object annotation, combination, and storytelling;
- Develop customisable avatars and expressive environmental elements;
- Enhance onboarding processes, feedback cues, and interface legibility;
- Support real-time collaboration and shared presence in immersive space;
- Provide fallback testing modes to safeguard against prototype instability.

8.1.3 Description of the Prototype and Testing Scenarios.

The version of the IMPULSE immersive platform deployed during the Leuven workshop represented an exploratory pre-alpha prototype, developed by WP2. The platform was intended to serve as a web-accessible immersive environment for creative interaction with digital cultural heritage resources, with a particular emphasis on spatial storytelling, object manipulation, and avatar-based navigation.

Built using Unity for the client and PHP for the backend, the prototype offered partial support for modular scene construction, content import, and user navigation via an HTTP

API. The full range of functionalities, including customisation tools, has not yet been implemented as foreseen in the platform work plan.

8.1.4 Functional Overview.

The prototype employed during the workshop in Leuven was characterised by the following characteristics and limitations:

1. Object Importation Module.

- Permitted the import of 2D images (e.g., .jpg, .png) and 3D models, with the ability to project them onto 3D primitives such as boxes, cylinders, and spheres. However, the archives selected for the Leuven workshop contained mostly images, so users didn't have the chance to test the importing of 3D assets;
- Texture mapping was automatic, though often imprecise (e.g. wrapping inconsistencies);
- The platform utilized content from a pre-existing database of assets in supported formats, and did not allow users to upload content in unsupported formats (e.g., .svg). However, the system frequently encountered crashes when handling large files.

2. Scene Construction Interface.

- Enabled users to spatially organise imported objects in a virtual room;
- Supported simple scene adjustments (background colour, object deletion);
- No advanced features such as lighting configuration or audio cues were present.

3. Avatar Representation.

- Provided generic default avatars without any visual or functional customisation;
- Navigation was enabled via keyboard/mouse (for desktop) or handheld VR controllers;
- Lacked gesture control, facial expressiveness, or social presence indicators.

4. Interaction and Navigation Tools.

- Movement in the environment was constrained to basic directional input;
- No teleportation or free-fly modes were supported;
- Interaction logic was minimally documented and frequently unclear to users.

5. Multi-user Functionality (Implemented).

The platform supports synchronous co-presence and navigation in all versions. However, some participants likely did not experience these features during the Leuven workshop due to technical issues preventing them from connecting to the virtual worlds.

6. Metadata and Annotation Features.

- User-applied labels were not supported; the system did not offer functionality for persistent or system-visible labels for other users.

8.1.5 Intended Testing Scenarios and Constraints.

The prototype was intended to support exploratory use cases involving:

- Importing, positioning, and narratively combining digitised cultural materials;
- Navigating through constructed scenes via avatars;
- Experimenting with storytelling configurations and interpretive structures.

Due to network and connectivity issues with the server, most participants were unable to access the platform as intended. While the basic functionality of the prototype was developed and operational, many participants did not have the opportunity to test it. Consequently, the workshop was restructured to focus on:

- Static observation of available prototype functions;
- Externalised narrative design using collaborative tools (see 8.1.1);
- Survey-based reflection on expectations and encountered barriers.

Although not fully operational, the prototype served as an early-stage conceptual framework that participants critically engaged with and reimagined. This stage is **crucial** for identifying and addressing technical issues while exploring design possibilities. The Leuven workshop thus functioned both as an empirical usability probe and a speculative design intervention. The insights generated during this hybrid session directly informed the qualitative UX analysis (see Section 8.1.6) and contributed to refining the functional roadmap for the next iteration, developed by WP2.

8.1.6 Observations, Interactions, and Participant Statements.

Despite the technical issues experienced with the prototype during the Leuven workshop, the data collected from participant interactions, including outputs from Miro boards and discussions on Discord, provided valuable insights into user expectations, challenges, and creative thinking. The workshop was structured in a way that encouraged speculative design and scenario development, which allowed participants to engage creatively with the platform despite its technical limitations

Forms of Interaction Observed.

Forms of interaction were recorded through a combination of facilitator logs, participant feedback, and group reflections. Key interactions observed included:

- VR-based gestures: Due to the lack of headsets or cameras for gesture recognition during the Leuven workshop, users were unable to test gesture-based controls. However, participants did engage with the platform's avatar interactions, such as basic hand movements (e.g., waving) via the available input devices. Technical issues, including movement registration failures and platform instability, limited the effectiveness of these avatar gestures, highlighting the need for more precise feedback on interaction status and improvements in gesture-based avatar control systems.

- Desktop-based interactions: Participants using desktop systems, primarily with keyboard and mouse, made efforts to scale, rotate, and position 2D objects onto 3D primitives. These interactions were often difficult to perform accurately, with many users expressing frustration over precision errors in object placement and manipulation.
- Collaborative storytelling: Participants engaged in collaborative discussions and visual storytelling, often referencing the cultural artefacts provided, such as Pages from Vesalius' annotated Fabrica and Glass slides depicting archaeological sites. Even with limited interaction, usersbuilt narratives based on the objects available.
- Metaphorical expressions: When facing technical challenges or limitations in interaction, participants expressed their conceptual intentions through metaphors like *"time-travel gallery"* and *"curator's dream space"*, which pointed to a desire for creative flexibility and interactive depth that was missing from the current system.
- Workarounds: Users employed various manual workarounds, including sketching narratives on paper or verbally simulating the desired user interactions (such as avatar actions or movement). These adaptive behaviours emphasized the need for more natural interaction paths.

Table 2. UX Themes Observed in Practice.

UX Dimension	Observed Behaviours and Comments
Navigation	Trial-and-error movement; confusion over directional control
Object Interaction	Frequent misplacement, unstable object behaviour, lack of feedback
Avatar Presence	Emotional distance; avatars seen as symbolic rather than embodied
Expressivity	Users mimicked expressions through gestures; desire for affective tools
Co-presence	Absence of voice/chat noted; participants "performed" interactions manually

8.1.7 User Group-Specific Results: G1, G2, G3.

This section provides a comparative analysis of user responses across the three user groups, as defined in D1.1 (G1: students, academic teachers and researchers, G2: artists and art school educators, and G3: cultural and creative industries professionals).

Methodological Approach.

Although the survey data did not explicitly label participants by group, we used a triangulation approach to assign users to these groups based on:

1. Workshop group assignment and participant role (facilitator records),
2. Content of qualitative responses (coded in Annex B),
3. Observed behavioural patterns and narrative engagement during the session.

G1 – Educators, Researchers and Students.

Perceptual Orientation.
G1 participants approached the prototype with a strong need for clarity, onboarding guidance, and reliable pedagogical tools. They expected intuitive controls and an educationally coherent framework.

Key Difficulties:

- Difficulty understanding how to import and manipulate content,
- Lack of scaffolding tools or step-by-step tutorials,
- Frustration with platform instability, especially for users unfamiliar with VR.

Notable Engagement:
G1 participants proposed concrete educational use cases, such as:

- *Anatomy-based learning* using Vesalius drawings,
- *Object-based learning* with artefacts,
- *Speculative interdisciplinary modules* where historical materials were placed in a futuristic narrative.

G2 – Artists, Art Teachers and Creative Practitioners.

Perceptual Orientation.
G2 users saw the platform as an opportunity for creative expression, narrative construction, and emotional immersion. They were most excited by the aesthetic potential of the platform, even though the system was unstable.

Key Difficulties:

- Lack of avatar customisation and expressive presence,
- No tactile feedback when interacting with objects,
- Difficulty simulating time-based narratives, especially in performance scenarios.

Notable Engagement:
Despite the technical limitations, G2 participants imagined:

- *"Ritual reactivation environments"* to engage in immersive cultural practices,
- *"Embodied memory walls"* to allow interaction with 3D representations of fragmented memories,
- *Dramaturgies of fragmented heritage* that allow users to perform narratives.

G3 – Cultural Sector Professionals and Creative & Cultural Industries.

Perceptual Orientation.
G3 participants focused on interpretive fidelity and responsible representation of cultural heritage. They emphasised the importance of contextualised, multi-layered narratives that engage both the user and the artefacts.

Key Difficulties:

- Inability to anchor metadata to objects in the scene,
- Lack of multi-user functionality for collaborative curatorial tasks,
- Concerns about the authenticity and provenance of virtual artefacts.

Notable Engagement:
G3 participants conceptualised use cases, including:

- Personalised digital exhibitions, allowing users to curate collections,
- Fragment-based storytelling, where users add their own interpretation to incomplete historical narratives,
- Visitor-generated narratives, integrating user contributions as part of the interpretive process.

Table 3. Cross-Group Comparative Summary.

Dimension	G1	G2	G3
Primary Expectation	Clarity, educational logic	Expressivity, embodiment	Curation, context, reliability
Reaction to Prototype	Cautious; usability concerns	Imaginative; high tolerance	Analytical; emphasis on structure
Main Barrier	Lack of guidance, instability	Limited expression, missing tools	Incomplete context, insufficient control
Commitment Level	Moderate, conditional	High	High (conditional on functionality)

8.1.8 Storytelling Scenarios and Narrative Prototyping (Leuven Workshop).

As an integral part of the Leuven participatory design process, four interdisciplinary teams engaged in speculative storytelling exercises using selected heritage assets from KU Leuven Libraries' collections. The goal was to explore how diverse user groups (educators, creatives, curators, researchers) conceptualise immersive cultural narratives under conditions of limited technical operability but high conceptual potential.

The storytelling exercises were intentionally conducted in a low-fidelity, speculative mode due to the technical constraints of the prototype (see Section 8.1.2). However, participants engaged deeply with the narrative affordances of 2D and 3D cultural objects, emphasising the potential of immersive experiences for creative exploration and cross-temporal encounters.

Method and Structure.

Each team worked with a dedicated set of curated digital materials. Their tasks included:

- Selecting a central narrative or interpretive path,
- Designing a user journey, interaction flow, or activity scenario,
- Mapping user roles and emotional/aesthetic dynamics,
- Identifying missing functionalities or barriers,
- Reflecting on ethical considerations related to the use of heritage objects.

The data were collected through the use of concept sketches, written vignettes, collaborative flowcharts, and critical reflection documents. The prototype utilised during the workshop in Leuven exhibited the following characteristics and constraints:

Team 1: Ancient Places, Living Heritage.

Planned Materials: digitised glass slides of archaeological sites, including Palmyra, Baalbek, Jerash, and Dendera; floor plans, architectural fragments, excavation images; 3D reconstructions (KU Leuven Workshop – Storytelling, available at https://ujchmura.sharepoint.com/:w:/r/teams/impulsewp1ex-story_group/Shared%20Documents/General/Task%201.1_UserResearch/1.1.3UserStudy(M7-15)/Report%26Research/Workshop_materials/KU%20Leuven%20Workshop%20-%20Storytelling_preparationForLeuven.docx?d=w146c9cd7f4274efdbf3e7a75b0738d26&csf=1&web=1&e=npzGDg).

Original Narrative Concept (based on KU Leuven Workshop – *Storytelling*): This team was invited to reimagine iconic archaeological sites as living, evolving environments. The core prompt encouraged participants to explore how these ancient places – from the grandeur of Palmyra to the intricacies of Dendera – could be transformed into immersive, educational experiences. Using glass slides depicting temple layouts and excavation scenes, the team was guided to construct stories about the rituals, social life, and technological achievements that once animated these spaces. A speculative angle – "What if Palmyra had never fallen?" – invited participants to envision alternate historical trajectories and cultural continuities, using immersive storytelling to bridge the past and the present.

Workshop Execution and Adaptation:

During the session, participants engaged in scenario-building based on these archival materials but also adapted the original brief to foreground the multiplicity of perspectives embedded in archaeological interpretation. Instead of constructing a linear reconstruction of ancient life, the team gravitated towards exploring the fragmented nature of historical knowledge. This led to the creation of a multi-perspective framework, where users could "step into the shoes" of various roles – an archaeologist, a local inhabitant, a 19th-century photographer – each offering partial, situated insights into the same space.

Key Features:

- A role-swapping mechanism, enabling users to explore the same heritage space from distinct socio-historical viewpoints.
- Layered data visualisation: overlapping historical narratives based on different artefactual interpretations.
- A temporal navigation tool, allowing users to trace changes across time – including speculative futures.

Identified Gaps:

- Absence of guided, dynamic perspective-switching functionality (currently requiring manual reinterpretation).
- Need for tools to support layered annotations and multimodal storytelling, especially when navigating conflicting heritage narratives.
- Limited interaction with certain archival materials (e.g., some slides or 3D models remained unused due to time or technical constraints).

User Roles (narrative-based):
In the file entitled "KU Leuven Workshop - Storytelling", the section dedicated to Band 1 contains concrete examples of the narrative application of social or professional roles to represent different perspectives on cultural heritage. The text under consideration comprises the following: *"How can glass slides of temple floor plans, architectural details, or excavation images inspire stories about the rituals, innovations, and people that shaped*

these places?", "An excavation image leads to a story about the rediscovery of forgotten artifacts, or the archaeologists' struggles to preserve them.", "A floor plan of an ancient temple inspires a story about a festival held there.", "What if Palmyra never fell?... How would they have evolved into the present day?" It is evident that these recommendations call upon participants to adopt perspectives, such as those of an archaeologist, a local resident, or a historian. Furthermore, the role of the photographer was proposed as a means of narrating the glass slides, which constituted a primary source material. Although not formally designated as "user roles," these individuals served as narrative test roles, i.e., roles that users were expected to "act out" as part of immersive scenario design.

Roles were assigned as part of the scenario-facilitation strategy and not reflective of participants' real-world identities. These included:

- The Archaeologist: interpreting excavation layers and artefacts.
- The Photographer: capturing and framing heritage through early visual media.
- The Local Resident: offering vernacular, embodied memory of place.
- The Historian: contextualising fragments within broader cultural narratives.

These roles were created to enable multivocal engagement with the content, prompting participants to question how heritage is curated, visualised, and made meaningful across time. The following excerpt is taken from a plan, as well as actual material developed during a two-day workshop in Leuven. The workshop materials are available at the following address: https://ujchmura.sharepoint.com/:f:/r/teams/impulsewp1ex-story_group/Shared%20Documents/General/Task%201.1_UserResearch/1.1.3UserStudy(M7-15)/Report%26Research/Workshop_materials?csf=1&web=1&e=yB1SG4

Team 2: Anatomy of Discovery.

Planned Materials:

Vesalius manuscript (Vesalius' annotated *De humani corporis fabrica*) pages; digitised slides of anatomical drawings and mummified bodies; historical anatomical illustrations; references to early medical practices and dissection techniques (*KU Leuven Workshop – Storytelling*).

Original Narrative Concept (based on *KU Leuven Workshop – Storytelling*): Team 2 was invited to explore the evolution of anatomical knowledge and medical visualisation through immersive storytelling. The core narrative prompt centred on the intersection between historical medical representations – from Vesalius' anatomical drawings to glass slides of preserved specimens – and contemporary understandings of the human body. Participants were encouraged to reflect on how these static, two-dimensional materials could be reimagined in a tactile, spatial, and affectively engaging

manner within a virtual environment. A critical speculative scenario – *"What if Vesalius had been a woman?"* – prompted reflection on gender, authority, and representation in the history of medical knowledge.

Workshop Execution and Adaptation:

During the Leuven workshop, participants interacted with digitised historical materials including Vesalius's illustrations and interpretive texts describing early dissection practices. The original narrative was expanded beyond anatomical linearity to include culturally and temporally layered understandings of the body. Participants created spatial scenarios juxtaposing precision-driven scientific visualisation with affective and embodied interpretations. Rather than presenting dissection as a solely clinical act, the team staged epistemic encounters between historical anatomists and contemporary users, interrogating the pedagogical and ethical dimensions of visualising the human body. A modular narrative structure emerged, reflecting episodic transitions between past, present, and speculative futures – including Egyptian embalming rituals and futuristic anatomy labs, as described in the storyboard (*Storyboarding_Leuven_Workshop.docx* available at https://ujchmura.sharepoint.com/:w:/r/teams/impulsewp1ex-story_group/Shared%20Documents/General/Task%201.1_UserResearch/1.1.3UserStudy(M7-15)/Report%26Research/Workshop_materials/Storyboarding_Leuven_Workshop.docx?d=wf1a50d6c2297479e8955813bcce8f32e&csf=1&web=1&e=TWzOh5).

Key Features:

- Layer-based interaction system to simulate the uncovering of anatomical structures in a controlled pedagogical sequence.
- Hotspot-driven annotations linking specific body parts with historical uses or cultural-symbolic meanings.
- Timeline interface contextualising Vesalius' work in a longue durée trajectory of anatomical inquiry.

Identified Gaps:

- Limited collaborative functionalities, constraining simultaneous user annotation or discussion during anatomical exploration.
- Incomplete 3D anatomical modelling, including surface detail and depth limitations which reduced embodied realism.
- Lack of gender perspective integration, particularly tools supporting speculative re-narration of scientific authorship and representation.

User Roles (narrative-based):

Drawing on the participatory strategy outlined in the *KU Leuven Workshop – Storytelling* document and implemented analogously to Team 1, the roles in Team 2 were designed

as narrative testing roles. They enabled participants to assume epistemic and interpretive positions vis-à-vis the anatomical materials. These roles were not reflective of the participants' actual professions but were assigned to stimulate diverse perspectives within the immersive scenario.

Cited inspirations include narrative questions such as: *"What stories do these slides tell about early scientific inquiry?"* and *"How can educators use these virtual spaces to create interactive and engaging lessons?"* (*Team2_AnatomyOfDiscovery file* available at https://ujchmura.sharepoint.com/:b:/r/teams/impulsewp1ex-story_group/Shared%20Documents/General/Task%201.1_UserResearch/1.1.3UserStudy(M7-15)/Report%26Research/Workshop_materials/Team2_AnatomyOfDiscovery.pdf?csf=1&web=1&e=QfFfMY). *T*he following excerpt is taken from a plan, as well as actual material developed during a two-day workshop in Leuven. The workshop material is available at the following address https://ujchmura.sharepoint.com/:f:/r/teams/impulsewp1ex-story_group/Shared%20Documents/General/Task%201.1_UserResearch/1.1.3UserStudy(M7-15)/Report%26Research/Workshop_materials?csf=1&web=1&e=yB1SG4).

Assigned roles included:

- The Anatomist: Interprets the dissection and visualisation of the human body; engages with Vesalius's materials to trace early scientific practices.
- The Medical Student: Learns through exploratory interaction with anatomical environments; serves as a proxy for contemporary educational uses.
- The Historian of Medicine: Contextualises materials within broader trajectories of medical epistemology, highlighting shifts in knowledge paradigms.
- The Speculative Scientist: Questions canonical narratives and explores alternative scenarios (e.g., gendered authorship in early anatomy).

These roles provided a multivocal narrative framework, enabling layered engagement with the material. The team used them to articulate differentiated user experiences and to test the pedagogical capacity of the VR space for diverse epistemic identities. The following excerpt is taken from a plan, as well as actual material developed during a two-day workshop in Leuven. The workshop material is available at the following address mentioned above.

Team 3: Reimagining Ancient Storytelling.

Planned Materials:

A curated selection of digitised glass slides depicting murals, reliefs, and mythological scenes from various ancient cultures, including Roman, Egyptian, and other Mediterranean civilisations. Artefacts include visual narratives such as Biblical stories in Roman murals and funerary imagery in Egyptian tombs. The objects are designed to reveal how ancient peoples encoded myths, religious ideas, and historical events into universal visual languages (*KU Leuven Workshop – Storytelling*; *IMPULSE Team 3.docx* available at https://ujchmura.sharepoint.com/:f:/r/teams/impulsewp1ex-story_group/Shared%20Documents/General/Task%201.1_UserResearch/1.1.3UserStudy(M7-15)/Report%26Research/Workshop_materials?csf=1&web=1&e=RXdmGX).

Original Narrative Concept (based on *KU Leuven Workshop – Storytelling*): This scenario invited participants to explore the role of visual storytelling across ancient civilisations and to reimagine how narratives were crafted, interpreted, and transmitted across different audiences and cultures. Central questions included: *How did murals and reliefs function as universal narratives? What if artists from different cultures collaborated on a shared visual story?* Participants were encouraged to craft immersive, layered stories inspired by fragments of ancient art, using speculative reconstructions and cross-cultural dialogues. The idea was not to reproduce history literally but to creatively re-envision how ancient storytelling might have transcended linguistic and cultural barriers. A speculative scenario proposed imagining a collaborative mural between a Roman and an Egyptian artist, merging symbolic systems to create a hybrid narrative world.

Workshop Execution and Adaptation:

Team 3 approached the materials not as static records but as dynamic storytelling opportunities. Participants explored how juxtaposition, sequence, and perspective could reshape the viewer's journey through ancient narratives (*Exploring Key Spatial Storytelling Techniques.docx* available at https://ujchmura.sharepoint.com/:w:/r/teams/impulsewp1ex-story_group/Shared%20Documents/General/Task%201.1_UserResearch/1.1.3UserStudy(M7-15)/Report%26Research/Workshop_materials/Exploring%20key%20spatial%20storytelling%20techniques.docx?d=w8e3a64f05a5e4da28df4b0ba66f2688f&csf=1&web=1&e=gsxovT). Techniques such as layering, scaling, and shadow projection were employed to build fragmented, non-linear experiences where the audience could assemble meaning through movement, interaction, and emotional resonance.

Special emphasis was placed on the use of light, transparency, and shifting perspectives: users could zoom into fragments, reveal hidden layers, or navigate between overlapping temporalities and cultural viewpoints. Narrative openness — where stories unfold differently depending on the path taken — became a central feature of the immersive design.

Key Features:

- Juxtaposition and sequencing to generate emergent storytelling from mural fragments and artefacts.
- Dynamic light and shadow manipulation, enabling users to experience different emotional tones and narrative layers.
- Perspective-switching mechanisms, allowing navigation between cultural viewpoints and story threads.
- Speculative co-creation tools, inviting participants to imagine intercultural collaborations through interactive visual compositions.

Identified Gaps:

- Absence of collaborative real-time editing, preventing multiple users from layering or editing narratives together simultaneously.
- Limited emotional scaffolding, restricting the system's ability to represent affective dimensions such as reverence, mystery, or wonder.
- Lack of frameless exploration tools, inhibiting free-form narrative construction across visual artefacts.

User Roles (narrative-based):

Following the narrative facilitation model used in all teams, user roles in Team 3 were conceptualised as speculative personas designed to explore the dynamics of ancient storytelling through visual and spatial means, not as reflections of participants' real professions. These roles enabled participants to interpret, reframe, and transform ancient narratives creatively.

Roles included:

- Story Weaver: Constructs speculative, layered stories from fragmented visual materials, weaving cross-cultural myths and themes.
- Shadow Caster: Uses light, scale, and perspective to animate murals and reliefs, shifting emotional tones and focal points.
- Memory Keeper: Archives emergent interpretations and fragments, reflecting on the evolution and transmission of stories across time.
- Light Architect: Designs the spatial environment of light and shadow, enabling dynamic storytelling encounters.

These narrative-based roles supported the exploration of multiple interpretive layers, embodying the guiding idea: *"How might ancient artists have created stories that spoke across cultures, and how can we today reimagine these encounters in an immersive world?"* (*KU Leuven Workshop – Storytelling* available at https://ujchmura.sharepoint.com/:w:/r/teams/impulsewp1ex-story_group/Shared%20Documents/General/Task%201.1_UserResearch/1.1.3UserStudy(M7-15)/Report%26Research/Workshop_materials/KU%20Leuven%20Workshop%20-%20Storytelling_preparationForLeuven.docx?d=w146c9cd7f4274efdbf3e7a75b0738d26&csf=1&web=1&e=zxn8TE.

Team 4 (Virtual): Echoes of Encounters.

Planned Materials:

A curated selection of digitised glass slides and composite artefacts depicting intersections of cultures across time: hybrid temple architectures, Roman-Egyptian sculptures, Greco-Islamic medical illustrations, and fictionalised reconstructions of intercultural exchange. Several slides suggest moments of transmission, adaptation, or hybridisation – such as Vesalius' drawings influenced by Islamic anatomical knowledge, or archaeological fragments showing stylistic fusion between Mediterranean civilisations (*KU Leuven Workshop – Storytelling*; *Team4_EchoesOfEncounter.docx* at https://ujchmura.sharepoint.com/:f:/r/teams/impulsewp1ex-story_group/Shared%20Documents/General/Task%201.1_UserResearch/1.1.3UserStudy(M7-15)/Report%26Research/Workshop_materials?csf=1&web=1&e=Hnf4jz).

Original Narrative Concept (based on *KU Leuven Workshop – Storytelling*):

This scenario explored what happens when cultures meet – intellectually, symbolically, and materially. Rather than focusing solely on individual artefacts, Team 4 sought to bring to life the *encounter* itself. Central questions included: *What if two cultures met in a virtual space for the first time? Could Vesalius debate with an embalmer? How might a Roman architect and a Tang dynasty engineer discuss form and function?*

Participants were invited to design immersive, dialogic narratives that transcended temporal and geographic borders. The VR environment became a speculative agora, where historical figures or their epistemic legacies could "speak" across civilisations. The concept moved fluidly between real objects and imagined interactions, emphasising syncretism, influence, and shared symbolic systems.

Workshop Execution and Adaptation:

Team 4 interpreted the prompt not as a linear reconstruction of a historical event, but as a dynamic space of creative cultural synthesis. Workshop participants interacted with artefacts depicting syncretic aesthetics (e.g., Greco-Egyptian temples), while also generating speculative scenes of intercultural dialogue. They reimagined the virtual museum as a *threshold space* for cultural memory, where timelines are porous and meaning is co-constructed. Emphasis was placed on the affective dimension of intercultural transmission — the emotional tone of cultural exchange, whether curiosity, reverence, misunderstanding, or wonder. Some teams used fictionalised avatars of scholars or artists to represent traditions in conversation, while others embedded “what if” speculative moments into object-based interaction flows.

Key Features:

- Intercultural dialogue simulation, where historical figures or traditions meet in virtual space to discuss, debate, or co-create.
- Narrative layering, combining visual evidence (slides, artefacts) with speculative reconstructions of encounters.
- Dynamic object interpretation, allowing artefacts to be seen from multiple civilisational perspectives (e.g. anatomical vs ritual vs architectural).

Identified Gaps:

- Absence of predefined dialogue scaffolding, limiting users' ability to script or branch intercultural interactions in real time.
- Lack of automated cultural referencing, such as annotations revealing hybrid styles, intellectual borrowings, or translational motifs.
- Limited modelling of emotional dynamics, such as tension, empathy, or ethical disagreement between traditions.

User Roles (narrative-based):

As in Teams 1–3, user roles in Team 4 were not professional identities, but speculative, narrative personas designed to test the interpretive and interactive potential of cross-cultural scenarios. Drawing on the plan's suggestion (*"What if Vesalius met an embalmer?"*), the roles focused on performative dialogue and cultural positioning.

Roles included:

- The Anatomist-Scholar: Brings empirical, text-based traditions into dialogue; represents European scientific rationality shaped by intercultural antecedents.
- The Ritual Practitioner: Embodies situated, embodied knowledge of healing or sacred symbolism; brings intuitive and symbolic interpretation.
- The Architect-Historian: Interprets material culture and design as reflective of civilisational values; traces continuity and innovation across styles.
- The Mediator: Bridges traditions; contextualises conflicts and commonalities between knowledge systems; invites reflective spectatorship.

These narrative-based user roles were used to explore epistemic pluralism and simulate creative friction between historical perspectives. As noted in the plan, *"Participants can explore how virtual spaces amplify creative dialogue across time and place.". T*he following excerpt is taken from a plan, as well as actual material developed during a two-day workshop in Leuven. The workshop material is available at the following address https://ujchmura.sharepoint.com/:f:/r/teams/impulsewp1ex-story_group/Shared%20Documents/General/Task%201.1_UserResearch/1.1.3UserStudy(M7-15)/Report%26Research/Workshop_materials?csf=1&web=1&e=NXlKRP.

Note on User Roles and Source Materials:

The user roles assigned in Teams 1–4 were designed as part of the preparatory work conducted by the KU Leuven team to facilitate immersive narrative testing during the workshop. These roles do not necessarily reflect the actual professional backgrounds of participants but were created to enable scenario-based exploration of intercultural and epistemic narratives. Additionally, the references to medical and anatomical materials in Team 2 are based strictly on the digitised resources and historical materials provided during the workshop sessions. This clarification ensures consistency and accuracy across all deliverables and aligns the terminology used for user roles and workshop content.

Table 4. Summary Table: Narrative Prototypes and User Roles in VR Storytelling.

Team	Materials	Narrative Focus	Key Features	User Roles (Narrative-based)	Identified Gaps
1 *Ancient Places, Living Heritage*	Archaeological slides (Palmyra, Baalbek, Jerash, Dendera); excavation images, floor plans	*"Seeing as others saw"* — interpreting historical sites from diverse social and temporal perspectives	Role-swapping across historical personas; layered visual interpretation; contextual timeline	Archivist, Photographer, Historian, Local Inhabitant	Limited multi-perspective switching; no dynamic annotation
2 *Anatomy of Discovery*	Vesalius' anatomical drawings; digitised mummified bodies; early medical illustrations	*"Unfolding the Body"* — reimagining anatomical visualisation through layered, affective VR interaction	Layer-based anatomy interaction; timeline narrative; speculative authorship module	Anatomist, Medical Student, Historian of Medicine, Speculative Scientist	Incomplete 3D modelling; limited collaborative tools; no gender-sensitive narrative scaffolding
3 *Reimagining Ancient Storytelling*	Glass slides with murals, reliefs, mythological scenes (Roman, Egyptian); narrative fragments	*"Voyages through Shadows and Fragments"* — creating nonlinear, participatory visual narratives	Projection mapping; dynamic light and shadow; narrative layering; perspective shifting	Story Weaver, Shadow Caster, Memory Keeper, Light Architect	No real-time collaborative editing; limited emotional scaffolding; absence of frameless exploration tools
4 *Echoes of Encounters (Virtual)*	Glass slides and composite artefacts showing cross-cultural	*"When Cultures Meet"* — speculative dialogue and	Intercultural dialogue simulation; dynamic object	Anatomist-Scholar, Ritual Practitioner, Architect-	No dialogue scaffolding; weak cultural referencing; limited

	exchange (e.g. Roman-Egyptian, Greco-Islamic); fictionalised encounters	visual hybridity in VR	interpretation ; narrative blending	Historian, Mediator	modelling of emotional dynamics

This summary table integrates both the planned narrative scenarios outlined in the KU Leuven Workshop – Storytelling document and the actual activities undertaken during the participatory sessions implemented in different documents available at: https://ujchmura.sharepoint.com/:w:/r/teams/impulsegeneral_group/_layouts/15/Doc.aspx?sourcedoc=%7BE6ABD907-DD51-4FFB-AF10-03053278F250%7D&file=KU%20Leuven%20Workshop%20-%20Storytelling.docx&action=default&mobileredirect=true.

The user roles presented were conceptualised as part of the workshop facilitation strategy and should be interpreted as narrative constructs rather than direct reflections of participants' real-world professions. The identified gaps reflect both technical limitations observed during the sessions and conceptual improvements proposed by participants. Key Insights and Design Recommendations

Key insights and design recommendation.

The following key insights and design recommendations synthesise the findings from the workshop, focusing on the collaborative features, narrative depth, and other essential elements of the immersive environments developed by the teams. These recommendations have been derived from the comparative analysis of the user responses, the core features identified, and the gaps that emerged during the workshop. They are intended to guide the next phases of development and ensure that the prototype better aligns with user expectations and requirements.

Collaborative Features.

A fundamental insight from all teams is the importance of collaborative features for co-curation and role-based interaction. Users across all groups highlighted the need for tools that enable collective narrative-building and interpretation. This feedback suggests that real-time multi-user functionality should be prioritised in future iterations to facilitate co-narration, shared engagement, and collaborative exploration of the virtual environments. The ability to work together as a group will enhance the immersive experience and provide users with a sense of collective agency in shaping the narratives.

Narrative Depth.

Users from all groups expressed a shared desire for increased narrative depth, which can be achieved by offering multiple layers of meaning, such as historical context, cultural

interpretation, and creative expression. Participants want the system to support non-linear storytelling that allows for flexible and multifaceted narrative exploration. This feature will help users engage with content in a more meaningful way, enabling them to interact with stories from diverse perspectives. Incorporating tools that support branching narratives or user-driven content exploration will further enhance the immersive experience.

Expressive Affordances.

Users highlighted the importance of expressive affordances, such as avatar customisation and multi-sensory feedback (e.g., spatial sound), to deepen emotional engagement and embodiment within virtual environments. These features will enable users to feel more connected to the virtual content, facilitating a more immersive experience. Future development should explore the integration of these features to enable users to fully embody their roles within the immersive world, further enhancing their sense of presence and interaction with the content.

Ethical Considerations for G3.

Ethical considerations, especially for G3 (cultural heritage professionals), were identified as crucial for the platform's success. G3 participants emphasized the need for responsible representation, metadata integration, and provenance tracking to ensure the integrity and authenticity of cultural heritage experiences. As these professionals work with sensitive cultural data, it is essential to provide accurate, reliable, and ethical representations within the platform. Future iterations of the system should incorporate robust provenance tracking systems, detailed metadata, and guidelines for ethical representation to foster trust and reliability in virtual heritage experiences.

8.1.9 Leuven Workshop UX Survey: Analysis and Findings.

The UX survey was conducted during the Leuven workshop to evaluate the user experience (UX) of the IMPULSE VR prototype. The survey aimed to capture participant feedback regarding the usability of the platform, technical issues encountered, and user expectations for future functionalities. The questionnaire was designed to provide both quantitative data (through Likert scale questions) and qualitative data (through open-ended responses), allowing for an in-depth understanding of the users' experiences and challenges.

The survey results are based on the feedback from the participants who tested the prototype, with a focus on identifying:

- Usability issues and challenges faced by participants.
- Expectations for additional features and missing functionalities.
- Meta-level reflections and experiential insights shared by users during the testing.

The survey included both closed-ended and open-ended questions:

1. Quantitative Section:
    a. Likert scale questions to assess the platform's usability, intuitiveness, and engagement.
    b. These questions focused on areas like ease of navigation, satisfaction with the interface, system responsiveness, and overall user engagement.
2. Qualitative Section:
    a. Open-ended questions allowed participants to provide detailed feedback on specific issues encountered, including:
        i. Problem description: Where users could describe any problems they faced during interaction.
        ii. Wanted functionalities: A section where participants suggested desired features or improvements.
        iii. Additional comments: A final section for users to offer further insights or reflections on their experience with the platform.

The primary aim of the UX survey conducted during the Leuven workshop was to gather user feedback on the IMPULSE VR prototype. The survey targeted key usability aspects and user experience elements, specifically focusing on usability issues, user expectations, and desired functionalities. The survey also explored meta-level reflections regarding the system's design and overall user experience.

Objective of the Questionnaire:

The questionnaire was designed to achieve two primary objectives: first, to ascertain users' expectations, challenges, and experiences with immersive cultural heritage environments, and second, to explore how these environments can be adapted to meet diverse user needs. It consisted of both closed and open-ended questions, aimed at gathering insights into usability, content engagement, emotional response, and potential barriers to interaction.

The overarching goal of the questionnaire was two-fold: to provide a comprehensive understanding of users' perceptions and to gather valuable data for the refinement of the prototype. Aligning these objectives ensured a unified research agenda, facilitating a more holistic analysis. This approach enables the findings to directly contribute to improving the user experience and guiding the platform's development.

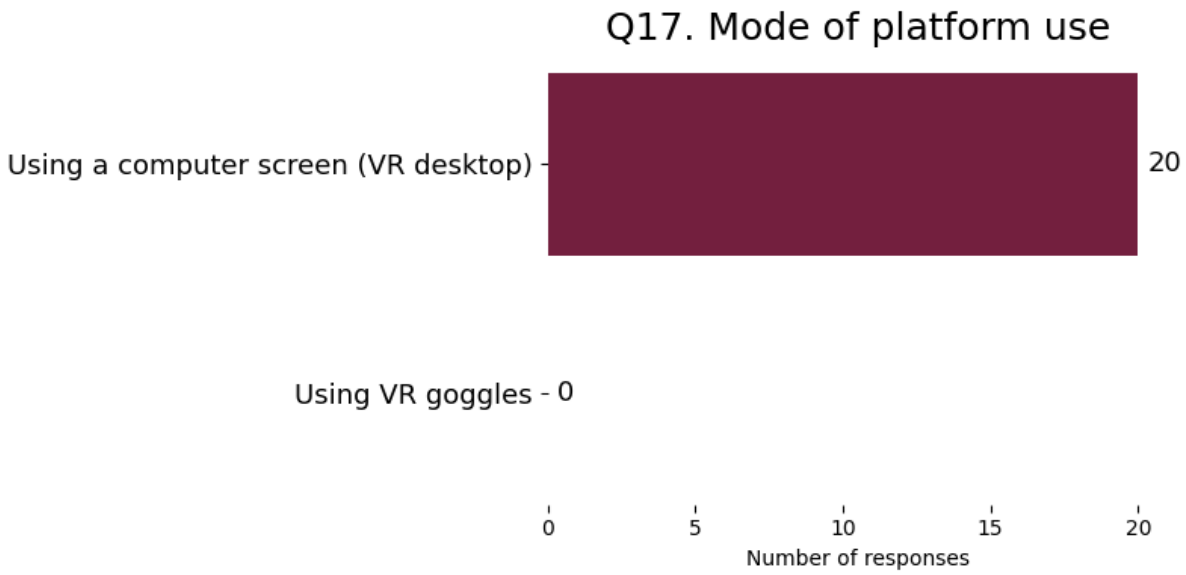
This survey complements the quantitative data and thematic coding from the structured questions, offering additional insights into user experience through open-ended responses. The data for thematic analysis was derived from three open-ended questions embedded in the user testing form:

1. Problem description – An open-text field where participants could describe any issues encountered during testing.
2. Wanted functionalities – A question asking for suggestions on desired features or improvements.
3. Additional comments – An optional space for further reflections or unsolicited feedback.

Out of 20 total participants, 17 provided substantive responses across these three fields, resulting in 23 unique open-ended statements that were carefully analysed.

According to responses to question Q17 (Fig.1), none of the participants experienced the platform using VR goggles. All respondents declared using the desktop VR version. However, this result should be interpreted with caution. The questionnaire did not offer alternative response options, despite the fact that unexpected and significant technical issues limited access to the platform. As a result, some participants were only able to experience the platform through a projector-based presentation, while others—those who managed to log in—interacted with the platform via their personal computers.

Fig. 1. Mode of use of the platform (prototype).

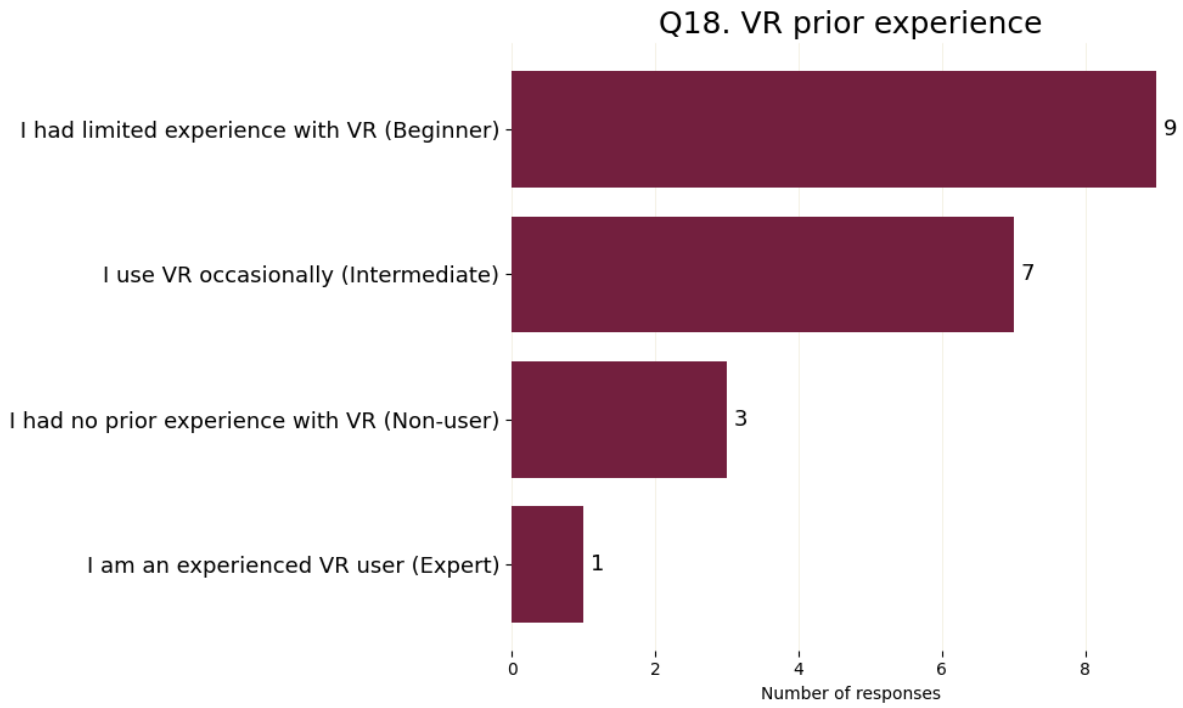


Responses to question Q18, which asked participants about their prior experience with virtual reality, indicate that the majority had limited or occasional exposure to VR:

- 9 respondents reported limited experience with VR (Beginner),
- 7 respondents selected I use VR occasionally (Intermediate),
- 3 respondents indicated no prior experience with VR (Non-user),
- Only 1 respondent identified as an experienced VR user (Expert).

These results suggest that most participants had little to moderate familiarity with VR technology prior to the test session. This limited background may have shaped how users approached the prototype and perceived its usability, especially in light of the technical difficulties encountered during testing.

Fig. 2. Users' prior VR experience.



Methodological approach for quantitative analysing closed-ended responses.

The analysis followed a multi-step procedure, outlined below to ensure clarity, transparency, and reproducibility of the quantitative processing of closed-ended survey data.

1. Data preparation and transformation:

- Survey responses were exported from Microsoft Forms into an Excel file.
- The Excel file was loaded into a dataframe using the *pandas* library in a Google Colab environment.
- Column headers, originally derived from full survey questions, were shortened for clarity and analytical consistency while maintaining semantic accuracy.
- Column headers were also translated from Polish (the default language of the university's Microsoft Forms account) into English to facilitate presentation to an international audience.
- Empty columns such as *Email address* and *Name*, automatically generated by Forms but unused in the survey, were removed.

- Multiple-choice responses (e.g., to questions such as *Difficulties importing 2D content*, *Changing size difficulties*, *Movement difficulties*, *Difficulties aspects*, and *Wanted functionalities*) were split into separate entries while retaining record IDs. These were stored in separate sheets within the same Excel file.

2. Preparing for visualization:

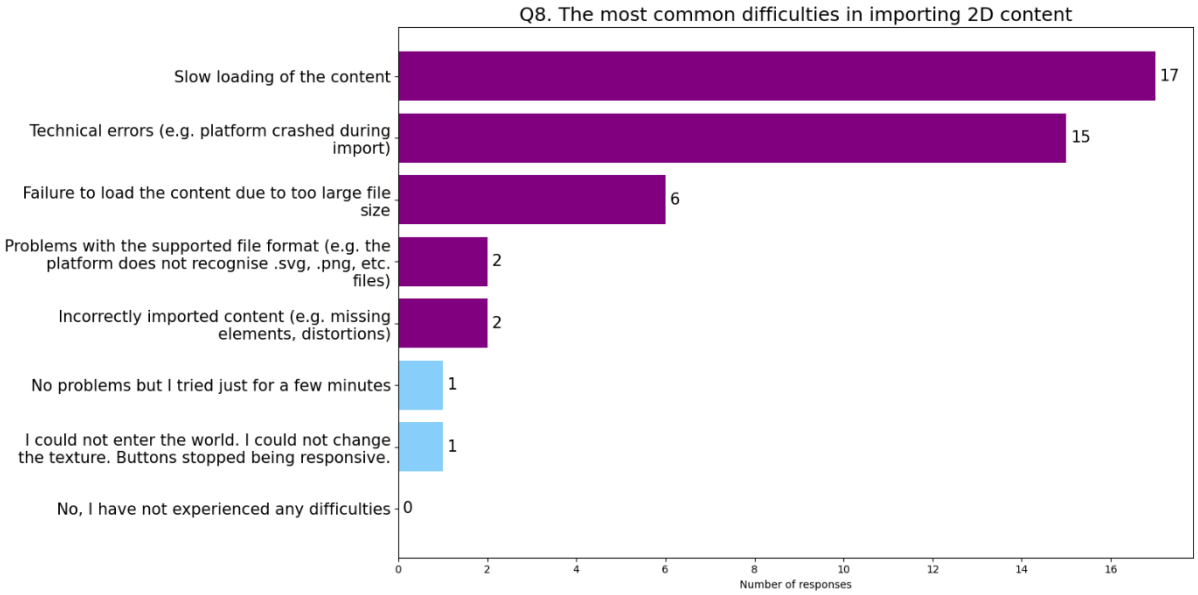
- The number of responses for each answer option was counted.
- All possible response options for each question were re-imported to ensure that even unselected answers (with zero responses) would be included in visualizations.
- For questions using a 7-point scale to evaluate selected attributes, both the distribution of responses and the average deviation from the neutral midpoint (value 4) were calculated and visualized.

3. Visualization:

- Visualizations were created using the matplotlib library.
- Each graph included clearly labelled axes, informative titles, data labels, and a layout designed for ease of interpretation.
- All charts were generated in Google Colab and exported in PNG format.

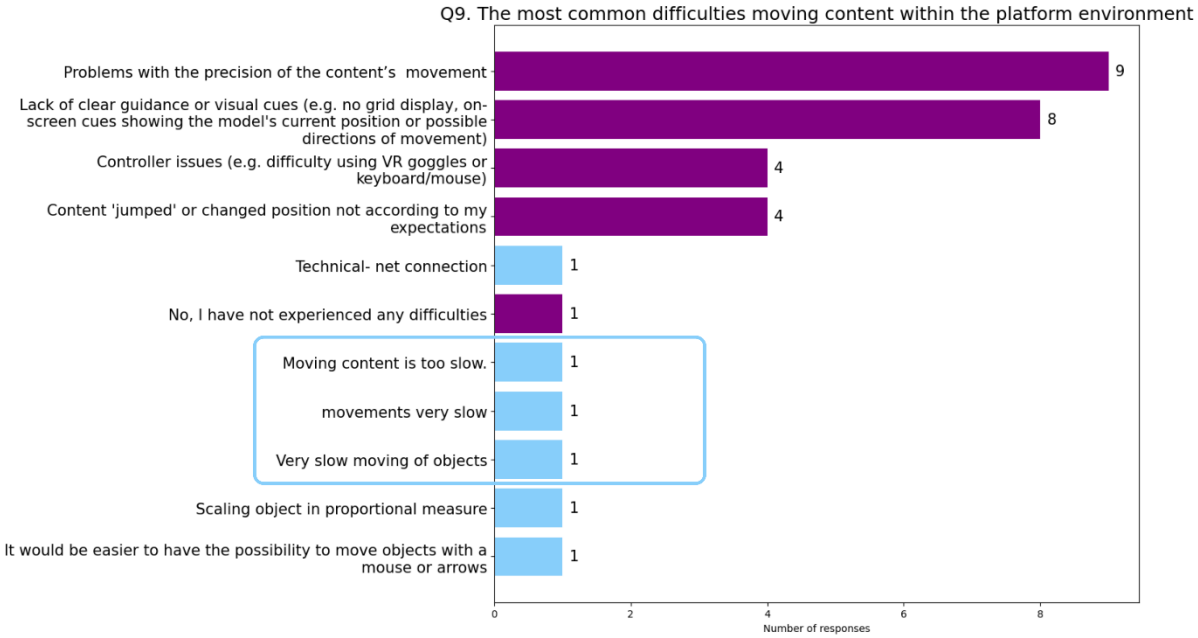
The responses are presented below, grouped by individual survey questions. Answers that respondents entered themselves after selecting the *"Other"* option are marked in blue.

Fig. 3. The most common difficulties with the import of 3D models.



The analysis of responses to question Q8 indicates that the most frequently reported issues when importing 2D content were slow content loading (reported by 17 out of 20 respondents) and technical problems with the platform (reported by 15 out of 20 respondents).

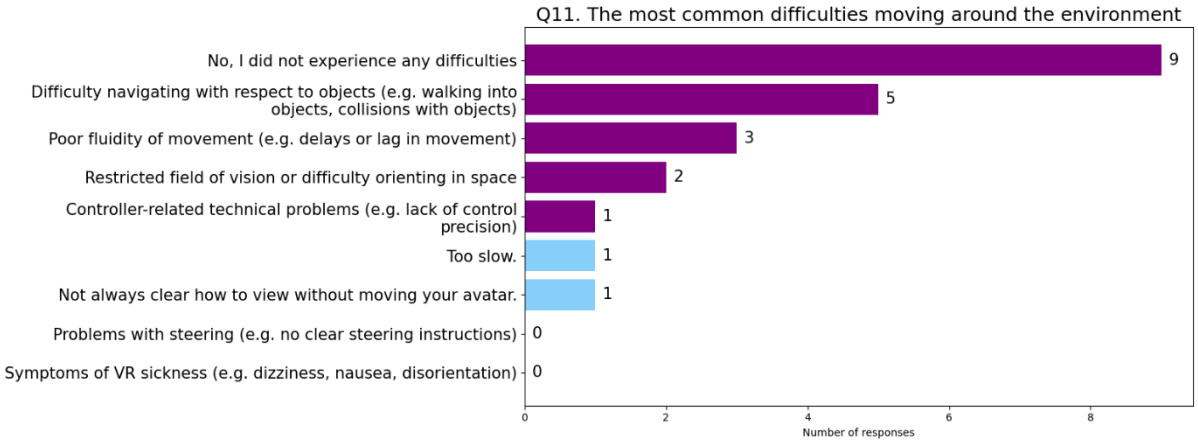
Fig. 4. Most frequent difficulties in moving content with platform landscape.



Issues related to the platform's slow performance were also noted by respondents answering question Q9, which addressed difficulties with moving content within the environment. Three participants chose to highlight this problem by entering it manually in the text field provided under the *"Other"* option.

The most frequently reported difficulties in this category (Q9) concerned the precision of content movement (reported by 9 out of 20 respondents) and the lack of guidance on the direction in which content should be moved (8 out of 20). Additional challenges included problems with controlling content using the keyboard (4 out of 20), and a suggestion that moving objects with a computer mouse or arrow keys would be more intuitive (1 out of 20). Unpredictable behaviour of objects was also mentioned (4 out of 20). Moreover, individual responses pointed to technical issues such as unstable internet connection and difficulties with proportionally resizing objects. One participant reported no difficulties related to the aspects addressed in Q9.

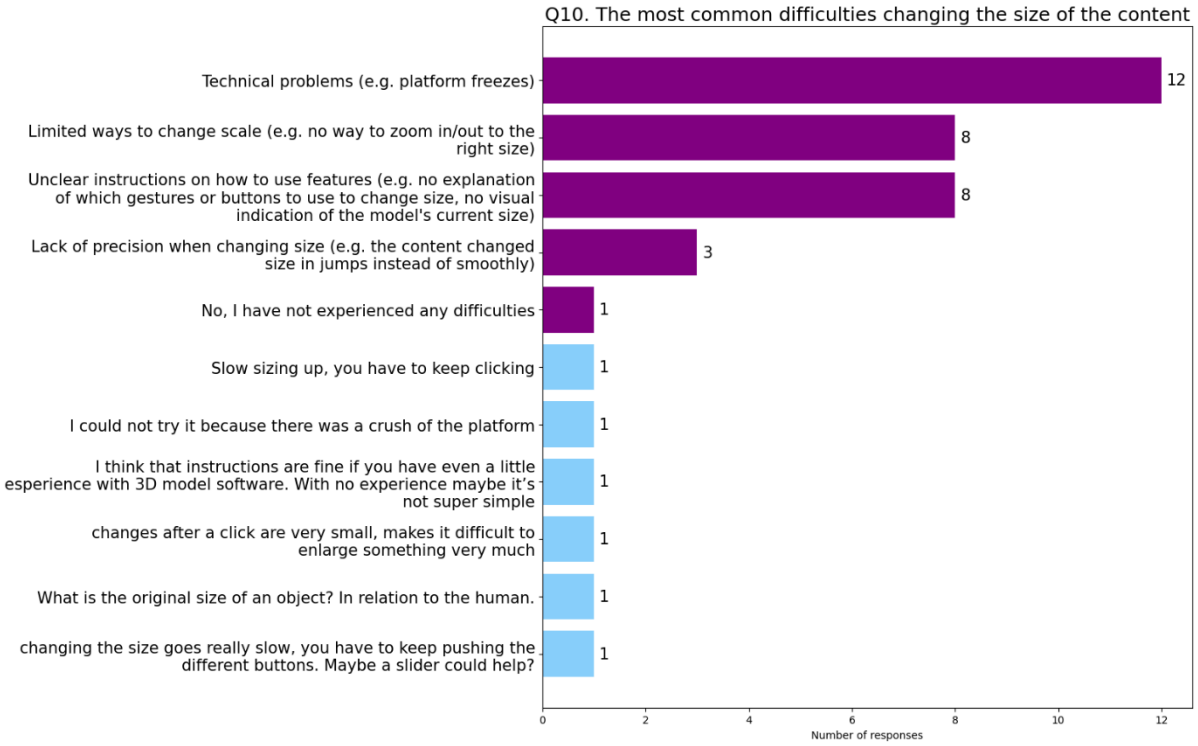
Fig. 5. The most common problems with platform movement.



In response to question Q11, the majority of participants reported no difficulties with navigating the platform. However, this result should be interpreted with caution due to technical issues that significantly limited free access to the platform. Similar caution is advised when interpreting the lack of responses indicating difficulties with controls. The absence of reports related to VR sickness should also be considered in context, as none of the participants had the opportunity to experience the platform using VR headsets.

The most frequently reported issues related to Q11 included problems with navigation in relation to objects (5 out of 20), poor fluidity of movement (3 out of 20), and overly slow movement speed (1 out of 20), as well as a limited field of view or difficulty orienting in space (2 out of 20), and once again, issues with movement precision (1 out of 20).

Fig. 6. Most common difficulties in resizing content.

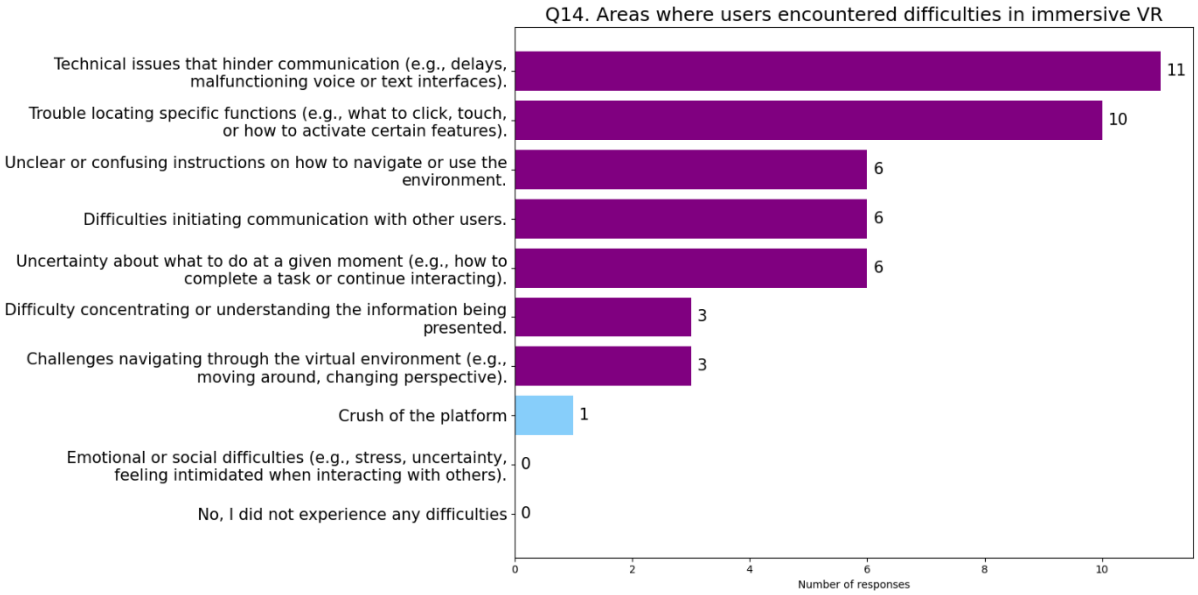


Regarding difficulties related to resizing content (Q10), the most frequently reported issues were technical problems with the platform (12 out of 20 respondents), limited options for adjusting content size (8 out of 20), and unclear instructions on how to use specific functionalities (8 out of 20).

Among the open-text responses, participants suggested two improvements: first, a resizing slider to make it easier to adjust the size of the object; and second, a way to indicate the original size of the object in comparison to the average size of a human, represented by the avatar. However, this latter option was not feasible during testing in Leuven due to the content upload procedure adopted there: participants selected a block from a set of basic 3D shapes, which could then be textured with 2D content. As a result, it was not possible to upload 2D content in its original dimensions relative to the avatar's size.

The suggestion regarding the original size of the object highlights a piece of information that was considered important by the participants. Therefore, this feature should be considered in future development work or recommendations for cultural institutions creating their own platforms and engaging in digitisation efforts.

Fig. 7. Areas where users have struggled with immersive VR.

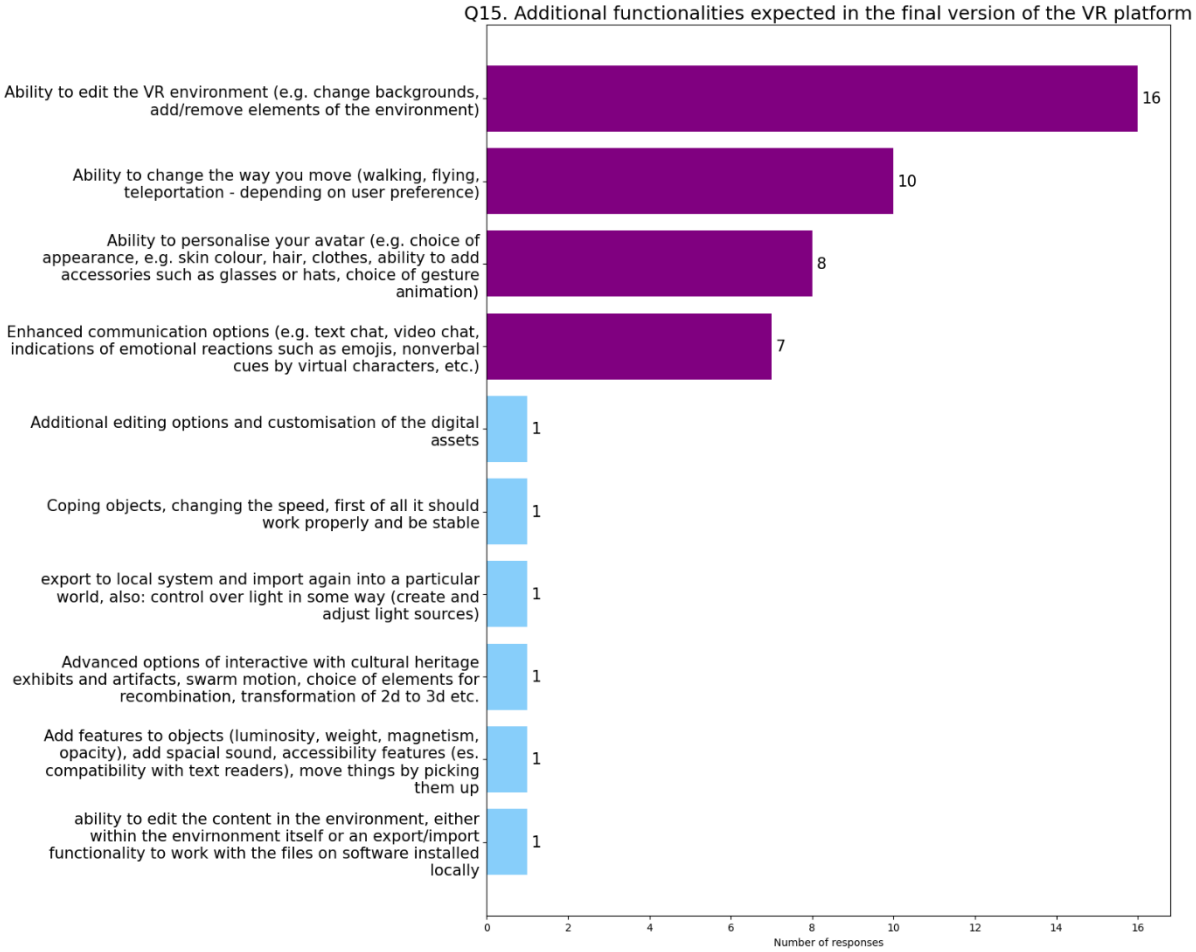


Question Q14 allowed respondents to provide a summary indication of the aspects of interaction with the prototype in which they experienced difficulties.

The most frequently reported issues included technical problems (11 out of 20, plus 1 additional response under the *"Other"* option), difficulties in locating specific functions (e.g., knowing what to click on) (10 out of 20), unclear instructions and uncertainty about what actions to take to achieve a given outcome (6 out of 20 each), as well as difficulties establishing communication with other users (6 out of 20).

No emotional or social difficulties were reported. However, it should be noted that the version of the prototype tested in Leuven lacked extensive functionalities in this area — participants could see other avatars (when the platform was functioning properly) and potentially greet them by waving their avatar's hand, but no more advanced interaction features were available.

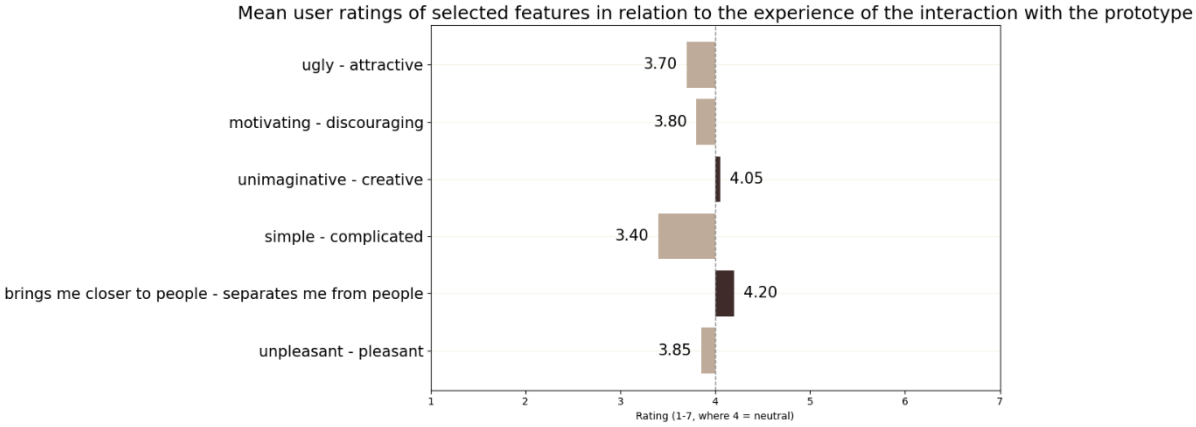
Fig. 8. Expectations for additional functionalities in the final version of the VR platform.



In response to the question about expected functionalities that, according to participants, should be included in the final version of the platform (Q15), as many as 6 respondents chose to provide their own suggestions. These open-text answers form the basis for the thematic analysis presented below.

Among the closed-ended options, the most frequently requested features included the ability to edit the VR environment (16 out of 20), the option to change the mode of movement (10 out of 20), avatar personalization (8 out of 20), and enhanced means of interacting with other users (7 out of 20).

Fig. 9. Average user ratings of selected features related to prototype interaction experience.



In relation to the evaluation of selected attributes, the average ratings presented in the figure reveal how participants positioned their impressions along various bipolar scales (1–7, where 4 represents a neutral midpoint).

Overall, the ratings are relatively close to the neutral midpoint (4.0), indicating a generally balanced or ambivalent perception of the prototype. The most positively evaluated attribute was simplicity (simple – complicated, M = 3.40), showing the greatest deviation from neutrality in a favourable direction. Conversely, the lowest-rated aspect was visual aesthetics (ugly – attractive, M = 3.70), suggesting a slightly negative impression in terms of appearance. Interestingly, both the dimension motivating – discouraging and brings me closer to people – separates me from people show a deviation of 0.2 points from the neutral value, but in opposite directions — reflecting subtle yet opposite tendencies in how participants perceived engagement and social connection.

The six charts illustrate how participants rated the prototype across bipolar adjective pairs using a 7-point Likert scale (where 4 = neutral). The results reveal relatively symmetric distributions centred around the neutral point, though some dimensions stand out with slight shifts in positive or negative directions.

- Simplicity vs. complexity: The dimension simple – complicated was rated most favourably, with a noticeable concentration of responses toward the “simple” end of the scale (mean = 3.40), indicating that users generally perceived the interface as easy to use.
- Visual attractiveness: In the ugly – attractive dimension, the distribution was more varied, though skewed slightly toward the negative side (mean = 3.70). Ten participants chose the neutral midpoint, while several leaned toward the "ugly" end, suggesting mixed impressions regarding the platform's aesthetics.
- Social connectedness: Ratings for brings me closer to people – separates me from people were highly concentrated at the neutral point (14 out of 20 selected 4), with

minimal variation (mean = 4.20). This indicates a rather balanced but inconclusive perception of social interaction, with a stronger opinion in separating direction.

- Pleasantness: The dimension unpleasant – pleasant also centered strongly around the neutral point (mean = 3.85), with 12 neutral responses. This balanced distribution suggests a generally stable, though somewhat muted, affective reception.
- Motivation: In the motivating – discouraging dimension (mean = 3.80), the distribution was more ambivalent, with responses spread across the entire scale — some users found the experience motivating (e.g., 5 responses at 2), while others reported it as highly discouraging (e.g., 2 at 6, 2 at 7). This points to notable individual differences in how the experience was perceived.
- Creativity: Ratings on the unimaginative – creative scale (mean = 4.05) showed a broad spread, with responses appearing at nearly every scale point. This dimension also reflects a highly ambivalent response pattern, suggesting a lack of clear consensus and varied user interpretations of the prototype's creative potential.

In summary, while most user opinions clustered around the neutral midpoint, a few dimensions stood out. Simplicity emerged as the most positively evaluated attribute, whereas visual attractiveness leaned slightly negative. The most balanced impressions were observed for pleasantness and social connectedness, whereas motivation and creativity showed more ambivalent distributions, highlighting divergent user experiences and preferences.

Fig. 10. Results of participants' evaluation of the simplicity of the prototype in pairs of bipolar adjectives using a 7-point Likert scale (where 4 = neutral).

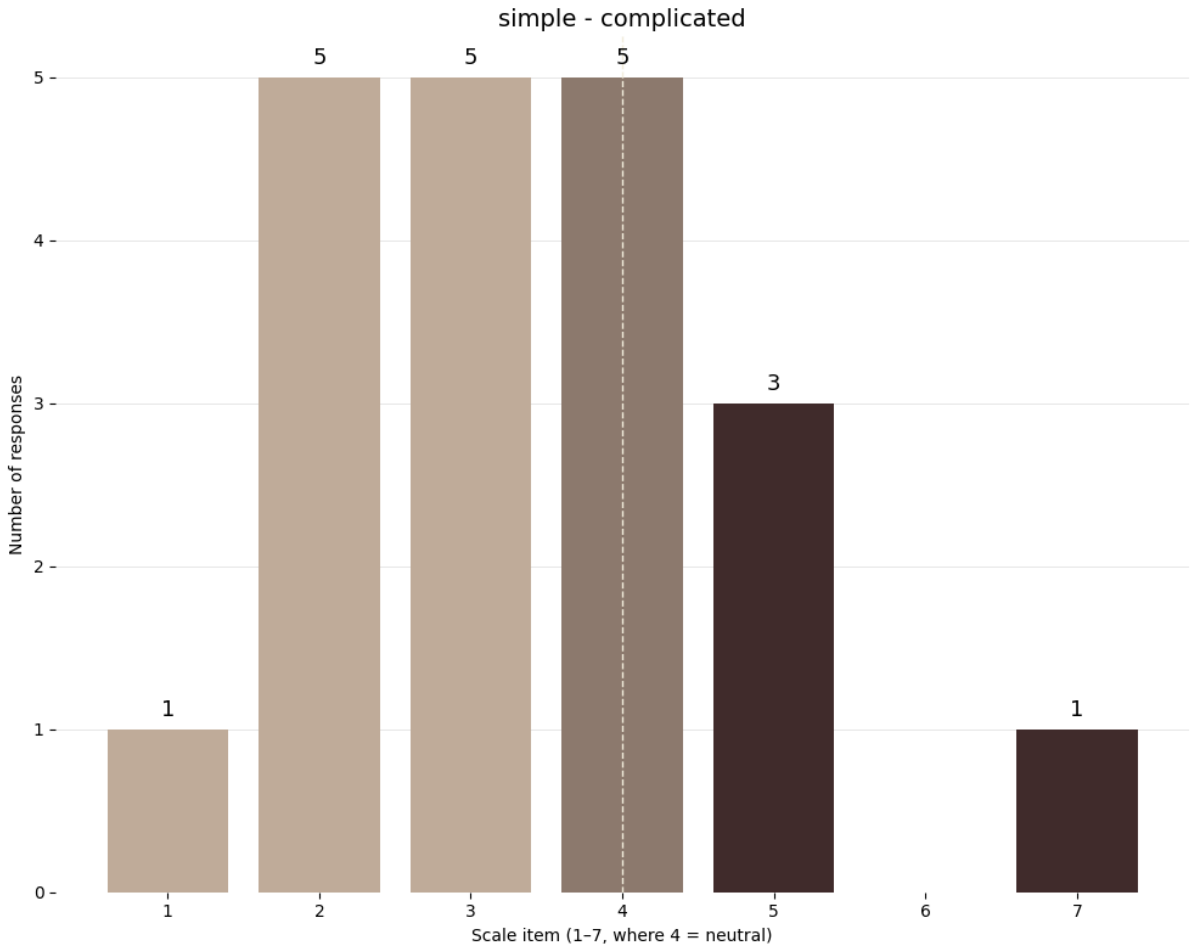


Fig. 11. Results of participants' rating of the attractiveness of the prototype in pairs of bipolar adjectives using a 7-point Likert scale (where 4 = neutral).

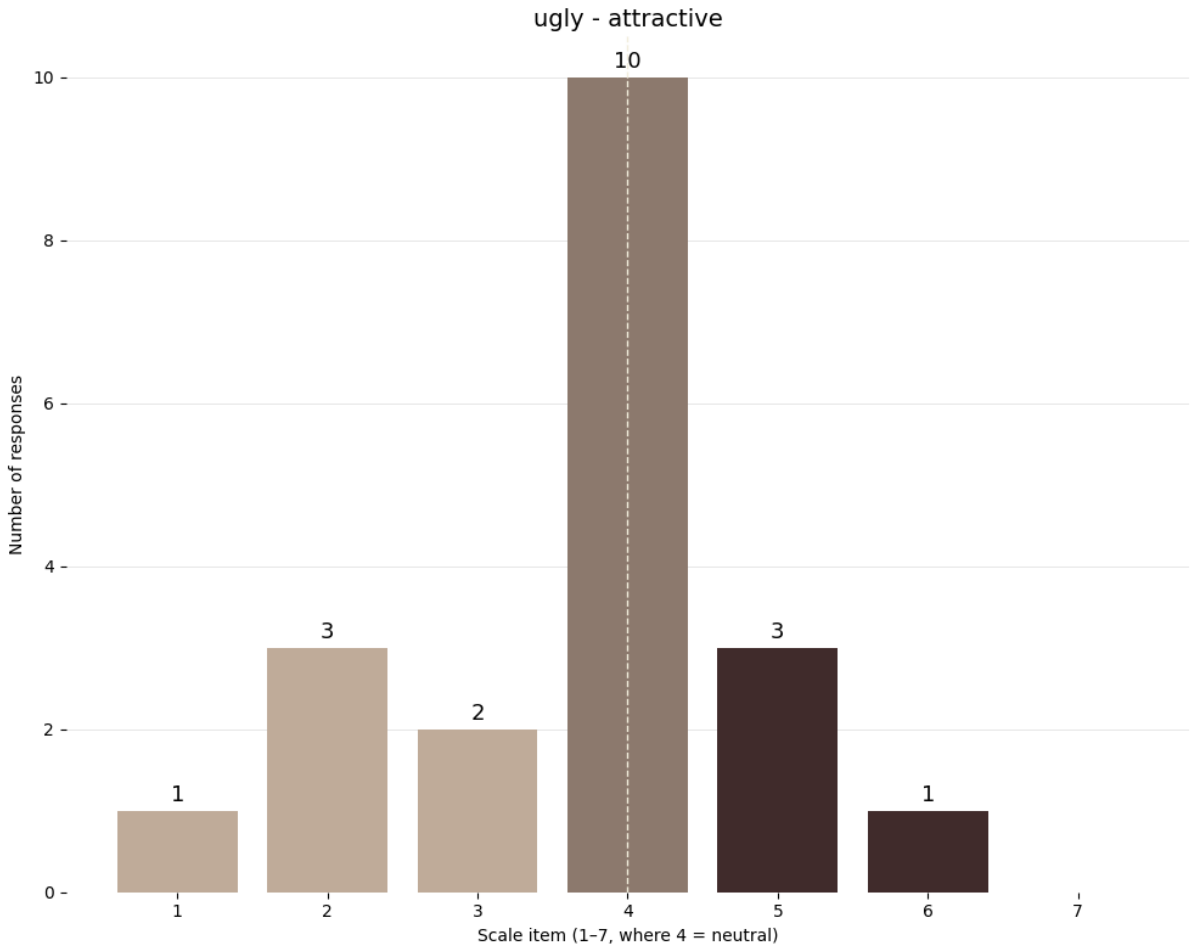


Fig. 12. Results of participants' evaluation of the social relatability of the prototype in pairs of bipolar adjectives using a 7-point Likert scale (where 4 = neutral).

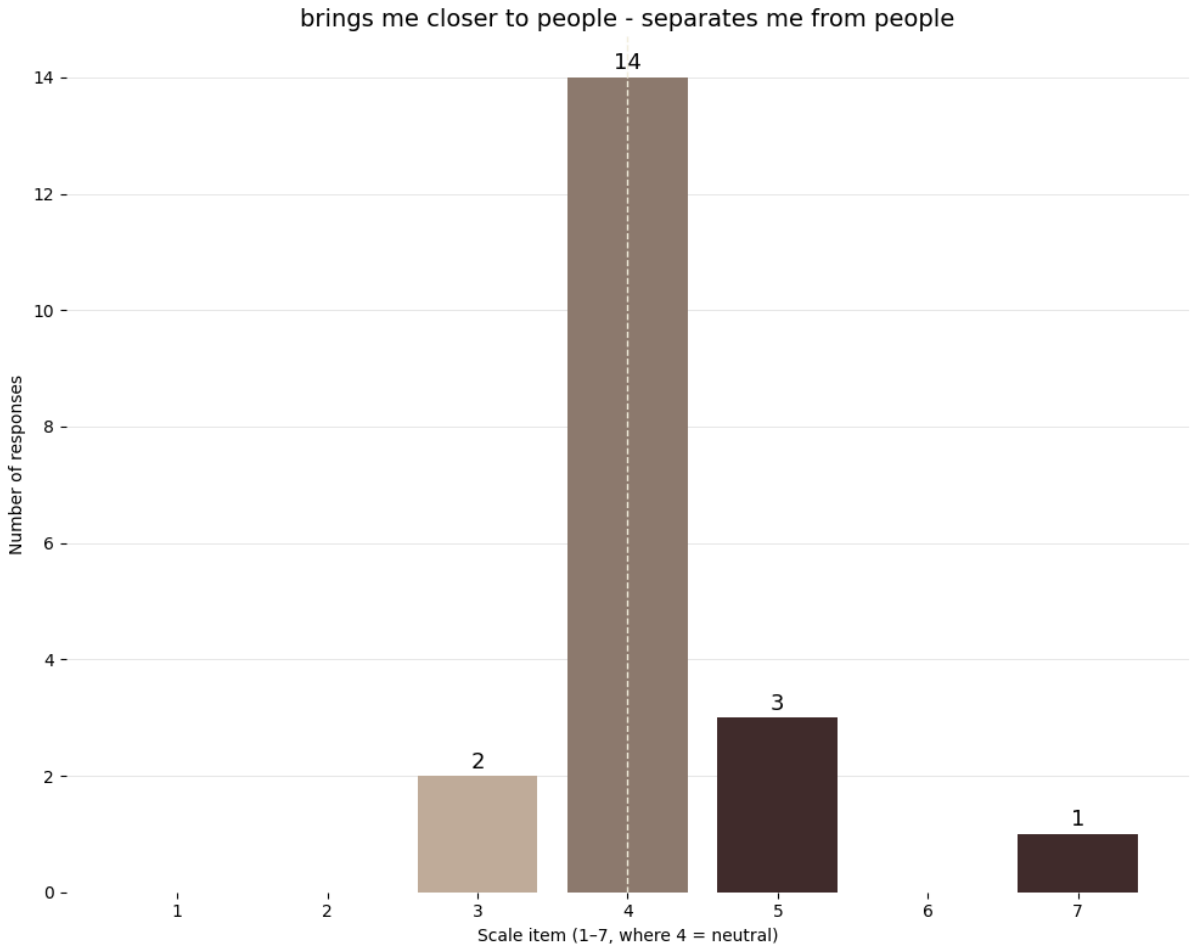


Fig. 13. Results of participants' rating of the prototype's sense of pleasure in pairs of bipolar adjectives using a 7-point Likert scale (where 4 = neutral).

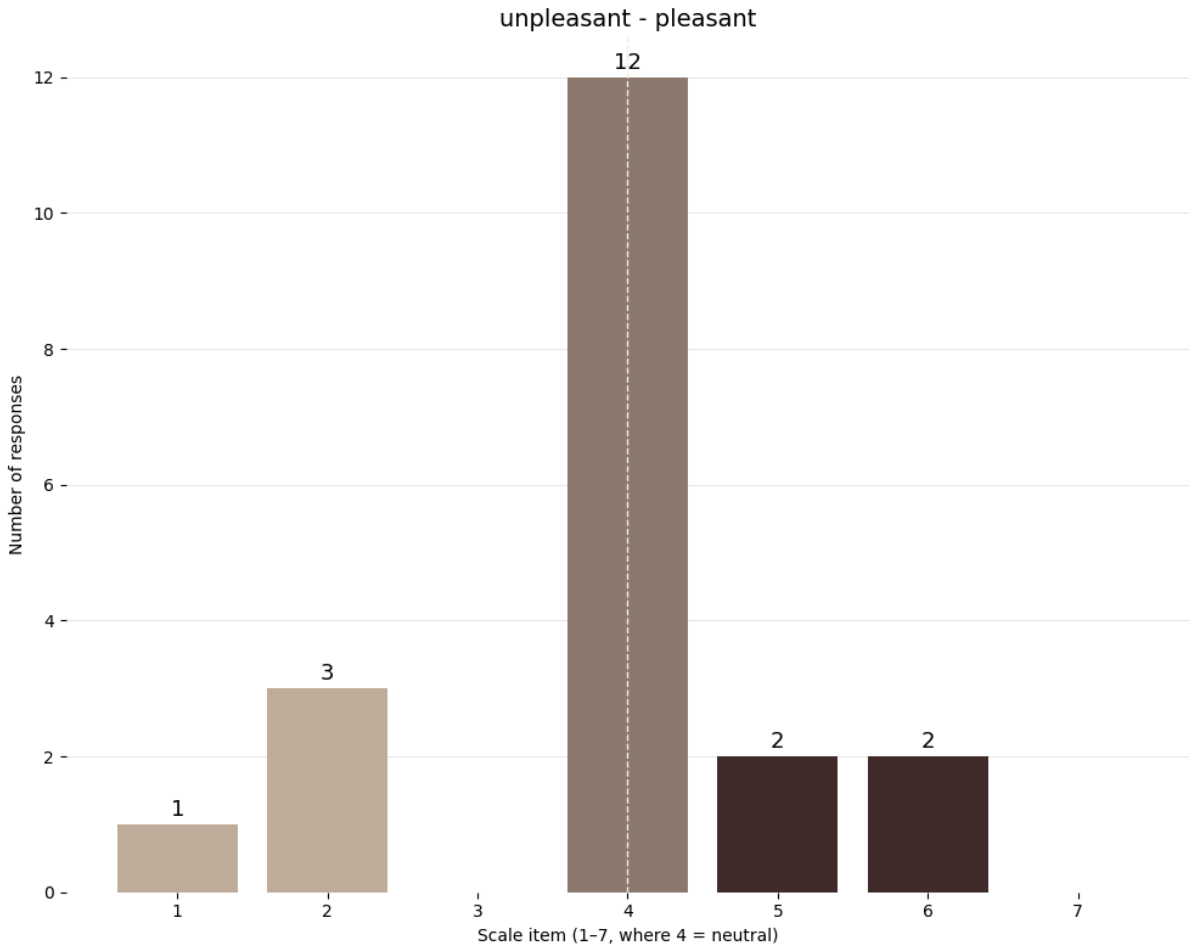


Fig. 14. Results of participants' rating of the prototype's sense of motivation in pairs of bipolar adjectives using a 7-point Likert scale (where 4 = neutral).

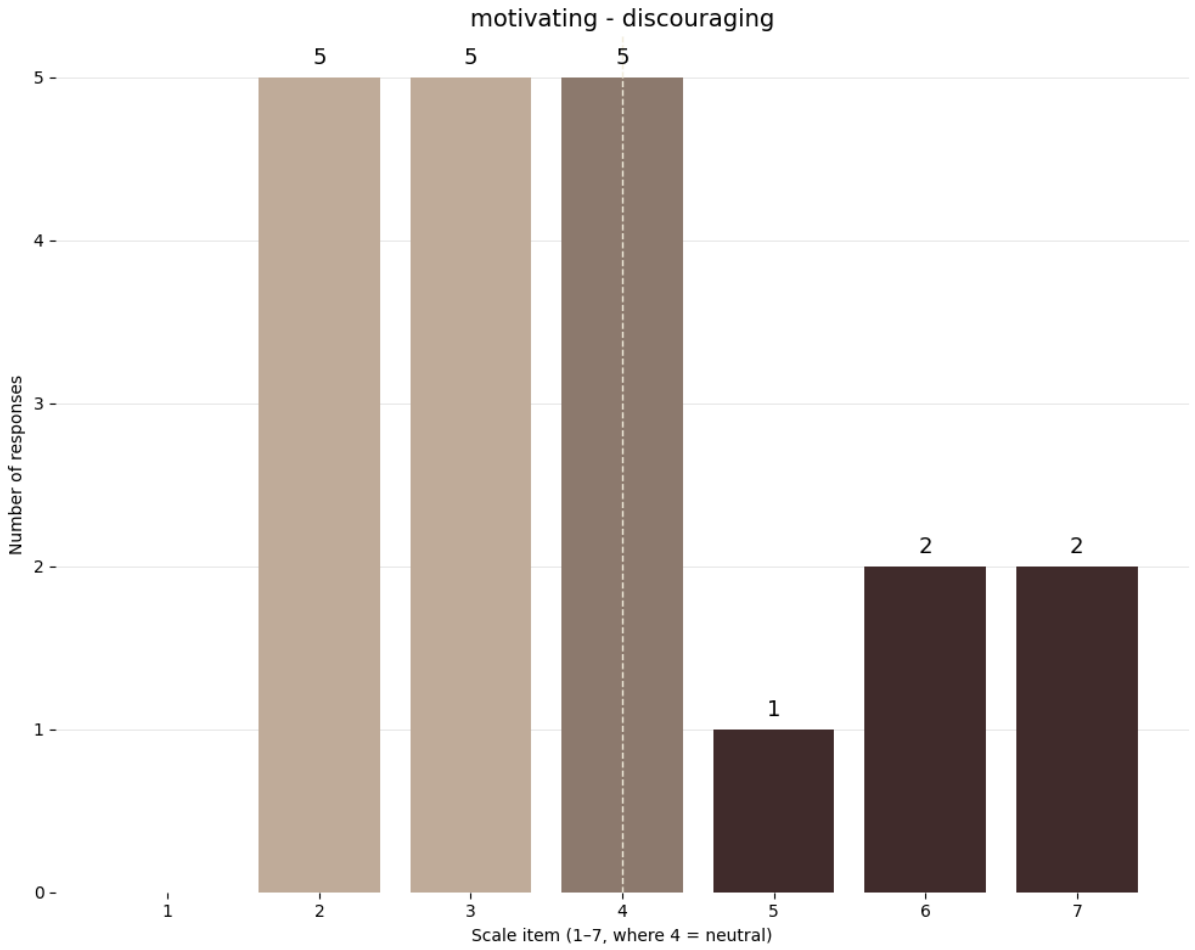
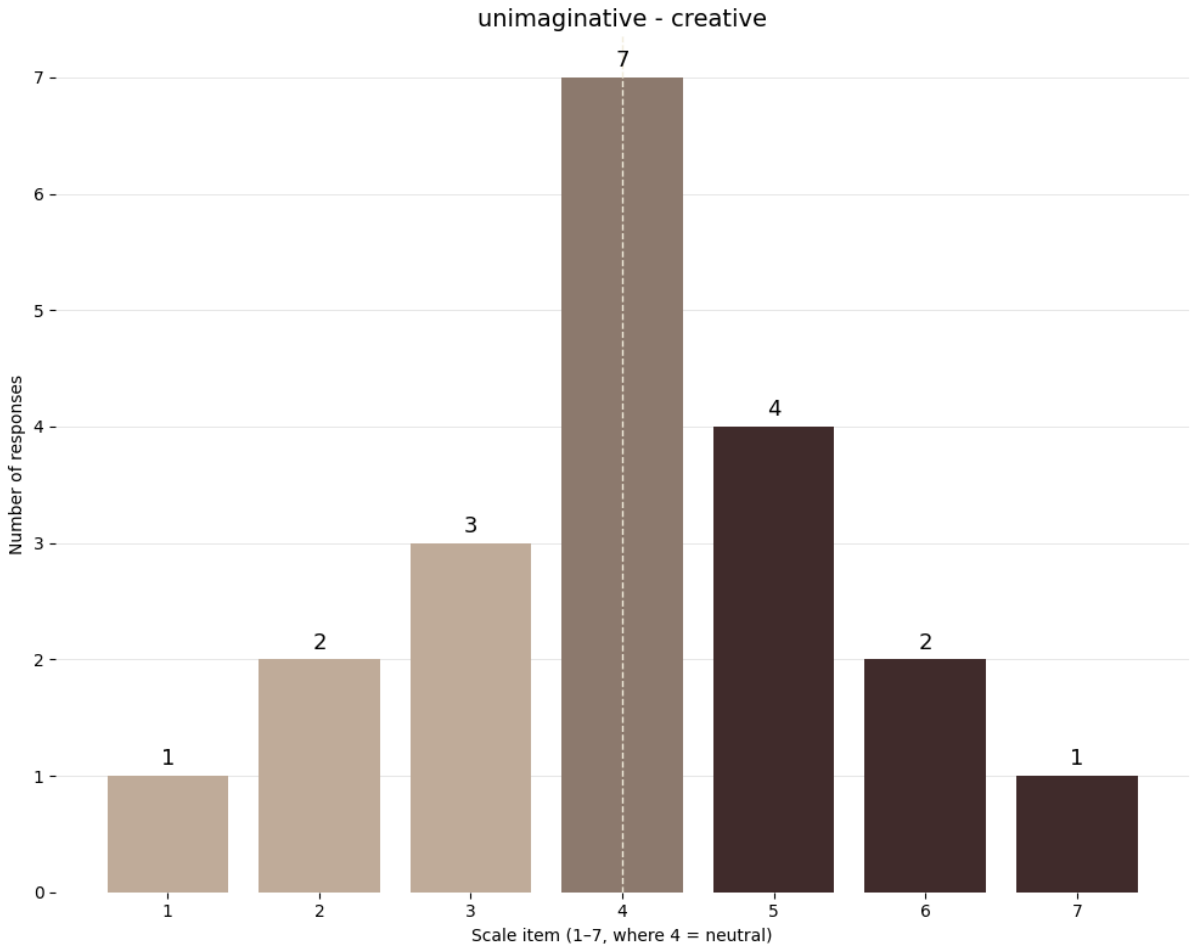
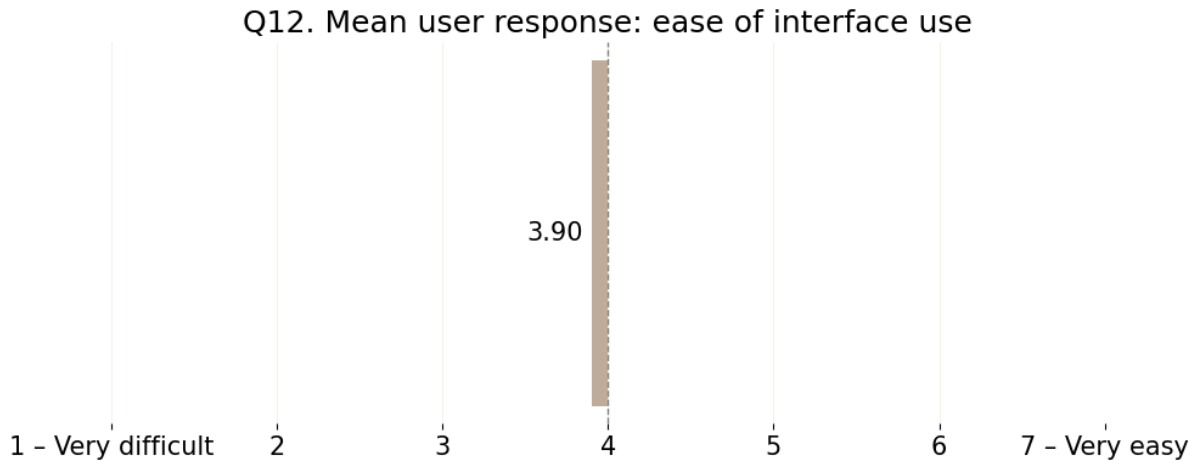


Fig. 15. Results of participants' rating of the sense of prototype creativity in pairs of bipolar adjectives using a 7-point Likert scale (where 4 = neutral).



The average user rating of the ease of interface use, as shown in answers for Q12, was 3.90 on a 7-point scale (where 1 = very difficult and 7 = very easy). This result is very close to the neutral midpoint (4.0), suggesting that participants overall perceived the interface as neither particularly easy nor particularly difficult to use. The nearly neutral average may reflect the mixed experiences reported in other parts of the survey, including technical issues or unclear instructions. While the interface was not rated as especially challenging, the score does not indicate a strong sense of usability either.

Fig. 16. Mean user reaction: Ease of use of the interface.



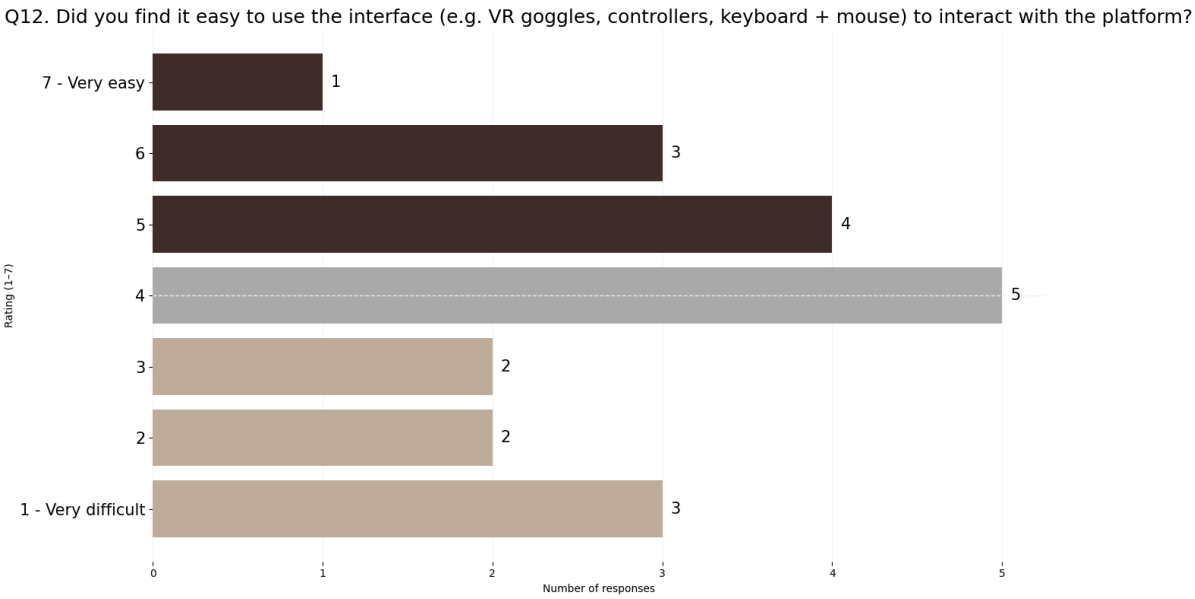
The horizontal bar chart illustrates the distribution of individual responses to question Q12, which asked participants how easy it was to use the interface (e.g., keyboard + mouse) to interact with the platform. Responses were given on a 7-point scale, where 1 indicated very difficult and 7 indicated very easy. It is important to note that both the prototype and the questionnaire were developed under the initial vision of WP2, with the intention to incorporate VR goggles and controllers for interaction. However, these devices were not available for use during the Leuven workshop, meaning participants interacted only with the alternative input methods (keyboard + mouse). The responses thus reflect this limitation, while future iterations of the platform are expected to fully integrate VR-based interactions as originally intended.

The results show a diverse range of experiences, with responses spread across the entire scale:

- 3 respondents selected the lowest score (1 – very difficult), indicating significant difficulty with interface use.
- 2 respondents chose each of the scores 2 and 3, reflecting moderate challenges.
- The neutral midpoint (4) was selected most frequently — by 5 respondents, suggesting an ambivalent or balanced perception of usability.
- On the positive side, 4 participants chose 5, 3 chose 6, and 1 chose the maximum score of 7.

This distribution suggests no clear consensus regarding ease of use. While some participants found the interface easy or very easy to operate, others experienced it as difficult or very difficult. The responses indicate a bimodal tendency, with a cluster of ratings around both lower and higher values, as well as a strong presence at the neutral midpoint — reflecting a high degree of variation in user experiences, potentially influenced by technical barriers or varying familiarity with interaction methods.

Fig. 17. The ease of use of the user interface for interaction with the platform.



Methodological approach for thematic analysis.

The analysis followed a qualitative content analysis approach, employing Braun & Clarke's thematic analysis (2006), adapted for human-computer interaction (HCI) and user experience (UX) studies. The methodological process involved the following steps:

1. **Data Preparation and Extraction**
   All responses from the three open-ended questions were extracted from the dataset. The responses were cleaned for duplicates and irrelevant blanks, then organised in a structured table. Each entry was linked to a respondent ID and the corresponding source question.
2. **Segmentation into Meaning Units**
   Each response was segmented into discrete meaning units, such as identifiable ideas, problems, or suggestions. For example, a compound response like *"platform crashed, and I couldn't test the collection"* was split into two distinct meaning units: (1) platform instability, (2) test process interruption.
3. **Open Coding.**
   The meaning units were coded using open coding techniques, where provisional labels were assigned to describe the core idea (e.g., *"crash at startup"*, *"lack of avatar editing"*, *"hard to resize objects"*). These codes were inductively generated from the data, without imposing predefined categories.
4. **Thematic Categorisation.**
   Related codes were grouped into thematic categories that formed higher-level clusters. For example, *"lack of precise placement"*, *"hard to scale objects"*, and

"missing object alignment grid" were grouped under the theme Spatial Manipulation Issues.

5. **Interpretation and Synthesis.**
   Themes were synthesised and interpreted based on their frequency, qualitative richness, and implications for design. Representative quotes were selected to illustrate each theme. The final synthesis includes both functional (usability-related) and affective (experiential and reflective) dimensions of feedback.

The following themes were identified based on the three open-ended questions:

A. User-Described Problems (Problem Description).

Key Themes (n = 7 responses):

- Critical system instability – Platform crashes preventing interaction (2 mentions).
- Failure in 2D/3D mapping – Distorted rendering of images on primitives (1 mention).
- Lack of precise manipulation tools – Difficulty setting or adjusting objects (1 mention).
- Experience-dependence of usability – Interface usability conditional on prior 3D knowledge (1 mention).
- Unavailable functions or navigation stages – Inability to access certain stages or actions (1 mention).

Example Quote: *"Mapping a 2D image onto a primitive wraps it in a weird way."*

Implication:
Participants need more predictable, stable, and user-friendly affordances for basic tasks like importing, scaling, and arranging digital assets. These findings suggest a need for improving system stability and object interaction tools.

B. Suggested features (desired functionality)

Key Themes (n = 10 responses):

- Environment editing and spatial control – Background modification, object addition/removal, spatial sound, lighting (4 mentions).
- Avatar personalisation – Editing visual features and gestures (2 mentions).
- Alternative movement styles – Walking, flying, teleportation (2 mentions).
- Enhanced communication tools – Chat, video, emotional cues (1 mention).
- Cultural object interactivity – Transforming 2D to 3D, recombining heritage elements (1 mention).

Example Quote: *"Ability to edit the VR environment (e.g., change backgrounds, add/remove elements of the environment)."*

Implication:
A modular system architecture is required to support multi-layered editing capabilities, avatar expression, and differentiated user pathways (e.g., exploration vs. curation). The integration of these features will enhance user control and flexibility.

C. Meta-level Reflections (Additional Comments).

Key Themes (n = 6 responses):

- Difficulty with object placement and scaling – Floor and tile components hard to arrange (2 mentions).
- Avatars require deeper personalisation – Current models insufficient (1 mention).
- Desire for platform transparency – Users want to know system requirements and limitations beforehand (1 mention).
- Short test session length – Limited exploration possibilities (1 mention).

Example Quote: *"Placement of tiles/floor pieces is hard to make good."*

Implication:
Beyond functionality, users expect stability, transparency, and expressive flexibility in the platform. Participants also indicated that perceived constraints on agency reduced their sense of usability.

Cross-cutting Insights and Recommendations.

From the triangulation of open-ended responses, the following cross-cutting design implications are proposed:

- Interactivity-first design: Empower users to modify and narrate within the environment, rather than just explore.
- Dual interface modes: Provide basic and advanced interface versions to accommodate different levels of prior experience.
- Integrated onboarding: Introduce walkthroughs that explain core interactions and provide access to real-time guidance for new users.
- Stability over complexity: Prioritise a robust core experience before layering more advanced editing and interaction features.

This thematic content analysis highlights several key areas for improvement in the IMPULSE VR prototype. Technical issues related to system stability and manipulation tools were the primary concerns raised by users. Additionally, there was significant interest in enhancing user expression through avatar personalisation, environment editing, and advanced movement styles. Finally, users emphasised the importance of platform transparency and user guidance in future iterations. The feedback from the survey directly informs the ongoing UX design process and provides critical insights into the user needs and expectations that will guide the next steps in the IMPULSE project.

The Leuven UX survey provided crucial insights into the usability and engagement of the IMPULSE VR prototype. The feedback revealed a strong interest in the creative and educational potential of the platform, despite the significant technical barriers. The key challenges identified were related to system stability, avatar customisation, metadata integration, and collaborative features. Moving forward, the next steps for WP2 and WP4 should focus on addressing these technical issues while enhancing the system's creative capabilities and user-centred design features.

Next Steps:

- WP2 should focus on improving platform stability and providing clearer onboarding instructions to guide new users.
- WP2 should prioritise the development of customisable avatars, enhanced movement styles, and modular environment editing tools.
- WP3 should work on ensuring metadata integration, responsible curation, and the ability for users to collaborate and co-curate within the platform.

8.2 Surveys (G1 & G2)

The general survey was designed for both current users and non-users (potential users) of the platform, with participants recruited from two target groups: G1 and G2. The questionnaire was developed based on the structure of the general survey outlined in Deliverable D1.1, but it was adapted in response to the conditions and insights gained during the Leuven test phase.

In particular, the following factors influenced the final shape of the survey:

- the absence of access to the VR platform prototype for respondents,
- the need for remote distribution, which required significant shortening of the questionnaire compared to the original version in D1.1,
- and the practical experience from the Leuven study, including observations about user needs and barriers.

Before launch, the survey underwent a pilot run during a UX research methodology class with students of the Electronic Information Processing program. We would like to extend our sincere thanks to the students for their valuable feedback, which helped refine and improve the final survey instrument.

The questionnaire was implemented using Microsoft Forms and prepared in two language versions: Polish and English. Each IMPULSE partner involved in distributing the survey within their institution or country was given the choice to either share the English version or develop a version in their preferred language.

The study was anonymous and voluntary, with participants informed that they could withdraw at any time without providing a reason. At the beginning of the form, participants were presented with a brief description of the study and the IMPULSE project, including a link to the project's official website for further details.

The final questionnaire consisted of 18 questions, structured into two separate response paths: one for VR users and one for non-users.

- The first question served to collect active, informed consent to participate in the survey.
- The second question asked whether the respondent had ever used VR, thereby directing them to the appropriate set of questions.

After this branching point:

- Non-users answered questions regarding barriers to VR use and factors that might encourage them to consider using VR in the future.
- VR users, on the other hand, responded to questions about:
    - frequency of use,
    - self-assessed proficiency,
    - devices and platforms used,
    - reasons for engaging with VR,
    - difficulties encountered,
    - types of experiences,
    - social interactions in VR,
    - expected functionalities,
    - interactions with virtual objects,
    - and their past experiences with digital cultural heritage in VR.

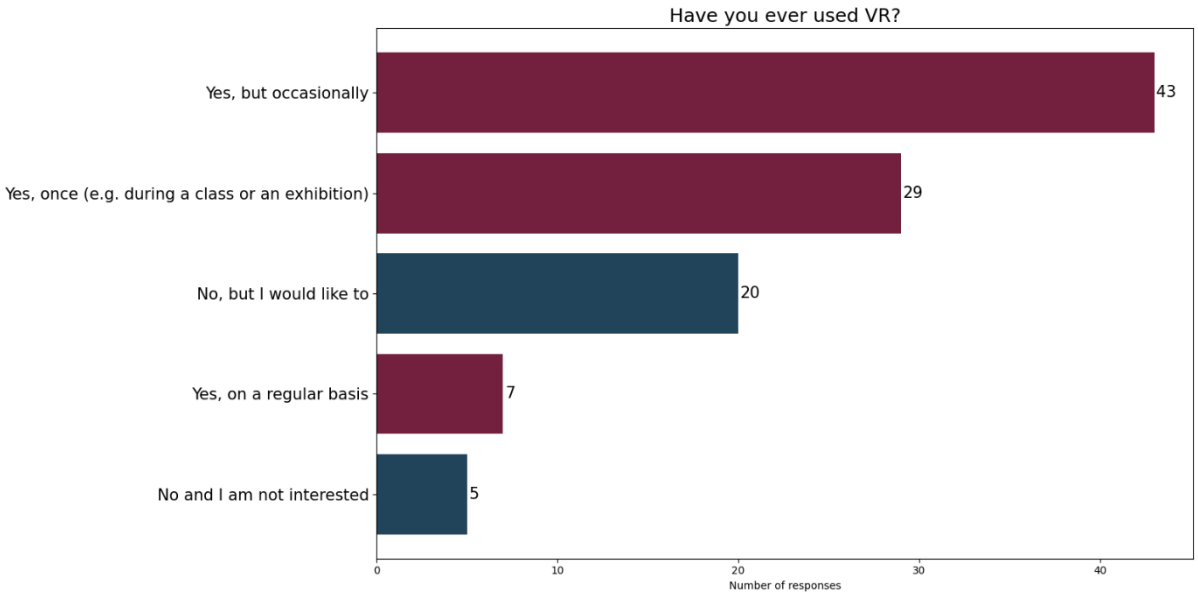
Both groups completed a shared demographic section, which included two brief items on academic status and field of study or specialization.

The questionnaire included multiple-choice items and three open-ended questions to allow for more detailed, qualitative input from participants.

The data analysis process followed a similar approach to the one used for the Leuven survey, combining both quantitative and qualitative methods. To prepare the dataset—including the creation of headers, splitting of multiple-choice responses, translation into English, and merging responses from different language versions into a single file—Python and Google Colab were used. A dedicated pipeline was developed in Google Colab to enable continuous updating of the dataset as new responses were submitted. Python was also used to analyse and visualise the responses to closed-ended questions. In the case of open-ended questions, a thematic analysis was conducted using MAXQDA.

As of April 11, 2025 (10:00 PM), a total of 109 responses had been collected — 51 in the Polish version of the survey and 58 in the English version. Out of these, 104 participants provided informed consent to take part in the study.

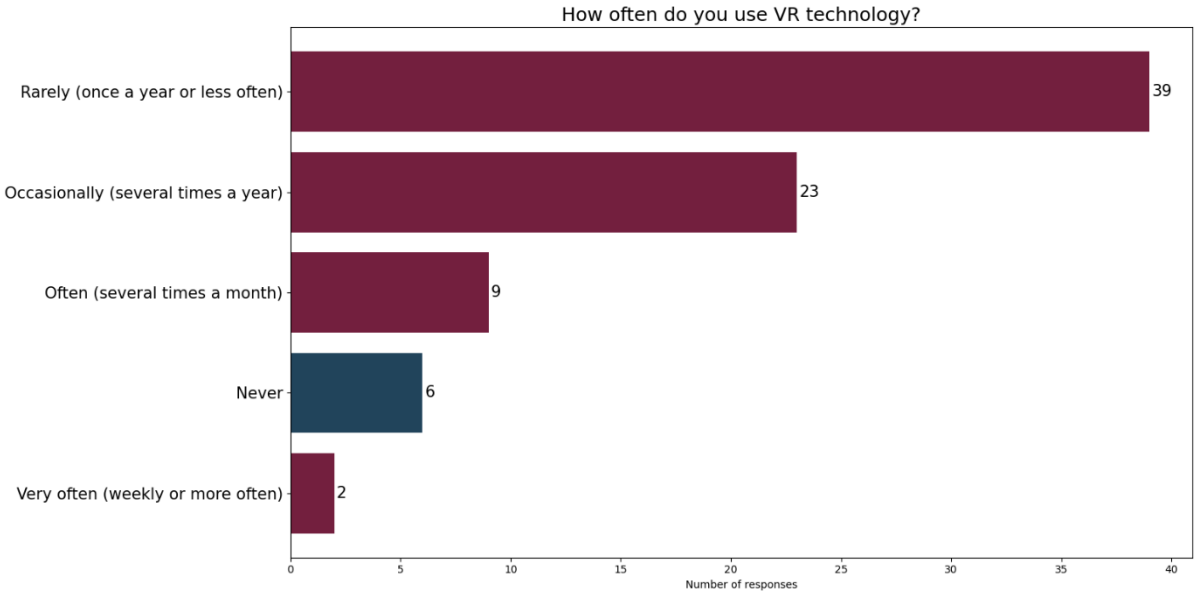
Fig. 18. The question of whether the users have ever used VR.



Among the respondents, 25 individuals identified as non-users of VR—this includes those who selected *"No, but I would like to"* (20 responses) and *"No and I am not interested"* (5 responses). These responses are represented on the chart in a dark teal color, indicating participants with no prior hands-on experience with VR. The remaining respondents—those who selected any of the *"Yes"* options—can be considered VR users, although with varying levels of experience. Their answers are shown in burgundy on the chart, representing different levels of engagement with the technology, from a one-time use to regular usage.

A total of 43 respondents indicated that they had used VR occasionally, making this the most common experience level among participants. Additionally, 29 respondents stated they had used VR only once, for example during a class or an exhibition. These figures suggest that while a majority (79 participants) have had some interaction with VR, for most it remains an infrequent or experimental experience. Meanwhile, the 7 respondents who use VR on a regular basis form a small but significant group of more advanced users. Taken together, the results reflect a general openness to VR, though its regular use is still relatively rare.

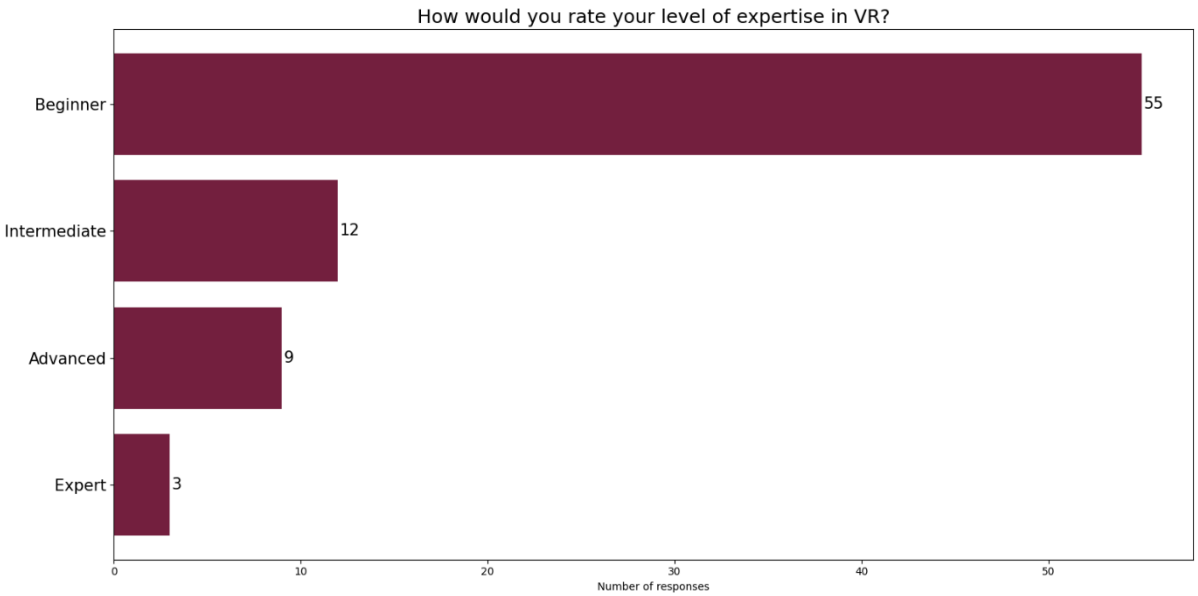
Fig. 19. Frequency of VR use.



Among respondents who identified as VR users, the vast majority reported using the technology infrequently. Specifically, 39 participants stated that they use VR *"Rarely (once a year or less often)"*, while 23 participants reported using it "*Occasionally (several times a year)"*. These two categories together account for over 80% of all VR users in the sample, indicating that for most participants, VR remains a sporadic activity rather than a routine part of their digital practices.

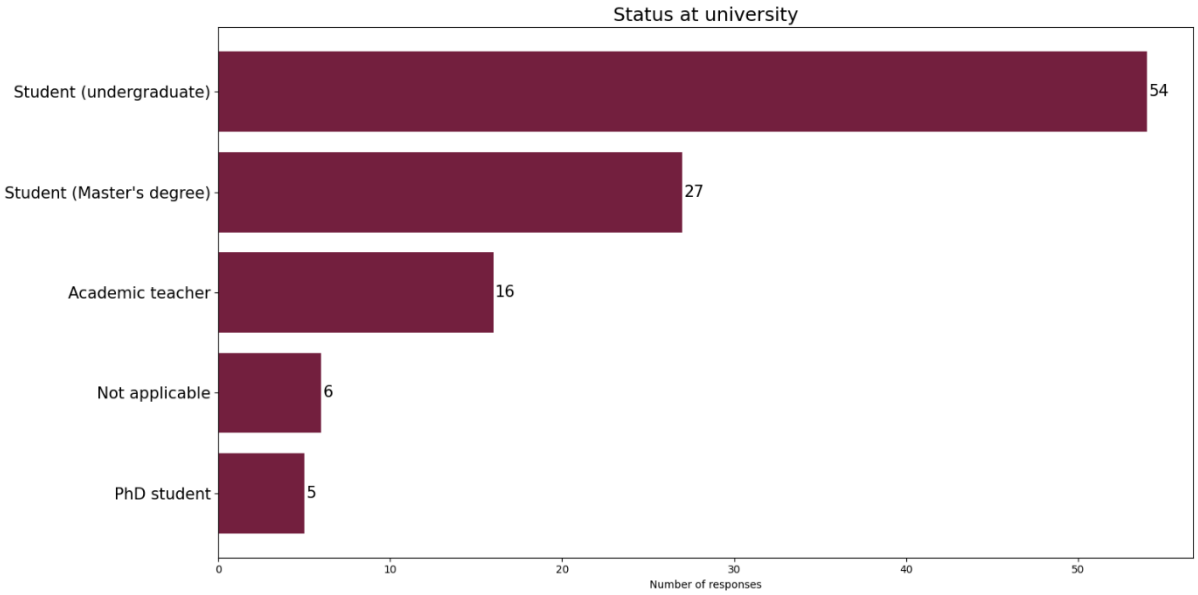
Only a small number of respondents use VR more regularly: 9 individuals reported using VR often (several times a month), and just 2 respondents stated they use it very often, defined here as weekly or more frequently. Additionally, 6 participants chose the option *"Never"*, confirming they had no experience with VR—this group overlaps with the non-users identified in the previous question. Overall, the data suggest that while exposure to VR is relatively widespread, its adoption as a frequent or habitual tool is still limited.

Fig. 20. Question on the assessment of the level of expertise in the VR field.



The vast majority of respondents consider themselves beginners when it comes to VR technology. Specifically, 55 participants rated their level of expertise as *Beginner*, which clearly indicates that most users have limited experience and are likely in the early stages of exploring VR environments and tools. A smaller group of 12 participants identified themselves as having an *Intermediate* level of experience, followed by 9 respondents who rated their expertise as *Advanced*. Only 3 individuals considered themselves *Experts* in the use of VR.

Fig. 21. University status question.



The sample was predominantly composed of undergraduate students, who made up the largest group with 54 responses. This indicates that much of the feedback and data collected reflects the perspectives and experiences of individuals at an early stage in their academic journey. The second largest group consisted of master's degree students (27 responses), followed by *academic teachers*, who accounted for 16 responses.

Smaller numbers of respondents identified as *PhD students* (5) or selected the *"Not applicable"* category (6), suggesting limited participation from those outside traditional university structures or with unclear academic status. Overall, the distribution suggests that the majority of insights come from students, especially at the undergraduate and master's levels, which may influence the general level of VR familiarity and perceived expertise observed in the other survey results.

Illustration 1. A word cloud to visualise the general fields of study or disciplinary backgrounds declared by the participants in the survey.

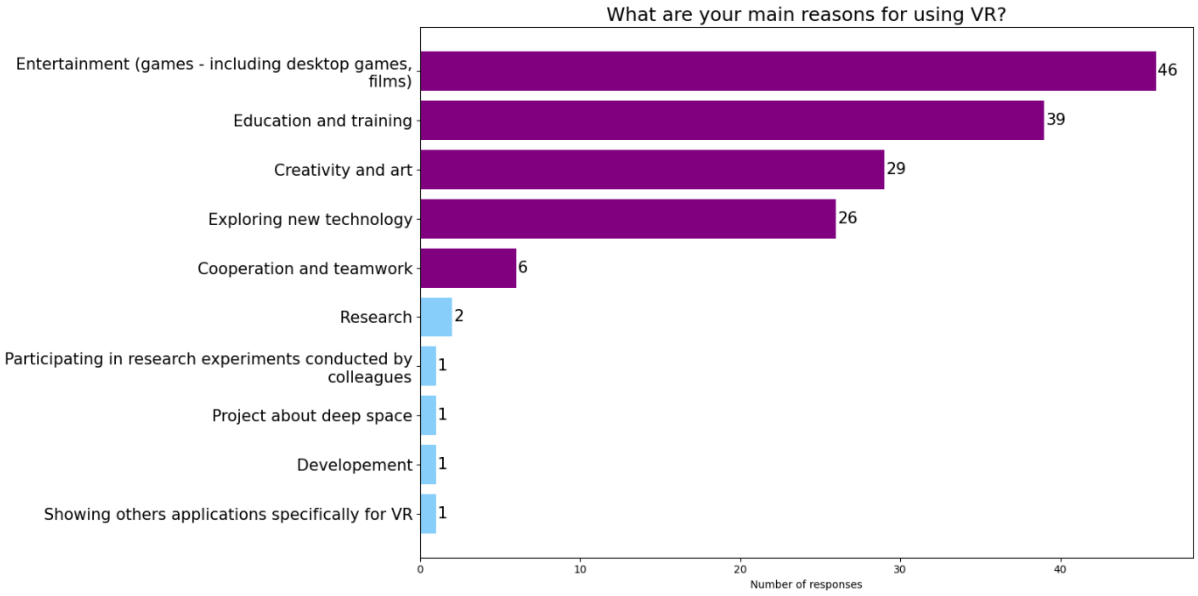
The word cloud visualizes the general fields of study or disciplinary backgrounds declared by survey participants, grouped into two categories:

- G1 (blue) – includes fields related to social sciences, media studies, information science and management, computer science, health sciences, and other areas typically associated with theoretical, applied, or technical orientations.
- G2 (dark red) – includes fields directly connected to artistic and creative disciplines, such as art, digital arts, film studies, fine arts, design, and interactive art.

The relative size of each term reflects the frequency with which it was mentioned in the responses, with "art" and "digital arts" standing out as particularly prominent among G2, and "social sciences", "communication and media studies", and "information management" leading within G1.

This visual overview highlights the interdisciplinary character of the participant group. While many respondents come from media, management, or social science backgrounds (G1), there is also a strong presence of individuals with formal education in artistic and digital creative domains (G2). Such a composition is particularly relevant for projects dealing with digital cultural heritage, immersive technologies, and art–science–technology intersections.

Fig. 22. VR's main reasons for use.



Entertainment is by far the most common reason for using VR among respondents (VR users), with 46 users indicating that they use VR primarily for games (including desktop games), films, and other recreational activities. The second most frequently mentioned reason was *education and training*, selected by 39 respondents, suggesting that many participants also recognize the potential of VR beyond entertainment. *Creativity and art* were also important motivations, cited by 29 users, reflecting the use of VR as a tool for artistic expression and design.

Another frequently mentioned reason was *exploring new technologies*, chosen by 26 participants, which points to users' curiosity and interest in engaging with emerging digital tools. *Cooperation and teamwork* were less common, indicated by 6 respondents, while *research* purposes were mentioned only twice.

In the open-ended responses, some participants mentioned unique or niche motivations such as participating in research experiments, working on a project about deep space, using VR for development, or demonstrating VR applications to others. While each of these was mentioned only once, they illustrate the diverse ways individuals are engaging with the medium.

When describing their associations with VR, users highlighted a range of aspects, which are elaborated on in the following paragraphs. The associations related to the purpose or area of VR use clustered around three main themes:

- (1) entertainment—perceiving VR as a toy, with links to gaming or gadgets, e.g.: *"I have used VR once, and it felt interesting and immersive. It reminded me of video games and gave a sense of being in a different world."* (EN_57, item 1);

- (2) an emphasis on the educational potential of VR (e.g.: EN_23, item 1);
- and (3) the use of VR in creative work, including the creation of experimental artworks as well as experiencing VR exhibitions, such as the popular immersive Van Gogh shows, e.g.: *"I am interested in creating and exploring VR as a creative medium and as a communications medium"* (EN_47, item 1) and *"Very nice in the framework of exhibitions (f.ex. statues of the Leuven Old City Hall; exhibition in Bozar, exhibition Antwerp Van Gogh; exhibition BAC ART LAB)."* (EN_34, item 1).

These categories were not mutually exclusive. Several participants mentioned multiple purposes side by side, combining, for example, artistic exploration with learning or gaming. For example, *"Design and implementation of VR environments in the context of artistic experimentation and educational purposes"* (EN_42, item 1) and "*Mostly for entertainment, but I did use a VR device once in an educational setting, and it was a really positive experience in terms of engaging the user"* (PL_32, item 1).

Social aspects were also mentioned among the associations with VR, although primarily in the context of spending time with people users already knew from outside the virtual world—such as friends and family. Rather than emphasizing the creation of new relationships in VR, participants focused on the technology's potential to enhance shared experiences with existing social circles. For example, *"I associate it with meeting up with friends, spending time together, or having fun."* (PL_26, item 1) and *"I associate my experiences with my friends and family (playing multi-player games using vr)"* (EN_51, item 1).

Another prominent theme in participants' associations with VR was physical discomfort related to its use. In some cases, the only associations mentioned were intense symptoms of VR sickness. For example, *"With headaches and nausea..."* (PL_38, item 1) and *"getting a killer migraine"* (EN_14, item. 1).

While some participants were able to name other associations with VR, they still admitted that—even when they recognized the technology's benefits—severe discomfort significantly shaped their overall experience. For some, this resulted in actively avoiding VR altogether. For example:

"I associate my VR experiences with a powerful tool to amplify the potential of reality, especially in creative and educational contexts. It opens new ways of learning, designing, and experiencing content in a more immersive way. However, I also associate VR with a certain level of physical discomfort during use, which sometimes affects the overall experience." (EN_26, item 1) and *"It's a cool thing, but because of issues related to how poorly my inner ear tolerates the technology, I simply avoid it."* (PL_25, item).

Participants also shared associations related to the technological aspects of VR. These included references to technical issues, the high cost of equipment, and occasional mentions of augmented reality (AR). In addition, VR was frequently linked with novelty and the opportunity to experience something otherwise inaccessible. Respondents

highlighted the interactive nature of VR, particularly its capacity to enable direct engagement with virtual environments and objects.

Participants also mentioned associations with virtual worlds, as well as with the realism and authenticity of the VR environment. Sensory aspects were highlighted as well, with several respondents emphasizing the importance of haptic sensations in shaping the immersive experience. For example, *"often underutilised or crappy graphics. Connection with the haptic is the most important for immersion."* (EN_8, item 1-2).

Beyond immersion, other frequently mentioned concepts included disorientation and presence—both reflecting users' awareness of the unique ways VR affects their perception of space, self, and reality. For example:

"My experiences in the VR environment so far can be associated with immersion, presence, and disorientation. The immersion reminds me of being absorbed in a film or video game completely transported. Presence relates to theatre or live performance, where despite knowing it's staged, your body and mind respond as if it's real. Disorientation is akin to vertigo or dream states, where spatial awareness and perception of time feel altered. Together, these evoke associations with gaming, cinematic storytelling, and even lucid dreaming." (EN_40, item 1).

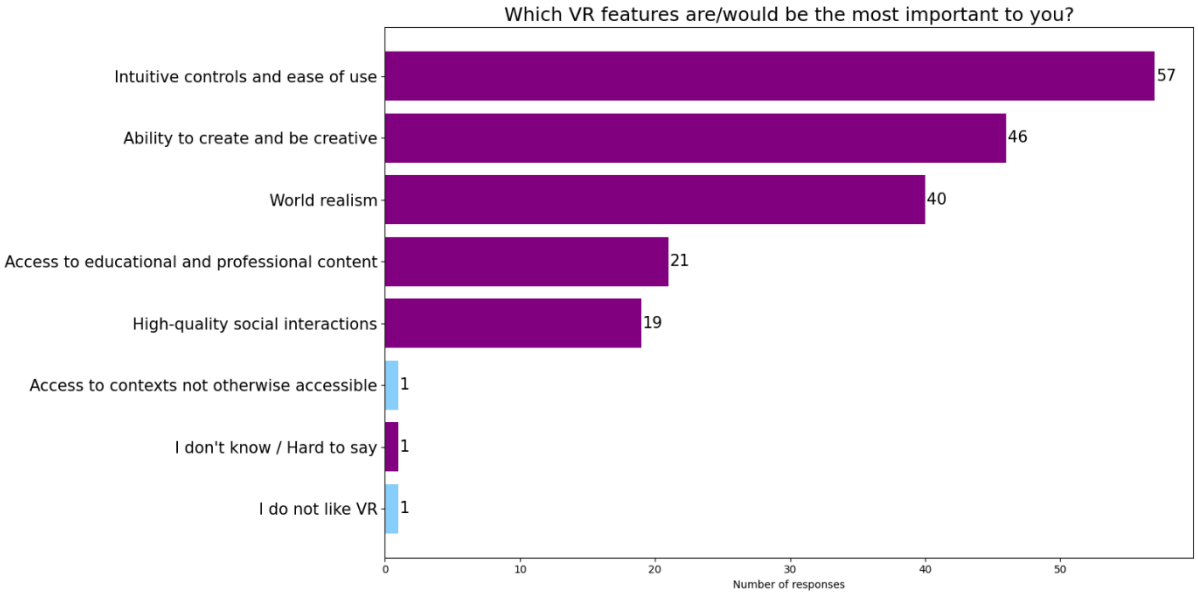
Associations with VR also included emotional responses—ranging from enthusiasm and curiosity to, in some cases, disappointment. While some participants expressed excitement about the possibilities VR offers (e.g.: *"An incredible way to gain new knowledge, experiences, and emotions. Some of the feelings I had while using VR goggles were unlike anything I've ever experienced in life."* (PL_33, item 1)), others noted that their actual experiences did not always live up to expectations (e.g.: *"In general I am content, but in most regards, there is room for improvement. The quality of image isn't at all what I'm used to in 2d, for example. The immersion that I felt I was promised only ever materialized half"* (EN_37, item 1)).

Finally, VR was also associated with challenge—both in a general sense, relating to the complexity of creating effective VR experiences, and in more specific comments. These included reflections on the importance of tailoring experiences to the intended audience, concerns about low visual quality, and doubts about the practical applicability of VR in certain projects. For example:

- *"Challenges with age groups, one VR solution is not always good for every age/target group, understanding this requires experience!"* (EN_35, item 1),
- *"I'm excited about the experience but scared by the difficulty of making it."* (EN_54, item 1),
- *"With something new, and interesting, but without established culture and daily interaction. I see it mostly as a cool technology gadget with potentials that are still not even developed"* (EN_58, item 1),

– *"Interesting experience. By itself it is not functional for the project. It is interesting to activate mixed design processes"* (EN_46, item 1).

Fig. 23. Question on which features are or would be most important to respondent users.



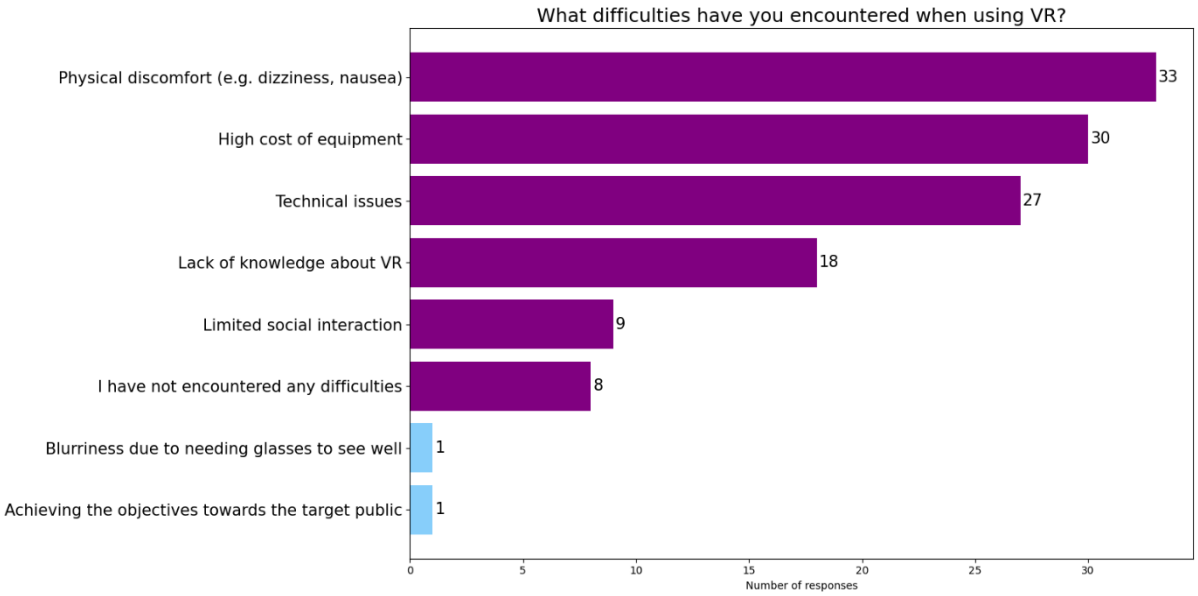
Based on the chart showing users' responses to the question about the most important features of VR, clear preferences emerge regarding usability and creative potential. The most frequently selected feature was *"intuitive controls and ease of use"*, chosen by 57 respondents. This highlights that even among experienced users, accessibility and user-friendliness remain top priorities. The second most important feature was the *"ability to create and be creative"*, indicated by 46 participants, underscoring the value of VR as a tool for artistic expression and design work.

"World realism" was the third most frequently selected feature, highlighted by 40 respondents. This suggests that users value virtual environments that resemble or convincingly simulate aspects of the real world, whether in terms of visual detail, spatial structure, or responsiveness. While this doesn't necessarily equate to immersion in a broader sense, it points to an appreciation for environments that feel coherent, consistent, and relatable within the VR context.

"Access to educational and professional content" was chosen by 21 users, confirming VR's relevance for learning and skill development. Slightly fewer participants (19) selected *"high-quality social interactions"*, which may point to lower expectations of VR's social functions or the current limitations of those features.

Other responses, such as *"Access to contexts not otherwise accessible"*, *"I don't know / Hard to say"*, and *"I do not like VR"*, appeared only once each and had no significant impact on the overall picture.

Fig. 24. Question about user difficulties with the use of VR.



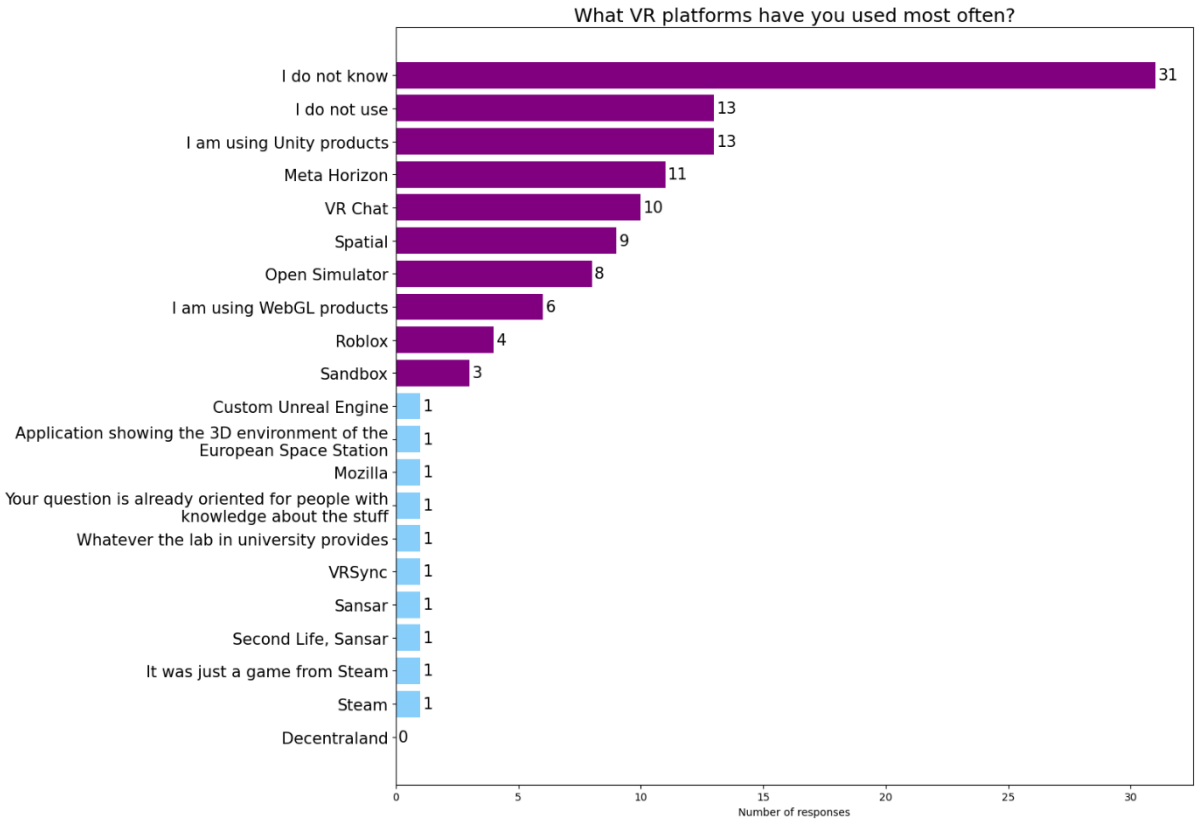
The most commonly reported difficulty among respondents (VR users) was *"physical discomfort"*, such as dizziness or nausea, mentioned by 33 users. In the context of VR users, this highlights the relevance of challenges related to VR sickness—a factor that did not emerge during the Leuven testing phase. It is important to note, however, that during those tests, interaction with the platform was not conducted using VR headsets, which may explain the absence of such feedback at the time. This result reinforces the need to consider the physiological side effects of immersive VR experiences when designing content or platforms.

Close behind was the *"high cost of equipment"*, selected by 30 participants, indicating that financial accessibility remains a significant barrier to broader adoption of VR technology.

"Technical issues" were reported by 27 users, suggesting that hardware or software reliability continues to impact the user experience. Additionally, 18 respondents noted a *"lack of knowledge about VR"*, which may reflect limited access to training or onboarding, especially among less experienced users. *"Limited social interaction"* was mentioned by 9 participants, showing that some users find VR isolating or not sufficiently engaging on a social level.

Interestingly, 8 users stated that they have *not encountered any difficulties*, which may reflect either greater familiarity with VR or more positive experiences overall. A few unique responses were also noted, such as *"blurriness due to needing glasses"* and challenges in *achieving objectives for a specific audience*—each of which was mentioned once, suggesting individual or context-specific concerns.

Fig. 25. The most commonly used VR platforms.

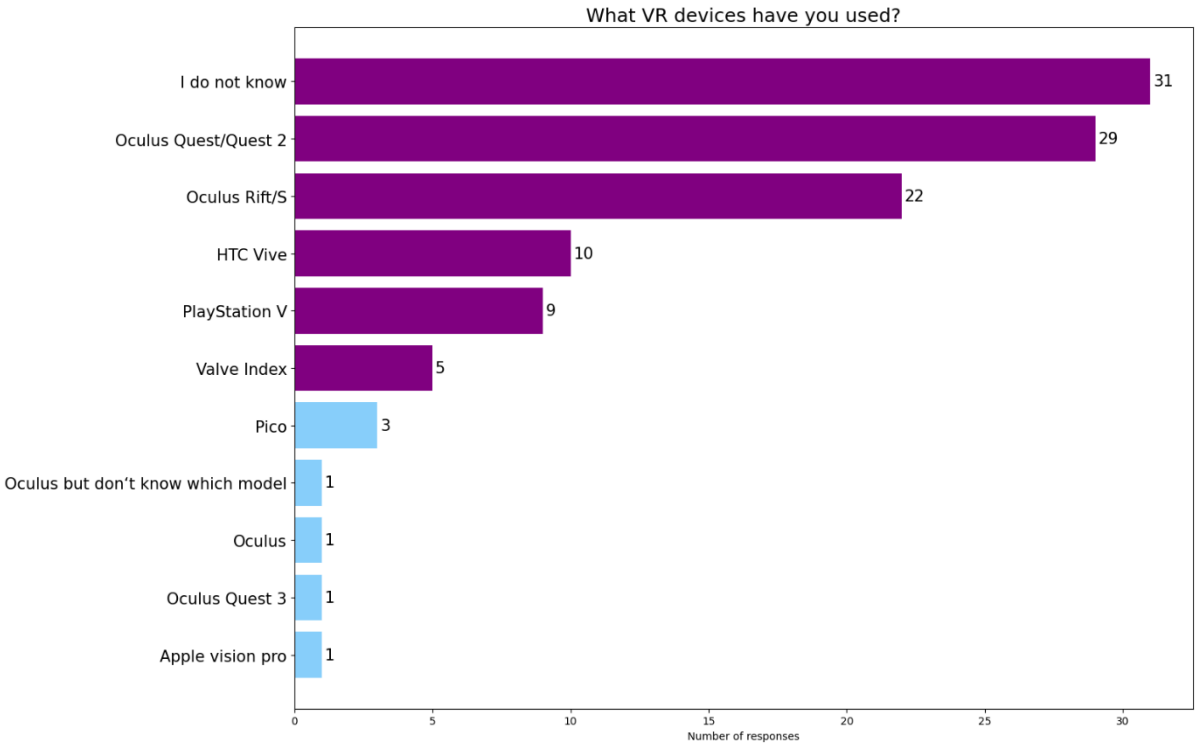


The most frequently selected answer to the question about VR platforms was *"I do not know"* (31 respondents), followed by *"I do not use"* and *"I am using Unity products"*, both with 13 responses. This suggests that many VR users—especially those at an early stage of engagement—either interact with standalone content, development tools, or are unaware of the specific platform they are using. This aligns with the earlier observation that the majority of VR users in the sample self-identified as beginners, which may explain the limited awareness of platform names.

Among named platforms, *Meta Horizon* (11 responses), *VR Chat* (10), and *Spatial* (9) stood out as the most frequently used. These platforms emphasize social presence, creative collaboration, or immersive environments, indicating that even less experienced users are accessing virtual spaces designed for interaction. It's worth noting that Meta Horizon is the default environment for many Oculus devices, particularly the Quest line, which may also explain its relatively high usage.

Less common platforms such as *OpenSimulator* (8), *WebGL products* (*6*), *Roblox* (4), and others like *Mozilla*, *Unreal Engine*, and various educational tools were mentioned by only a few respondents each, revealing a fragmented landscape shaped by individual exposure, institutional tools, or developer interest.

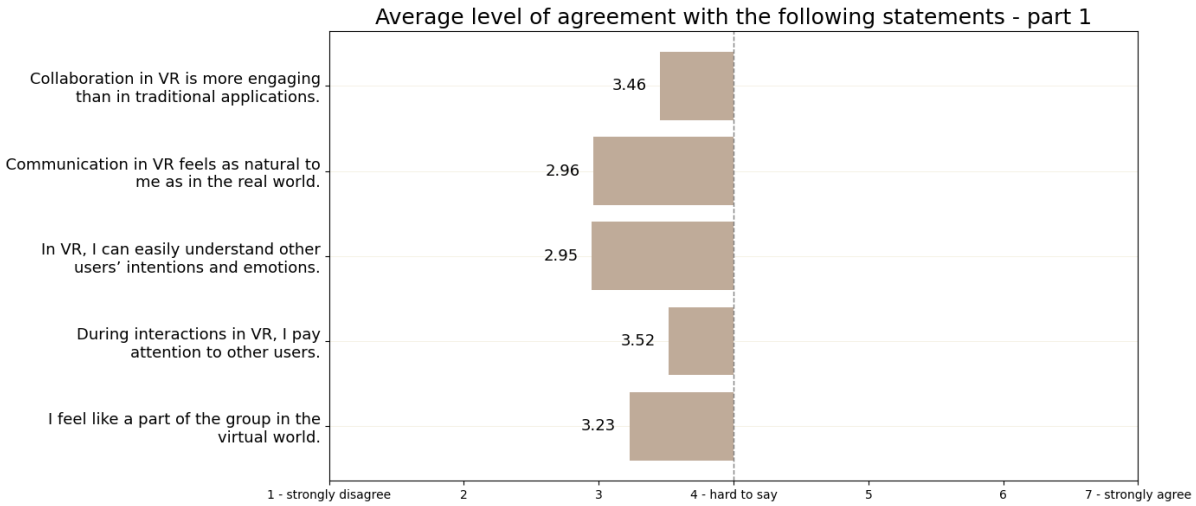
Fig. 26. VR devices mostly used.



A similar trend was observed in the responses about hardware: 31 respondents selected *"I do not know"*, again reflecting a general unfamiliarity with device specifications or use in non-personal, institutional contexts. However, among those who did indicate a specific device, *Oculus Quest / Quest 2* stood out with 29 mentions, followed by *Oculus Rift / S* (22), *HTC Vive* (10), and *PlayStation VR* (9). These results confirm that Oculus/Meta headsets dominate the user experience, and given their integration with Meta Horizon, it is likely that some users accessed this platform by default, possibly without realizing it.

Additional mentions included *Valve Index* (5), *Pico* (3), and a few individual responses referencing newer or less common devices such as *Oculus Quest 3*, *Apple Vision Pro*, or simply *"Oculus"* without further specification. This again points to a mix of personal and shared usage contexts, where device identification may not be clear or relevant for the user.

Fig. 27. Perceptions of social experience and interaction in VR environments.

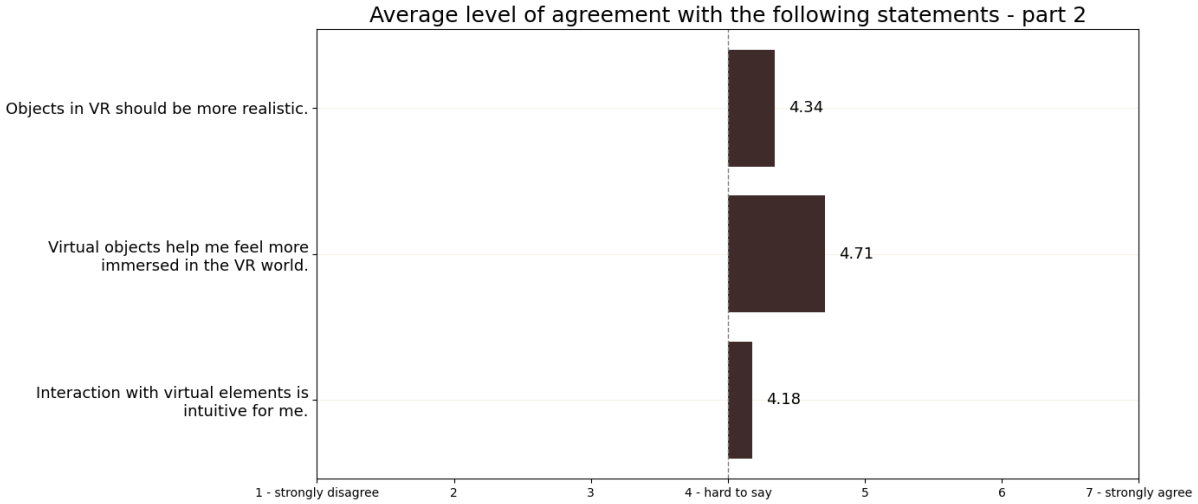


Responses from VR users regarding social experience and interaction show relatively low levels of agreement with statements related to communication, collaboration, and group dynamics in virtual environments. Ratings were given on a 7-point Likert scale (1 = *strongly disagree*, 7 = *strongly agree*, with 4 = *hard to say* as the neutral midpoint).

- The highest agreement was with the statement: *"During interactions in VR, I pay attention to other users."* (average 3.52), indicating moderate social attentiveness during virtual interactions.
- Other statements scored below the neutral point:
  - *"Collaboration in VR is more engaging than in traditional applications."* – 3.46
  - *"I feel like a part of the group in the virtual world."* – 3.23
  - *"Communication in VR feels as natural to me as in the real world."* – 2.96
  - *"In VR, I can easily understand other users' intentions and emotions."* – 2.95

These responses suggest that VR users do not yet experience virtual communication as natural or socially fulfilling. There is a notable gap between current virtual interaction capabilities and users' expectations for meaningful, emotionally resonant exchanges.

Fig. 28. Perceptions of object interaction and realism in VR environments.



Responses from VR users regarding interaction with objects and realism reflect generally higher levels of agreement. Here, users expressed more positive perceptions of how virtual environments support immersion and usability.

- The strongest agreement was with the statement: *"Virtual objects help me feel more immersed in the VR world."* (average 4.71), indicating that objects play an important role in enhancing the immersive experience.
- *"Objects in VR should be more realistic."* received a score of 4.34, pointing to a moderate desire for improved visual fidelity and authenticity.
- *"Interaction with virtual elements is intuitive for me."* was rated at 4.18, suggesting that many users find virtual interactions reasonably intuitive, though there is still room for improvement.

To sum up the average agreement of VR users with the sentences:

- VR users rate object-based and environmental aspects of the experience more positively than social and interpersonal dimensions.
- The data on social interaction reveals clear limitations in current VR platforms' ability to support natural conversation, emotional understanding, and group presence.
- Meanwhile, the emphasis on realism, intuitiveness, and immersion in responses about virtual elements confirms the importance of these features for user satisfaction, in line with earlier results on preferred VR functionalities.

Moving on to the responses provided by non-users of VR.

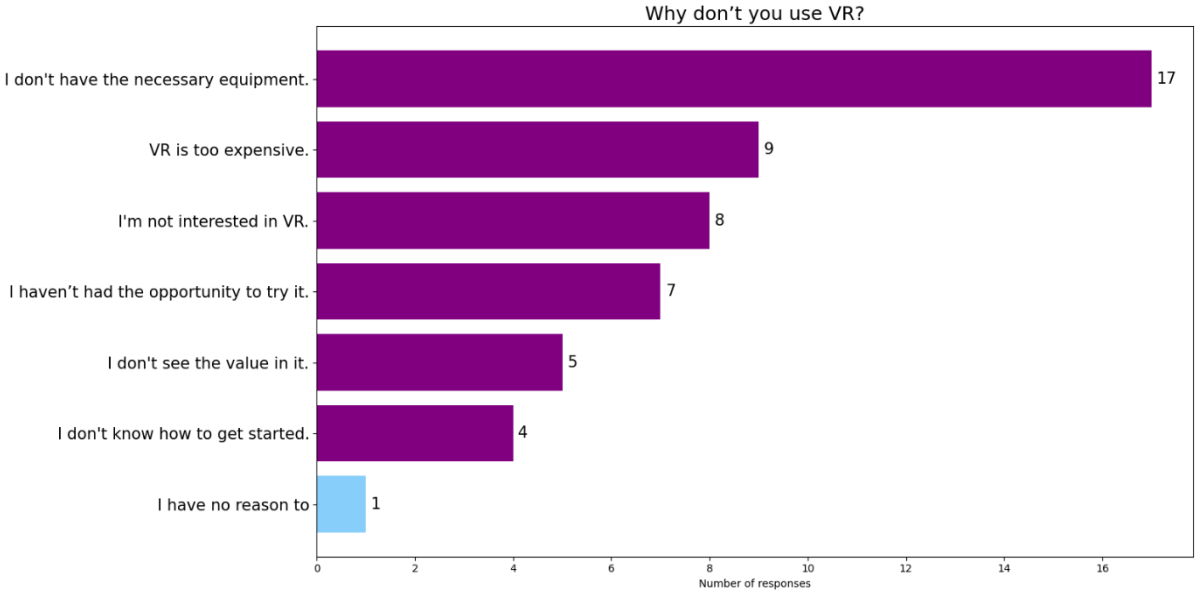
The following charts summarize the answers given by participants who stated that they have not used VR, either due to lack of access, interest, or opportunity. These insights

help to identify the key barriers preventing VR engagement, as well as the conditions under which non-users might consider trying it.

Among non-users, the most commonly cited reason for not using VR was *"I don't have the necessary equipment"*, mentioned by 17 respondents. This was followed by "VR is too expensive" (9 responses) and *"I'm not interested in VR"* (8 responses). These answers clearly indicate that cost and access remain the most significant obstacles for potential users, especially when combined with a lack of personal interest or perceived relevance.

Other reasons included *"I haven't had the opportunity to try it"* (7 responses) and *"I don't see the value in it"* (5 responses), which reflect limited exposure and unclear benefits. A smaller number of respondents admitted to *not knowing how to get started* (4) or simply *lacking a reason* to engage with VR (1). These findings suggest that both practical limitations and conceptual barriers (e.g., understanding, motivation) shape non-engagement with VR technology.

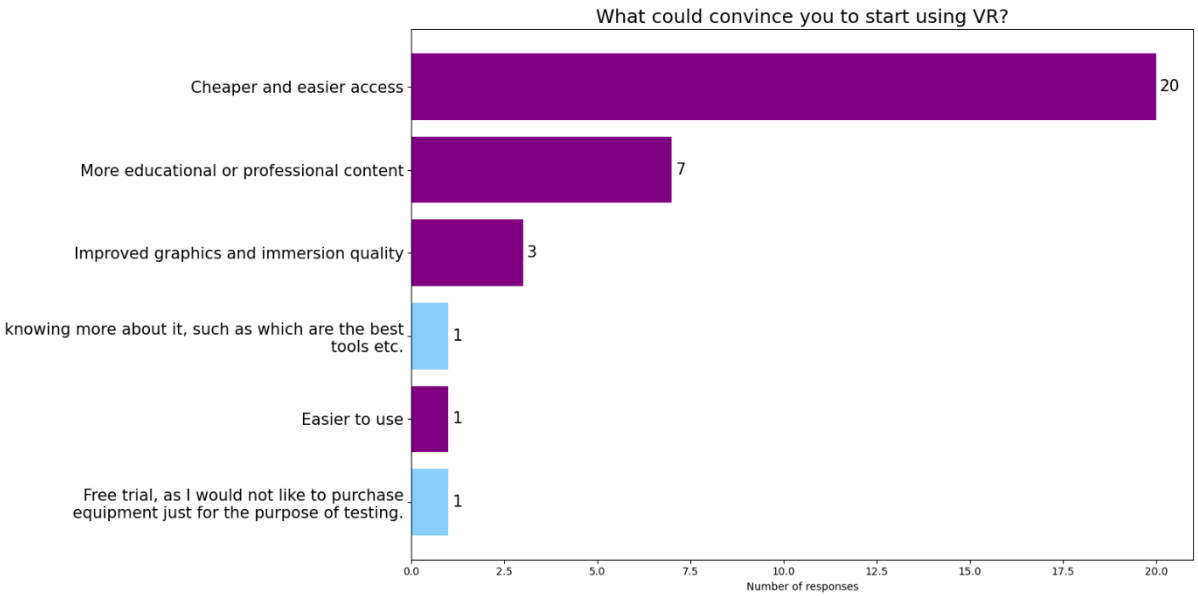
Fig. 29. Declared Reasons for not using Virtual Reality Technology.



When asked what might motivate them to use VR, non-users pointed most strongly to *"Cheaper and easier access"* (20 responses) as a key factor. This mirrors the previously identified barriers and reinforces the importance of affordability and availability in driving adoption.

Other motivating factors included *"More educational or professional content"* (7 responses) and *"Improved graphics and immersion quality"* (3 responses), indicating that while access is the primary issue, content quality and relevance also matter. Individual responses pointed to needs such as clearer information about tools, simplified usability, or a free trial to test VR without the upfront investment.

Fig. 30. Perceived drivers of willingness to try Virtual Reality.



Taken together, the responses from non-users suggest that lowering the entry threshold—both in terms of cost and complexity—could significantly broaden interest in VR. Additionally, offering meaningful, professionally or educationally valuable content, and creating opportunities for first-hand experience, may help convert hesitant or curious individuals into active users. Addressing these barriers is essential for inclusive and sustainable expansion of VR technologies.

Within the IMPULSE project, we do not have control over the cost of VR headsets or hardware. However, what we can do is focus on developing valuable, meaningful experiences, and on raising awareness of the benefits of using VR—particularly in the context of engaging with cultural heritage objects, whether through educational activities or artistic practice. By emphasizing content relevance and communicating potential uses, we can help make VR more approachable and attractive, especially for those encountering it for the first time.

Returning to the topic of cultural heritage, among respondents who identified as VR users, the question *"Have you previously interacted with digital cultural heritage objects?"* revealed a relatively balanced split, with a slight majority answering *"Yes"* (44 responses) and 35 respondents answering *"No"*.

Fig. 31. User Experience with digital representations of cultural heritage.

This indicates that a significant portion of VR users already have experience engaging with digital representations of cultural heritage, suggesting familiarity with digitized artifacts, museum content, or heritage-based virtual experiences. At the same time, the fact that over a third of users reported no prior interaction highlights the continued need for outreach, accessibility, and awareness-raising in this area—especially considering the potential of VR for education, interpretation, and creative practice within the cultural heritage domain.

When describing their experiences with digital cultural heritage, respondents referred to a wide range of examples—including general digital objects and 3D models, as well as books, paintings, museum collections, and resources from Europeana. They also mentioned augmented reality experiences and cultural content encountered in video games. Places played an important role in these associations as well—both in general references to historical sites and digital twins, and in specific mentions of scanned environments such as the Valletta underground and the Terezín ghetto.

Some participants also revealed their involvement in the active creation of digital cultural heritage. This included producing scans using LIDAR or photogrammetry, digitizing materials—particularly books and paintings—as well as providing consultation on digitization processes.

Some participants pointed to the opportunities offered by digital cultural heritage objects, particularly in terms of enabling new forms of user interaction with such materials. They also emphasized the value of making these resources accessible to people regardless of their geographic location or physical ability to visit museums—an issue that became especially apparent during the pandemic.

In the context of the IMPULSE project, particular attention should be given to the challenges related to developing appropriate ways of engaging with digital cultural heritage objects. Participants pointed out issues such as low graphic quality, lack of detail, the absence of multisensory experiences—especially touch—and the isolation of objects from their original context, which can lead to them being perceived as artificial or unreal, e.g.: *"Artificial, floating in the air, unreal."* (PL_19, item 2).

The perceived artificiality of such objects can evoke highly negative reactions and a sense of being deceived, as expressed in the following comment:

"Distance, untrust, when virtual things trying to make me believe they are real, I just reject the all stuff cause I feel fooled" (EN_48, item 2).

Participants saw potential for addressing these challenges through the use of storytelling and by placing digital objects within a meaningful context—an approach that was often linked to the importance of site-specific references. For example:

- *"2D and 3D digitization of heritage objects, the more it acts as a digital twin, the better. When these results can be used in VR applications, that is good. It gives context to otherwise isolated objects. An example from my own work is an isolated fragmented Assyrian palace relief, contextualized in a 3D model of a reconstructed palace room."* (EN_35, item 2).

8.3 Interviews

The interviews conducted as part of the IMPULSE project serve as a crucial source of qualitative insights into the user experience with immersive VR environments. These interviews were undertaken with a range of participants from various professional and academic backgrounds, providing valuable data on user expectations, challenges, and perceptions of immersive VR technologies. By analysing their reflections on the platform, the interviews offer a deeper understanding of how users engage with immersive systems, the functionalities they prioritize, and the barriers they encounter while using the technology.

Between March 25 and April 11, 2025, researchers from the IMPULSE project conducted and prepared nine interviews for further analysis, including transcription, description, and initial coding. Four interviews were conducted remotely, while five took place in person. Most of the interviews in this first phase of the study were conducted with representatives of Group 1. Three interviews were held with representatives of Group 2, and one interview involved a representative from Group 3.

The findings from these interviews complement the quantitative data gathered from surveys and other structured activities in the project. They provide nuanced, in-depth

insights into personal experiences that contribute to the iterative design process of the IMPULSE VR prototype. These interviews serve as an important source for understanding how users conceptualize and navigate the virtual environment, as well as their emotional responses and reflections on the platform's potential.

Given the composition of participants, the current dataset and findings are primarily oriented toward the educational dimension of VR use. This focus aligns with the themes explored during the workshops held in Leuven, where the potential of VR in pedagogical contexts was a central topic of discussion. The involvement of G1 participants in this phase reflects their strong connection to the educational applications of the technology. As future research continues, greater emphasis will be placed on exploring the experiences, needs, and expectations of participants from G2 and G3. This will ensure that the platform is refined to meet the needs of a diverse range of user groups and will support future iterations of the IMPULSE VR platform that cater to both creative and curatorial use cases.

The insights gathered from these interviews will be synthesized to inform the iterative development of the IMPULSE VR prototype, guiding the refinement of its functionalities and the design of an inclusive, user-centred immersive environment. These interviews, therefore, represent a critical foundation for understanding user engagement, emotional responses, and perceptions of immersive technologies, shaping the strategic direction for the platform's future iterations.

In the case of participants from G2 and G3, recruiting additional interviewees will benefit from collaboration with WP5 and the growing IMCo (IMPULSE Community of Practice) network. This process will naturally require time, as well as adjustments in scheduling and interview formats to accommodate participants from these groups, who tend to be less readily available than those in G1. Postponing the in-depth interviews with G2 and G3 representatives may also prove advantageous, as conducting these conversations after gaining access to a stable version of the platform prototype is likely to yield more concrete feedback and actionable recommendations.

The interviews were conducted by: MA, GG, AH, PK, ST, KT and ZV. The transcription files include the initials of the researcher who conducted each interview.

The following sections present the results of a preliminary thematic analysis conducted using MAXQDA. The aim of this analysis was to identify key barriers to VR use, users' expectations regarding VR, and functional features perceived as useful or desirable. These initial findings offer a foundation for further, more detailed analyses, which will be carried out in the next phases of the research.

At this stage of the IMPULSE project, in line with the planned timeline, it is particularly important to deliver practical insights for WP2, especially in relation to the design of the

platform. The current analysis is therefore intended to inform ongoing design decisions and support the development of user-centred solutions.

8.3.1 Indicated barriers

Participants' statements revealed a wide range of barriers related to the following aspects:

1. **Physiological barriers**, including symptoms of VR sickness and headaches, discomfort during prolonged use, difficulty using VR headsets while wearing glasses, discomfort caused by the perceived weight of the headset, and concerns about hygiene when using shared equipment, e.g.:
    a. *"There are medical reasons why a lot of people won't have had regular people in our laboratory refuse to try experiences because they anticipate having motion sickness or getting migraines."* (AH01_transcription, item 141-142)
    b. *"For example, there are those who perceive nausea, or those who see blurred inside the viewer (which often depends only on an eye distance setting that is not the same for everyone)."* (GG01_transcription, item 64)
    c. *"However, there are obstacles related to the fact that objects like headsets are not comfortable to use. They are very bulky"* (MA01_transcription, item 43)
    d. *"Well, during corona, you suddenly felt a bit uneasy about whether you might pick up some bacteria. Since then, I've had an awareness of the exchange of physical proximity via the glasses."* (ST01_transctription-eng, item 48)
    e. *"To be honest, the main reason is quite mundane, I have problems with my eyesight. Without glasses I can only see monocularly, and when I put them on, they simply don't fit under the VR goggles. This is quite a discomfort for me and puts me off a bit."* (KT01_transcription, item 27)
    f. *"After 10/15 minutes many people need to "get out". This represents a constraint."* (MA01_transcription, item 47)
2. **Affective and cognitive barriers**, including fear among novice users caused by visual isolation from the physical environment and feelings of disorientation; uncertainty about what to expect during VR experiences; boredom with available VR content; a perceived lack of social readiness to embrace VR; viewing VR as an impractical, game-related gadget with limited everyday use; lack of accessibility and inclusiveness for people with special needs; the belief that VR contributes to information overload and sensory overstimulation; perceiving VR as a prosthetic version of reality; the feeling of being confined or enclosed in a space that is imposed rather than chosen; the belief that VR content production is prohibitively expensive; and viewing VR through the lens of past, not particularly positive, experiences with the technology, e.g:
    a. *"Fear sometimes comes after, especially when you're talking about a VR headset, and they suddenly can't see their surroundings. Some people do feel disoriented."* (AH01_transcription, item 70);
    b. *"Even when I've had people who have had no experience, they're not sure what to expect. And then once they're inside an experience. Okay, there's surprise,*

enthusiasm, fear sometimes. but they're they never seem to have expectations per se. They're, they're always quite unsure of what to expect." (AH01_transcription, item 63-64);

c. *"Equipment limitations, financial limitations and the lack of admiration for those VR activities or VR exhibitions I've had to deal with, which, as I say, are on the one hand spectacular, on the other monstrously boring and falsify reality, although this pleases the general public. It has to be realised at a very high, truly extraordinary level to impress specialists. I saw three VR exhibitions in Japan in December and got tired."* (PK01_transcription, item 48);
d. *"Well, the question is how to look at social reality, whether this social reality adapts to some technological change, whether it sort of, that is, after the fact, something happens, or whether it anticipates these technological changes and already adapts and then when these technological changes come, society is ready for it."* (KT02_transcription, item 78);
e. *"One might expect would not adopt this technology, so until this becomes something that is perceived as being useful for more than just games."* (AH01_transcription, item 143-144);
f. *"Yes, it is a technology reserved for a healthy population. For a healthy society. All the people who are a bit off, well, non-normative, they often feel uncomfortable in such spaces, not to mention some medical conditions. This is a technology that we should have a choice to use, whether we use it or not. It is spectacular, but in my opinion, it also brings with it a whole range of different pitfalls."* (PK01_transcription, item 50);
g. *"Well, in virtual reality, well, let's say, if we extend it to reality, let's say, to this augmented reality, well, then we are obviously dealing with an extra portion of information which pops up for us somewhere all the time. And I think that if meditation leads us somewhere to some kind of inner peace and tranquillity, well, the opposite is just such an excess of information. And this overload of information will also lead to the opposite, to some, I don't know, mental disorders or simply weaker mental health."* (KT02_transcription, item 64);
h. *"The other reason is psychological: the fact of having, for example, wrap-around glasses that provide not only visual but also auditory immersion makes some people feel uncomfortable."* (MA01_transcription, item 41);
i. *"VR is the creation of a space to which humans are constrained."* (PK01_transcription, item 78);
j. *"But still, nothing can replace the touch, the smell of live wood, let's assume. Artificial worlds of all kinds will only be a prosthesis of reality and will work as prostheses work: they are getting better and better, but they are only prostheses."* (PK01_transcription, item 34);
k. *"Often, it is a matter of production costs, which one imagines to be very high, but in reality, it is not so, or in any case costs are very similar to the creation of an animated video"* (GG01_transcription, item 61);
l. *"Maybe there are people who are wary because they tried technologies from 10 years ago, not so sensational, and they believe VR is just that. Often, the viral*

technologies of the beginnings spoil the field for subsequent developments." (GG01_transcription, item 61).

3. **Equipment-related limitations**, including the high cost of VR hardware; lack of access to appropriate equipment and supporting infrastructure; the belief that powerful computers are necessary to use VR; difficulties related to the creation and maintenance of multi-user virtual environments (MUVE); the dependency of VR experiences on stable power supply; and the need to constantly keep up with rapid technological changes and updates, e.g:
    a. *"Accessibility is still an issue. It's still something again expensive, relatively expensive to buy"* (AH01_transcription, item 163);
    b. *"When it comes to working with students, I think the main problem is the lack of availability of equipment. At the university, we don't have VR goggles or any infrastructure that would allow us to use this technology in class."* (KT01_transcription, item 29);
    c. *"To be able to run it, you also need a fairly beefy computer"* (ZV02_transcription, item 32);
    d. *"The technology gallops away"* (ST01_transctription-eng, item 45)
    e. *"In company presentations and communications, for example, there is often a reference to the dimension of multi-user interaction, but in practice, it is technically complicated to set up in an experimental environment."* (MA01_transcription, item 43);
    f. *"And all these activities hinder our perception for trivially simple reasons. For example, because of the lack of electricity."* (PK01_transcription, item 40-42).
4. **Barriers related to the competencies required to use VR**, including a lack of relevant competencies; absence of adequate support during implementation; limited time to explore or integrate VR into one's practice; and the belief that using VR requires specific technical skills and formal training for users, e.g:
    a. *"There is a lack of literacy and this creates resistance."* (GG01_transcription, item 61);
    b. *"With VR and AI you always need someone to facilitate the devices"* (ST01_transctription-eng, item 55);
    c. *"The time constraints involved in educating future artists. The pace of working with them, the number of students and the activities involved, such a daily grey day of a teacher, from my perspective, completely excludes such activities. It can be done on the basis of workshops, some one-off meetings, but not continuous full learning, only as a gadget and a kind of break from the hard reality related to the specifics of our work."* (PK01_transcription, item 46);
    d. *"Also, my technical knowledge is lacking, I'm not an expert on how to use such devices, so I would need some training or support to start using it at all."* (KT01_transcription, item 27).
5. **Barriers related to the quality of VR content**, including the perception that available content is uninteresting or not suited to a broad audience—often due to its origins in STEM fields; the lack of high-quality, engaging content; and concerns that VR may prioritize technological spectacle over meaningful substance; some

participants also expressed fears that VR could pose a threat to traditional forms of learning and cultural experience, e.g:

   a. *"I also feel there's a bit of a stigma associated with it, specifically in the gaming sphere, is that I do not like to associate. It doesn't have the same cultural capital that, let's say, a single-player 3D video game like The Witcher has, that I can justify in terms of my research. VR I find more difficult to justify beyond the whole field of ludic studies, like game studies, like ludography, whatever you want to call it."* (ZV02_transcription, item 32);
   b. *"Yes, I have happened to hear criticisms, mainly from people who are more 'traditional' in their approach to communication and teaching. From their perspective, VR can be seen as too 'flashy' and distracting from the educational content. Such proverbial form over substance."* (KT01_transcription, item 31).

6. **Limited immersion compared to that experienced in the physical world**, including the reduction of immersion caused by disconnection from the physical environment; the absence of real sensory input, particularly touch; issues with equipment fit—such as VR headsets not sealing properly and allowing light to enter around the nose bridge, which disrupts the sense of full isolation; and the limitation of interpersonal contact, which some participants viewed as essential to meaningful engagement, e.g:
   a. *"These notions of immersion, that it actually would achieve the opposite of what I'm talking about now, that instead of it heightening immersion when people go and see a theatre performance and are more aware of their perception, that actually it will alienate them more from like the materiality in which they find themselves."* (ZV02_transcription, item 42);
   b. *"Sometimes it's a bit crappy, in the sense that, for instance, the goggles are too big, and then you see (...). Like you see, you don't, you're not completely immersed in the environment. Because the light is coming from the room, and, or you hear other people chatting. So, yeah, you should be immersed in the environment, but, like, it's literally impossible if you're not in a place that allows you to be immersed and focused."* (ZV01_transcription, item 46);
   c. *"This is because there is another limitation, which can occur, for example, when there are VR installations, related to the fact that the user who is testing is alone, and there is little interaction with those who are watching or assisting with the test"* (MA01_transcription, item 43).
7. **Lack of perceived need to use VR**, e.g.: *"I can't say that I am actively and systematically exploring this topic, as no such specific need has arisen so far"* (KT01_transcription, item 11).
8. **A belief in the limited applicability of VR**, e.g.: *"cost and limited application at the moment the primary use"* (AH01_transcription, item 139).
9. **The impact of the "wow effect" among beginner users**, e.g.: *"On all occasions when I have used headsets for experiments or training sessions, it emerged that for most users, it was their first time trying this type of equipment. This situation, in my opinion, generates a level of distortion in the results because users are very impressed"* (MA01_transcription, item 41).

10. **Ethical concerns:** *"But for AI, there's also the ethical consideration, I think, about using all that energy in all those data centres, which, again, I presume by now there's also data centres in the EU that are being used, but still is primarily located in North America. And so I do think there is a significant – I'm thinking of the correct term right now. I think there is a very significant threshold of accessibility, where when you have access to those technologies, then, yes, they can definitely augment your workflow. And I myself am fairly positive when it comes to using computers, digital media in general. However, I do feel that specifically – like I feel more positive about VR and AR than I do about AI"* (ZV02_transcription, item 34).
11. **Reflections on the influence of transhumanism on the development of VR**: *"Well, it depends. If, thinking from the side, if we went in the direction of transhumanism, that is, that people would be augmented by artificial intelligence through certain connections between the biological layer and the technological layer, well, of course, these could be new scientists. At the same time, they wouldn't exactly be people as we understand them and today."* (KT02_transcription, item 83).

Some of these barriers reflect perceptions or assumptions that may not necessarily align with technological realities once accurate information about VR is obtained. Nonetheless, they currently function as real obstacles for users and significantly shape their willingness—or reluctance—to engage with the technology.

The interviews yielded a rich set of functionalities that participants encountered during their own experiences with VR. These functionalities vary in terms of complexity and ease of implementation. Rather than representing a list of mandatory requirements for the prototype being developed within the IMPULSE project, they serve as indications of what users believe could or should be included in a VR environment. As such, they offer valuable recommendations for the future activities of cultural institutions.

Among the functionalities mentioned were:

- **the ability to interact with objects**, including viewing 3D objects, changing the size of objects, copying and moving them within the environment, touching or simulating tactile interaction, approaching objects to observe them more closely, and importing custom 3D objects, e.g:
    - *"And one of the fascinating points was how everyone could grab the sculpted piece and create a duplicate and scale it and interact with it. So everyone basically had a copy of the sculpture in their own hands and virtual hands and was able to interact with it in ways that would not be possible, or in the real world, or would be expensive or would be damaging, which again, it depends on what your goal as an artist is some people. Some artists want their art piece to be lived right? Maybe the destruction of the art piece is its very purpose of existing. So, having an art piece that's easily replicated would defeat the point. But it depends what the artist's objective is for somebody else."* (AH01_transcription, item 190-191);

- *"But, for me, VR is like a bit more, like, it involves, it should involve more, like, sensory experiences, and really being able to move, maybe, or to pick things, or, I don't know, to sort of, yeah, interact with the objects."* (ZV01_transcription, item 32);
- *"being able to zoom in and get a lot closer than you would if you are seeing the thing in person."* (AH01_transcription, item 232);

– **navigation-related functionalities**, including intuitive and familiar input methods similar to using a computer mouse or keyboard, as well as comfortable and immersive hand tracking solutions that eliminate the need for physical controllers, e.g:
  - *"On the other hand, the impact of novelty is more contained when, for example, a video game (with mouse/keyboard input) is used as a platform for experiments. These are still virtual worlds or realities, but these platforms have largely codified and familiar interaction modes for a good portion of users. Of course, there are differences in age, experience, etc., but generally, what I find is that with systems using traditional mouse/keyboard input, there is a lower barrier to entry compared to using headsets."* (MA01_transcription, item 41);
  - *"it's definitely improving the fact that hand tracking is becoming so seamless and the need, the known, the lack of need for controllers that is obviously going to make experiences a lot more seamless because people can interact with the virtual scenes in a more intuitive fashion. It's not about learning which button to press, or which joystick to push. So I think it's going to become a lot a lot easier."* (AH01_transcription, item 164-165);
– **functionalities related to movement within the virtual world**, including the ability to rotate the user's point of view and to move between locations using portals, e.g:
  - *"They can simply turn round and see the rest of the room"* (ST01_transctription-eng, item 36);
  - *"The concept of portals that you can walk through. So you can immediately walk from one environment to a completely different environment which doesn't even necessarily match in scale."* (AH01_transcription, item 205-207)
– **functionalities related to camera and perspective**, including the ability to change and select different points of view, as well as to adjust camera settings, e.g:
  - *"In terms of scale, like the ability for a VR experience to have you walk around as if you were a child. So, seeing everything from a lower level, or the way things, the way your expectations of the world can have something appear real or in proportion, or suddenly be a miniature item, even though it's the same object your own wired up perception, preconceived notions."* (AH01_transcription, item 198-199);
  - *"by being able to choose your own point of view"* (AH01_transcription, item 236);
  - *"make a camera movement through a linear drawing, or theoretically move around in the space"* (ST01_transctription-eng, item 26);

- **multi-user functionality in real time**, allowing multiple users to interact within the same virtual environment simultaneously, e.g.:
  - *"virtual spaces and 3D assets can become not only spaces for acquiring knowledge but also spaces for design, for example, by prototyping solutions, concepts, and projects in real-time among different connected users."* (MA01_transcription, item 51);
- **functionalities related to the specific nature of virtual environments**, including the use of spatial sound to enhance immersion and support spatial orientation; the ability to break free from physical laws such as gravity; and the possibility to manipulate space and time within the environment, e.g:
  - *"spatial sounds, which also draws attention to where the sound comes from"* (ST01_transctription-eng, item 43);
  - *"In VR, you don't need to stick to the rules of reality, so sometimes it helps to try and find something that lends itself more naturally to the medium rather than replicate what we're familiar with from reality."* (AH01_transcription, item 86-89);
  - *"its ability to manipulate space or manipulate time to surprise and engage the audience in an unexpected way, giving them a novel experience."* (AH01_transcription, item 85-86);
- **the ability to create virtual galleries**, for example, to exhibit student work or other curated collections, e.g:
  - *"import three-dimensional materials created by students to make virtual galleries, which if you want also looks a lot at the dimension of the metaverse, therefore of shared spaces."* (GG01_transcription, item 55);
- **the ability to draw in 3D within the VR headset**, enabling users to create spatial sketches and visual annotations directly in the virtual environment, e.g:
  - *"a piece of software - I can't think of the name right now - where you can draw in three-dimensional space, under the VR glasses, you have the VR glasses on and draw with them."* (ST01_transctription-eng, item 25);
- **functionalities related to the creation and experience of films**, including support for 360-degree video content and the use of visual effects (VFX) within the VR environment, e.g:
  - *"Blending of different locations and different storylines in 360-degree space"* (ST01_transctription-eng, item 35);
  - *"You're freer to choose your camera angle and you can use a studio set by working cinematically and you can work with VFX who can add a ceiling or you can use a complete 360-degree world."* (ST01_transctription-eng, item 58).

In addition to the desired functionalities, interview participants also shared a wide range of expectations related to the use of VR. These included:

1. **Increased accessibility** – enabling broader access to places, experiences, and experts that might otherwise be out of reach, e.g:

a. *"being able to visit, to see, to interact with a lot of experiences that otherwise might not be available to you. To be able to do those virtually is a huge bonus from an education perspective."* (AH01_transcription, item 218);
b. *"A virtual classroom can, for example, facilitate the presence of experts who might not otherwise be physically present. A video call could also do it, but the experience is completely different. In a collective immersive space, you are aware that you are sharing that virtual place, and you can perceive the presence of other people (because it simulates reality). It is something that could change the course of certain paths and, above all, it could lead students to have a better predisposition towards group work (gain experience during the training years of what the world of work will be like)"* (GG01_transcription, item 78);
c. *"VR could improve the learning of subjects such as science and history (e.g. virtual tours in ancient Rome), to give pupils a more tactile experience, compared to a classic visit to the museum."* (GG01_transcription, item 53).

2. **Support for specific activities**, such as skill development in simulated environments; historical event reconstructions; documentation of crime scenes; simulation-based analysis of complex phenomena; collaborative prototyping; 3D modelling; running simulations; artistic creation; preserving experiences; supporting traditional teaching activities; and enriching content with annotations, e.g:
    a. *"Again, safety and training or use of equipment which you would not have access to. So again, we've seen the examples with medical training. But obviously we could have simpler things. I don't know VR experiences where kids learn how to cook, you know, which is safe, because you don't have any real fire, but they could still be learning how to, you know, prepare and handle knives and things of the sort in a manner that doesn't put them at risk. So there's a lot of, I think, a lot of applications in in every possible field for learning using. VR."* (AH01_transcription, Poz. 221-224);
    b. *"Regarding my field, communication, VR opens up fascinating possibilities. For example, one could analyse how people behave in different simulated social situations, how interactions change depending on context, space, distance."* (KT01_transcription, item 22);
    c. *"Virtual spaces and 3D assets can become not only spaces for acquiring knowledge but also spaces for design, for example, by prototyping solutions, concepts, and projects in real-time among different connected users."* (MA01_transcription, item 51).
3. **Further development of VR technology**, especially in relation to more comfortable hardware solutions and advances in spatial sound, e.g:
    a. *"Another example is that of devices that become lighter and integrated into people's daily clothing, ensuring a more massive adoption."* (GG01_transcription, item 74);
    b. *"But I also like spatial sound, for example. So, VR could develop even more in that area. Yes, there would be more."* (ST01_transctription-eng, item 58).

4. **The ability to convey content in a new and original way**, offering novel forms of engagement and expression, e.g:
    a. *"As far as school teaching is concerned, on the other hand, VR could improve the learning of subjects such as science and history (e.g. virtual tours in ancient Rome), to give pupils a more tactile experience, compared to a classic visit to the museum. Gamification has ramifications everywhere and could be a method to reinforce teaching."* (GG01_transcription, item 53);
    b. *"In the educational field, it would be very interesting to work with VR tools to create scenarios and environments where users can move around and have design experiences."* (MA01_transcription, item 51);
    c. *"I would use it like as a sort of engagement tool."* (ZV01_transcription, item 84).
5. **The expectation of voluntary use**, emphasizing that VR should remain an optional tool, not a compulsory requirement: *"It is a technology that we should have a choice to use, whether we use it or not."* (PK01_transcription, item 50).
6. **High-quality graphics**, with users expecting visually appealing and detailed environments: *"If you've got a high, you know, like a high detailed scan, 3D scan of a of an oil painting or something of the sort experiencing it and actually seeing the different levels of the paint build up."* (AH01_transcription, item 230-231).

One aspect that, while obvious from a UX perspective, remains important to emphasize is the need to tailor content to the intended audience. For example:

"Try to be more attractive, give exclusive content. This has already been proven and has not attained the desired effect, because those who join are already skilled experts. Yet, you have to work on being attractive. For example, this is a separate market from that of those who go to the cinema. The latter does not necessarily translate into the market of people who use VR apps. Therefore, it is necessary to diversify and intercept that target." (GG01_transcription, item 74).

Expectations were also expressed in relation to the inherent characteristics of VR. For example, one participant emphasized the importance of designing VR experiences with the physical space in mind—the actual space in which users will interact with the environment:

"I wouldn't separate the two. The virtual, the physical, the studio space is still an integral element of a lot of virtual reality experiences, if nothing else, from a safety perspective, making sure that that people do have space to navigate, that the experience you're creating isn't encouraging the user to move in a way that might cause them or people around them, or objects around them, any harm or damage, so the space itself cannot be separated from the use. Then there's also on the experience itself. Some experiences might be designed for minimal movement." (AH01_transcription, item 97-98).

This participant also highlighted the awareness that VR will not replace the physical world; however, it was acknowledged that it offers more possibilities than traditional means of visualizing content:

"The moment you're going to be missing out on smells, on sounds and things of the sort, but it's still better than nothing for people that might not have a way of experiencing these things. And VR is a step up from just visualizing just seeing pictures on a website or a Youtube video, because you can actually have some agency and walk around in these sites and things of the sort." (AH01_transcription, item 220-221).

Finally, a suggestion was made regarding what could increase interest in VR among non-users—namely, the opportunity to try out VR equipment for free:

"Definitely the possibility of renting equipment or even creating a VR studio at the university that we could use during classes. This would be a huge improvement, as currently access to such equipment is very limited." (KT01_transcription, item 38).

8.4 Synthesis and Cross-case Analysis

8.4.1 Synthesis and Cross-case Analysis

The synthesis of results across the three research methods—participatory workshops, quantitative surveys, and semi-structured interviews—has provided a nuanced understanding of the diverse ways users from various professional backgrounds interact with the IMPULSE VR prototype. These methods were employed to triangulate data and uncover deeper insights into users' expectations, challenges, and functional needs. This synthesis not only identifies common barriers faced by users but also offers key recommendations for refining the prototype to better suit the needs of specific user groups.

8.4.1.1 Comparison of Results from Three Methods

The three research methods employed in this study—participatory workshops, surveys, and interviews—complement each other, yielding a holistic view of user engagement with the VR system.

1. **Participatory Workshops:** These workshops provided real-time interaction with the prototype, fostering immediate feedback and collaborative scenario development. The interactive nature of the workshops allowed participants to engage deeply with the system, generating spontaneous insights into usability issues and emotional engagement. The workshops also revealed immediate technical problems such as system instability, slow performance, and difficulties in navigating and manipulating content. These observations, made during active

interaction with the system, highlighted the users' reactions to the prototype in practical conditions, with a particular emphasis on the technical difficulties they encountered.

2. **Quantitative Surveys:** The surveys were designed to provide a broader and more structured view of users' perceptions of the system. Through a standardized set of questions, the surveys captured data related to usability, immersiveness, narrative engagement, and interaction patterns. They provided statistical evidence of the trends observed in the workshops, notably confirming concerns about system instability, slow content loading, and difficulty with spatial movement. In addition, the surveys highlighted specific user expectations around accessibility and personalization features, such as avatar customization and more intuitive movement options.
3. **Semi-structured Interviews:** The interviews provided a more in-depth, qualitative understanding of user experiences. Through detailed personal reflections, the interviews offered nuanced insights into how participants with varied backgrounds perceived immersive technologies. The interviews captured complex emotional and cognitive responses to VR, including fear among novice users regarding visual isolation and disorientation, and concerns about **physical** discomfort and technology-related anxiety. Unlike the surveys and workshops, interviews offered a deeper exploration of users' expectations for future VR applications, including the potential for creative expression and narrative flexibility.

8.4.1.2 Mapping Insights and Behavioural Patterns.

By triangulating these methods, the study revealed several consistent themes and patterns that inform both the design and anticipated user interaction with the IMPULSE VR prototype.

1. **Usability Issues:** The most prominent usability issues across all methods were system instability and slow performance, with significant technical barriers related to crashes, navigation difficulties, and difficulty manipulating content. Participants in the workshops and interviews described unpredictable object behaviours and unclear navigation controls, which detracted from the user experience. These recurring issues across different methods underline the critical need for technical optimization. Addressing these concerns will improve the platform's stability, thereby making it more reliable for real-world use and user testing.
2. **User Expectations:** One key finding across all research methods was users' desire for greater control over the immersive environment. Participants expressed a strong interest in customizing various elements, such as backgrounds, objects, and avatars, to better align the environment with their specific goals. This was especially pronounced among G2, who emphasized the importance of creative expression. Both the workshops and interviews highlighted a need for more dynamic control over the virtual space. Features such as avatar personalization,

spatial control, and alternative movement options (e.g., teleportation or flying) were repeatedly mentioned as essential for increasing user agency and enhancing the immersive experience.

3. **Affective and Experiential Insights:** The emotional engagement and narrative aspects of the VR system were identified as key drivers of user engagement, particularly for G1 and G2. For G1 participants, particularly those with limited VR experience, structured educational content and guided navigation were paramount. They expressed a preference for clear, easily navigable systems that could support their educational goals without overwhelming them with complexity. Conversely, G2 participants, with a stronger emphasis on creativity, prioritized artistic freedom and emotional resonance in narrative construction. For G3, the focus shifted to the technical robustness of the platform, with specific emphasis on metadata integration, multi-user collaboration, and curation tools.

8.4.1.3 Differences Between User Groups.

The comparative analysis of G1, G2, and G3 revealed distinct differences in how each group engages with the IMPULSE VR prototype, shaped by their professional backgrounds and digital competences.

1. Group 1:
    a. Key Needs: Clear and structured content, intuitive interface, stability;
    b. Challenges: Technical instability, lack of pedagogical scaffolding tools, beginner user struggles;
    c. Expectations: The expectation for predictable, stable VR environments that could be seamlessly integrated into educational settings.
2. Group 2:
    a. Key Needs: Creative freedom, artistic expression, avatar customization;
    b. Challenges: Limited customization options, absence of tactile feedback, frustration with platform limitations;
    c. Expectations: Flexible storytelling, narrative engagement, and the ability to express creativity through the platform.
3. Group 3:
    a. Key Needs: Metadata support, multi-user functionality, robust content manipulation;
    b. Challenges: Insufficient multi-user options, inability to fully integrate with professional workflows;
    c. Expectations: Reliability, professional-grade tools for curation, exhibition development, and collaboration.

8.4.1.4 Impact of Previous Digital and Cultural Competences.

A key influence on user engagement with the IMPULSE VR system was participants' prior digital and immersive technology experience. The level of exposure to digital tools shaped users' engagement and comfort with the platform, as follows:

- G1 participants, many of whom had limited VR experience, required more instructional guidance and sought educational content that could help them navigate the immersive environment.
- G2 participants, who had more exposure to visual arts and creative practices, engaged more freely with the system, seeking tools that would allow for non-linear interaction and artistic control.
- G3 participants, with strong professional backgrounds in cultural heritage, were more focused on the functional aspects of the system, especially its ability to handle metadata, track provenance, and support multi-user interaction for professional curatorial tasks.

Conclusion

This synthesis and cross-case analysis has provided a detailed understanding of how users from different professional and academic backgrounds interact with the IMPULSE VR prototype. The triangulation of insights from workshops, surveys, and interviews revealed both shared challenges and group-specific expectations that will guide the next steps in the iterative design process. The study highlights the critical need for system stability, customization tools, and improved technical features such as multi-user functionality and interactive narrative options.

These insights provide clear recommendations for improving the IMPULSE VR prototype in line with user expectations, ensuring that the platform is more inclusive, user-centred, and able to meet the diverse needs of its intended users in the cultural and educational sectors.

8.5 Recommendations

The findings from the IMPULSE project research activities—participatory workshops, quantitative surveys, and semi-structured interviews—reveal essential insights that will guide the refinement of the VR prototype. This section synthesizes the results into actionable recommendations across multiple domains: general design, narrative and interaction design, and strategic recommendations for future work packages (WP). Additionally, recommendations related to inclusivity and cultural sensitivity will ensure that the prototype remains accessible and culturally relevant to diverse user groups.

8.5.1 General Design Recommendations

The overall design of the **IMPULSE VR platform** should address the key usability and technical challenges identified across all research methods. The following general design recommendations are proposed to enhance the user experience and ensure the platform's success:

The following set of inclusivity and cultural sensitivity recommendations has been developed based on user research and workshop insights. While some of these recommendations are being directly addressed within the scope of the IMPULSE VR platform, others extend beyond the current technical and organisational remit of the project. They are therefore intended as strategic guidelines for future initiatives operating at the intersection of immersive technologies (e.g., VR, multi-user virtual environments) and cultural heritage.

By distinguishing between implementable and aspirational elements, this section aims to contribute to broader discussions on accessibility, ethical cultural representation, and inclusive design in digital heritage environments.

Of the recommendations, the following are of particular note:

1. **System Stability and Performance: t**he most consistent concern across all methods was system instability. Participants highlighted platform crashes, slow performance, and difficulty with object manipulation. To address these issues, it is crucial to prioritize technical optimization. This includes:
    a. Enhancing the processing power of the system to handle complex 3D objects and multiple users simultaneously;
    b. Reducing latency in user interactions and ensuring smooth transitions between virtual environments.
2. **User Interface (UI) and Accessibility:** based on the feedback from G1, G2, and G3, the UI should be intuitive, customizable, and easy to navigate:
    a. Clear guidance and onboarding tutorials should be provided, particularly for novice users in G1;
    b. Simplified controls should be available for beginners, with the option to move to more advanced features for experienced users;
    c. Accessibility features, such as customizable font sizes, colour contrast options, and keyboard navigation, should be considered and recommended for future initiatives to ensure the platform can be used by a wide range of users, including those with disabilities.
3. **Personalization and Adaptability:** to address the needs of users from G2 and G3 the platform should include greater personalization:

a. Avatar customization and interactive environmental elements that allow users to adjust the virtual space according to their personal or professional needs;
b. Multi-user functionality must be enhanced to facilitate collaborative work across users, especially in the context of cultural and educational tasks.

8.5.2 Narrative and Interaction Design.

The **narrative and interaction design of the IMPULSE VR platform** plays a pivotal role in shaping the user experience, particularly for G2 and G3 users, who are more inclined toward storytelling and curation in immersive environments.

Recommendations include:

1. **Narrative Flexibility and Artistic Expression:** as highlighted by G2 participants, the platform should allow for non-linear storytelling and artistic freedom. This could be achieved through:
    a. Tools that enable users to rearrange and customize objects, backgrounds, and narratives dynamically;
    b. Enhanced interaction models that support multivocal storytelling, understood as the coexistence of diverse voices, perspectives, and narratives within a single environment, allowing users to combine various cultural narratives or artistic expressions in a shared storytelling space;
    c. The platform should support immersive environments for emotional and sensory engagement, enhancing user connection with the virtual content.
2. **Spatial Interactions and Movement**: both G1 and G2 participants expressed a desire for more immersive movement and spatial interactivity. This could include:
    a. Intuitive movement controls like teleportation or free-range walking, ensuring smooth navigation;
    b. The ability to interact with objects within the environment, such as scaling, rotating, or duplicating objects;
    c. Enhanced tactile feedback, allowing users to feel interactions with objects, either through haptic feedback or simulated tactile sensations. Enhanced tactile feedback, allowing users to feel interactions with objects through haptic feedback or simulated sensations, such as collision detection or visual/auditory cues that mimic tactile responses.
3. **Narrative Tools for G3**: for G3, who require metadata support and curation tools, the platform should allow users to:
    a. Anchor narratives to specific objects or events;
    b. Integrate external datasets for objects, such as historical context, cultural significance, and provenance, which are crucial for the cultural heritage sector;
    c. Include tools for collaborative storytelling, allowing curators and educators to create shared, immersive cultural experiences in real-time.

8.5.3 Strategic Recommendations for Next WP.

The insights gained from the analysis of user interactions, feedback, and expectations across the participatory workshops, surveys, and interviews provide a crucial foundation for the ongoing development of the IMPULSE VR prototype. Based on the synthesis of these findings, strategic recommendations have been formulated to guide the next steps in the project, specifically within the context of WP2, WP3, and WP5. These recommendations aim to address the identified usability challenges, align the platform with user needs, and optimize its educational, creative, and cultural engagement capabilities. By incorporating both the technical and experiential insights derived from the research, the recommendations offer targeted guidance to enhance the overall user experience, support effective immersion, and ensure that the platform is adaptable and inclusive across diverse user groups. These strategies will inform not only the immediate development priorities for the next work packages but also the long-term goals of fostering a more accessible, engaging, and robust immersive environment for all users.

This paragraph sets the stage for the detailed recommendations to follow, emphasising the integration of user feedback into the strategic decisions for the next phases of the project.

8.5.4 Strategic Recommendations for WP1: User Research and Persona Development.

WP1 plays a pivotal role in the IMPULSE project, providing foundational user insights that shape the design, functionality, and user engagement strategies of the immersive VR platform. The work package focuses on gathering user requirements, defining user personas, and establishing user profiles that guide the development of an environment tailored to meet the diverse needs of G1, G2, and G3 user groups. Based on the insights from the current research phase, the following recommendations have been formulated to strengthen WP1's contributions to the project's evolution.

8.5.4.1 Refinement of User Personas.

One of the key outcomes of WP1 has been the development of provisional user personas, which encapsulate the behavioural patterns, needs, and expectations of the primary user groups (G1, G2, G3). These personas are based on a combination of desk research, literature analysis, and early-stage empirical data.

Recommendation:

- WP1 should continue refining these personas based on further qualitative data from interviews and workshops, ensuring that they evolve alongside the project's

ongoing findings. By integrating real-time feedback from the next phase of user testing, WP1 can ensure that the personas remain accurate, contextual, and dynamic.

Additional Guidance:

- Multi-Dimensional Personas: Ensure the personas reflect multiple dimensions of user experience, including digital literacy, experiential orientation, interaction preferences, attitudes towards immersive technologies, and cultural values. These dimensions should be regularly updated based on longitudinal user engagement data.
- **Contextual Relevance:** The personas should be adapted according to emerging user expectations, particularly considering the barriers and functional gaps identified in the most recent interviews and surveys. It is important to recognize the distinction between users, non-users, and experts, as previously detailed in Deliverable 1.1 (Krakowska, Zych, Deja, 2024, p.13-18), to ensure clarity and avoid any confusion regarding the needs of each group.
- **Users**: these individuals are actively engaging with the system or have the potential to do so. Within this category, we have further differentiation:
    - **Non-expert users** (e.g., students or early-career artists) who may require more structured learning pathways and clear guidance.
    - **Expert users** (e.g., experienced educators or professional artists) who seek greater artistic flexibility, advanced functionality, and deeper immersion within the platform.
- **Non-users**: individuals who have not yet engaged with the technology, either due to lack of awareness, resources, or perceived relevance. This group requires a tailored approach that addresses barriers to adoption, such as awareness-building and simplified onboarding processes.
- **Experts**: users who possess deep knowledge and experience with immersive technologies or cultural heritage practices. These individuals may require higher-level customization and functionality to suit their advanced needs. They are also likely to have specific feedback on how the system can be refined to support professional workflows and research purposes.
- For example, G1 users may need structured pathways to help integrate immersive environments into their learning, while G2 users might look for more flexible, open-ended creative tools. By considering both user expertise and familiarity with immersive technologies, the development of personas can be better aligned with the full range of user needs, ensuring a more targeted and user-centred approach.

8.5.4.2 Expansion of User Research Methodologies.

While the interviews, surveys, and participatory workshops have provided essential insights into user needs and barriers, WP1 can benefit from expanding its methodological toolkit to cover a wider range of user feedback techniques.

Recommendation:

- Incorporating Observational Research: Given the limitations of self-reported data, especially when it comes to immersion and emotional engagement, WP1 should consider integrating more observational research methods. Observing users' interaction patterns and behavioural responses during live sessions or user testing will provide additional qualitative insights into how users interact with the VR platform.

Additional Guidance:

- Ethnographic Approaches: Exploring contextual interviews or ethnographic methods to understand how users engage with VR in real-life settings (e.g., museums, classrooms, or art studios) will help in contextualizing the personas and ensuring they represent real-world environments.

8.5.4.3 Integration of Cross-Group Data.

Given the varying needs of G1, G2, and G3, WP1 must prioritize cross-group analysis to identify shared patterns and distinct differences in user behaviour.

Recommendation:

- Comparative Analysis of Personas: Conduct comparative analysis of user personas across G1, G2, and G3 to identify both commonalities and discrepancies in their needs, expectations, and barriers. This analysis will help align the platform's design and narrative elements with the requirements of different user groups.

Additional Guidance:

- Cross-Case Analysis of User Data: By incorporating findings from both the workshops and interviews, WP1 can gain a deeper understanding of cross-group behavioural patterns. For instance, G2 artists may exhibit distinct creative and emotional needs compared to G1 or G3 groups. These differences highlight the importance of identifying unique needs across each group, enabling the personalization and customization of VR content and interactions. G3, consisting of CCI as well as the cultural heritage professionals such as curators and educators, may place a greater emphasis on the functionality and reliability of the

system in supporting professional tasks, such as curation and exhibition development.

8.5.4.4 Focus on Barriers and Functional Gaps.

WP1 should continue to monitor, identify, and analyse the barriers and gaps that participants encounter in their VR experiences. As revealed in the interviews and surveys, users face a range of barriers, such as technical limitations, physiological discomforts, affective challenges, and equipment-related issues.

Recommendation:

- Barrier Identification and Prioritization: WP1 should systematically identify and prioritize these barriers, ensuring that they are addressed in the development of future prototypes. This may involve collaborating with WP2 to ensure that these barriers are mitigated in the technical design and WP3 to ensure they are considered in the UX design.

Additional Guidance:

- User-Centric Solutions: Based on the identified barriers (e.g., motion sickness, equipment discomfort, lack of navigation clarity), WP1 should propose targeted solutions that can be tested in future iterations of the prototype. These solutions should prioritize user comfort and accessibility, while ensuring that the system remains intuitive and engaging for all user groups.

8.5.4.5 Further Testing and User Feedback.

Given that the current dataset and insights are based on a small sample size, WP1 should aim to broaden the scope of user feedback in future research phases.

Recommendation:

- Continuous User Engagement: In alignment with the iterative design process, WP1 should continue engaging with users throughout the project's life cycle. This includes conducting additional interviews, focus groups, and user testing sessions to capture long-term feedback as the platform evolves.

Additional Guidance:

- Longitudinal Research: WP1 should design a strategy for longitudinal research to track how user needs and expectations evolve over time. This is particularly important in the context of G1, whose engagement may deepen as they familiarize themselves with the platform, and G3, who may refine their needs as the platform integrates into professional workflows.

8.5.4.6 Collaboration with Other Work Packages.

WP1 should maintain close collaboration with WP2 (Prototype Development) and WP3 (Data Standards and Interoperability) to ensure that user insights directly inform design and development decisions. WP1's focus on understanding user needs and experiences in immersive environments will provide crucial input for WP2's technical design and for WP3's work on data standardization and integration strategies.

Recommendation:

Feedback Integration Across WP2 and WP3: WP1 should regularly share its findings with WP2 and WP3, facilitating the integration of user insights into the iterative development of the platform. This will help ensure that user personas evolve alongside the platform's technical and data infrastructure, ultimately leading to a more user-centred product. By maintaining an ongoing dialogue between user research, technical design, and data integration teams, WP1 can contribute to the development of a coherent and user-optimized platform that addresses both functional and experiential needs.

8.5.5 Conclusion: Strengthening WP1's Role in the IMPULSE Project.

WP1 is crucial for understanding and meeting user needs through comprehensive user research, persona development, and barrier identification. By continuing to refine personas, expanding research methodologies, addressing user barriers, and ensuring continuous feedback integration, WP1 will play a central role in shaping the user-centred development of the IMPULSE VR platform.

The focus on iterative research, especially in relation to user engagement and barrier mitigation, will ensure that the platform aligns with the real-world needs and expectations of users from various professional and academic backgrounds. WP1's role in synthesizing user feedback and integrating it into the platform's design and development ensures that the system is not only technically proficient but also resonates with its intended user base. This comprehensive approach will ensure the long-term success and usability of the IMPULSE VR prototype.

8.5.6 Strategic Recommendations for Future Tasks within WP2 and WP3.

WP2 (Immersive technologies for digital cultural heritage upcycle – TECH) and WP3 (Standards simplification – STAND) are key work packages in the IMPULSE project. WP2 focuses on the technical development of immersive virtual environments for cultural heritage reuse, while WP3 addresses standardisation and simplification challenges in digitisation, metadata handling, and paradata integration. The insights gathered from previous user research activities (e.g., workshops, surveys, and interviews) offer

substantial guidance for the next stages of prototype enhancement. The recommendations below aim to inform technical refinement, promote interoperable design, and ensure that the platform remains accessible, inclusive, and responsive to the diverse needs of G1, G2, and G3 user groups.

8.5.7 WP2: Development of Immersive Technologies for Digital Cultural Heritage.

WP2 – Immersive technologies for digital cultural heritage upcycle (TECH) – is dedicated to the development of modular and extensible immersive environments that support the reinterpretation and reuse of digital cultural assets. This includes the design and implementation of core technological components for the IMPULSE VR prototype, such as content handling, spatial interaction, and narrative integration.

Based on the insights gathered from participatory workshops and survey feedback, particularly in relation to usability constraints, platform stability, and interaction limitations, the following recommendations are proposed to support WP2 in advancing a more robust and adaptive prototype architecture.

8.5.7.1 General Technical Recommendations.

- **System Stability and Performance:** across all user groups (G1, G2, G3), one of the most consistently reported challenges was related to the stability and responsiveness of the platform, including difficulties accessing the environment and navigating between scenes. These issues, highlighted particularly during the Leuven workshop and in survey feedback, significantly affected user engagement. WP2 should therefore prioritise backend optimisation, including faster content loading, smoother transitions, and improved error handling. Early-stage stability improvements are essential to facilitate broader participation in future testing phases.
- **Cross-Device Compatibility:** although the Leuven testing was conducted primarily on desktop interfaces, broader accessibility will require ensuring compatibility across multiple platforms, including VR headsets, tablets, and standard web browsers. This will enable users to interact with the immersive environment in ways that suit their individual technical setups, thereby increasing inclusivity. WP2 should support scalable interaction models that adapt to different devices without compromising usability or core functionalities.
- **Improved Navigation and Object Manipulation:** several users reported difficulties in navigating the environment and manipulating objects, especially when attempting to position or scale digital assets. WP2 is encouraged to refine interaction models to ensure greater intuitiveness, for example through improved drag-and-drop features, anchor points for object placement, and clearer visual cues. While gesture-based or controller-based navigation was not tested in this

phase, future development could explore these methods as optional interaction pathways for users with access to advanced hardware.

8.5.7.2 Multi-User Functionality.

- **Expanding Multi-User Interactions:** while limited multi-user functionality—such as synchronous co-presence and shared navigation—was available in the Leuven prototype, several participants, particularly from G2 and G3, highlighted the need for more advanced real-time collaboration features. These included simultaneous manipulation of virtual content, co-curation scenarios, and shared narrative development within immersive environments. WP2 should therefore consider expanding the platform's multi-user capabilities, enabling deeper forms of collaborative learning, artistic experimentation, and professional engagement across distributed user groups.
- **Cross-Device Compatibility:** participants across all groups expressed interest in interacting with the platform through various devices, reflecting differing levels of access to immersive hardware. WP2 is encouraged to continue developing adaptive interaction models that function reliably on both desktop systems and VR headsets. This includes ensuring responsive design, optimising interface elements for different input modes (e.g., keyboard and mouse, touch, VR controllers), and maintaining consistent functionality across platforms. Supporting this flexibility is especially crucial for G1 users, who may have limited access to specialised VR hardware within institutional settings.

8.5.8 WP1: User-Centred Narrative Integration and Pedagogical Scenarios.

WP1 is instrumental in shaping the user-oriented narrative framework and pedagogical foundations of the IMPULSE platform. Drawing on findings from user interviews, quantitative surveys, and participatory workshops, this work package focuses on ensuring that immersive storytelling aligns with users' cognitive, emotional, and educational needs. The following recommendations are intended to strengthen the narrative coherence of the platform, enhance personal relevance for diverse user groups (G1, G2, G3), and support the design of pedagogical scenarios that facilitate learning, creativity, and meaningful engagement with cultural heritage.

8.5.8.1 Narrative and Interaction Design (WP1).

Flexible Storytelling Options: users from G2 expressed a clear preference for open-ended, non-linear storytelling formats that foster creative exploration within immersive environments. To accommodate these expectations, WP1 should support the development of interactive narrative models that allow users to construct personalised storylines. This may include features such as dynamic narrative pathways, user-

controlled plot developments, and modular arrangements of heritage content. Such affordances are essential for enabling artistic experimentation and enhancing narrative engagement across multiple use cases.

Personalisation and Agency: insights gathered from G1, G2, and G3 consistently highlight the need for greater user agency and content personalisation. Participants expressed interest in adapting their virtual environments — including avatar customisation, spatial reorganisation, and content selection — to better reflect their learning goals, professional roles, or creative intentions. WP1 should ensure that narrative and interaction designs offer sufficient flexibility to empower diverse user groups and support differentiated interaction scenarios.

Inclusive Storytelling: to ensure broader accessibility and relevance, WP1 should promote the creation of inclusive and culturally sensitive narratives. Feedback from participants indicated that overly complex or narrowly framed content can limit engagement, particularly among less technically experienced users. Future narrative designs should incorporate multilingual options, visual scaffolding, and alternative modes of narration (e.g., audio descriptions or subtitles) to accommodate a wide spectrum of abilities and cultural backgrounds.

8.5.8.2 Pedagogical Integration (WP1).

Educational Scaffolding: participants from G1 consistently emphasised the importance of clear instructional support within the immersive environment. Many expressed the need for structured guidance that would help users navigate and engage with the content effectively, especially those with limited experience in VR. WP1 should consider integrating features such as onboarding tutorials, guided tours, embedded prompts, and context-sensitive help functions. These components will provide pedagogical scaffolding that lowers the cognitive threshold and facilitates meaningful educational interaction.

Collaboration and Social Learning: feedback from G1 participants also indicated strong interest in leveraging immersive environments for collaborative and peer-based learning. To support this, WP1 should explore the implementation of real-time collaboration tools, including shared virtual workspaces, co-narration modules, and feedback functionalities. These affordances are essential for fostering social presence, supporting group work, and enabling active knowledge construction in educational settings.

8.5.9 3. Recommendations for Cross-Work Package Collaboration.

WP1, WP2 and WP3 Synergies: to ensure a cohesive development of the IMPULSE platform, it is essential to foster continuous collaboration between WP1 (User Research and UX Design), WP2 (Platform Development), and WP3 (Standards Simplification and Integration). WP1 should act as a bridge between the technical development and content

structuring processes by translating user needs, identified through interviews, surveys, and participatory workshops, into concrete design and functionality recommendations.

WP2's technical iterations—including optimisation of interaction models and cross-device performance—should be systematically tested using the narrative use cases and pedagogical scenarios informed by WP1 activities. Similarly, WP3's work on metadata standards, interoperability, and simplification protocols should feed back into the system architecture and inform how narrative and educational content is structured, described, and rendered across the platform.

Cross-Work Package Workshops: interdisciplinary workshops involving teams from WP1, WP2, and WP3 should be organised regularly to facilitate knowledge exchange, mutual understanding, and collaborative prototyping. These sessions would allow technical developers to better understand the narrative and educational needs of different user groups (G1, G2, G3), while also informing content creators and user researchers of technical constraints and implementation possibilities. Moreover, these workshops could serve as iterative validation checkpoints, integrating user feedback into agile development cycles and refining the overall user experience in alignment with project goals.

8.5.10 Conclusion.

The recommendations formulated in this deliverable are designed to support the ongoing coordination between WP1 (User Research and UX Design), WP2 (Platform Development), and WP3 (Standards Simplification and Integration), ensuring that the IMPULSE VR prototype evolves in alignment with user expectations, technical feasibility, and interoperability standards.

To create an immersive environment that is both technically robust and meaningfully engaging, the next development phases should prioritise improved system performance, adaptability to different user needs, and support for both creative exploration and educational scaffolding. WP2's focus on infrastructure development and platform functionality must be continually informed by WP1's empirical insights into user behaviour, affective responses, and interaction preferences. Simultaneously, WP3's contribution to metadata structures, interoperability, and integration standards will be essential for ensuring the long-term usability, scalability, and contextual integrity of cultural heritage content within the VR system.

Collaboration across these work packages is crucial for delivering a user-centred platform that fosters inclusive participation, supports diverse narrative practices, and reflects the complex requirements of education, creativity, and cultural heritage mediation. The integration of design, development, and standardisation efforts will ensure that the IMPULSE platform not only meets immediate user needs but also lays a foundation for sustainable and extensible digital heritage practices.

8.5.11 Inclusivity and Cultural Sensitivity Guidelines.

To support the development of inclusive and culturally sensitive immersive environments in the field of virtual heritage, the following guidelines are proposed as recommendations for current and future initiatives working at the intersection of virtual reality and cultural heritage (VR + CH). While not all elements may be implemented within the current scope of the IMPULSE project, they reflect critical areas for long-term consideration and strategic planning:

1. Linguistic Inclusivity:
    a. It is recommended that immersive VR platforms designed for cultural heritage applications consider supporting multiple languages to enhance accessibility for international and multilingual audiences, particularly in educational and museum-based contexts. This could include offering both audio and textual translations, thereby enabling users to engage fully with the content regardless of their linguistic background. While full implementation may extend beyond the scope of the current IMPULSE prototype, multilingual design should remain a key objective for future development stages and comparable initiatives in the VR + CH domain.
2. Cultural Sensitivity:
    a. Cultural representation in VR environments should be handled with care, ensuring that narratives and objects are accurately and respectfully presented, while also allowing for creative flexibility, particularly in artistic experimentation. The balance between accuracy and creative expression may vary depending on the context, with educational settings prioritizing accuracy, while artistic experimentation may offer more freedom for reinterpretation;
    b. The platform should be designed with the flexibility to allow users to create and curate culturally relevant content that aligns with specific local or regional contexts;
    c. Collaboration with cultural professionals should ensure that the platform's content reflects the richness of global cultural heritage without marginalizing minority or underrepresented groups.
3. Physical Accessibility:

Future VR systems designed for cultural heritage applications should provide customisable accessibility settings to accommodate users with disabilities. These may include features for individuals with visual impairments—such as high-contrast modes and text-to-speech functionalities—as well as alternative input methods like eye-tracking or hand tracking for those with mobility limitations.

Additionally, special consideration should be given to the accessibility of VR hardware, ensuring that it can be adjusted easily and used comfortably by people with sensory or

cognitive impairments. Such inclusive design principles are essential to broaden participation and ensure equitable engagement across diverse user groups.

8.5.12 Strategic Recommendations for WP5: Dissemination, Communication and Stakeholder Engagement.

WP5, responsible for *Dissemination, Communication and Stakeholder Engagement*, plays a strategic role in amplifying the visibility of the IMPULSE project, supporting knowledge exchange across work packages, and ensuring engagement with diverse user communities. While WP5 does not lead the technical development or user research, its functions are critical for facilitating informed participation, recruitment, and stakeholder feedback, thereby indirectly supporting the evolution of the IMPULSE VR prototype.

Given the iterative and user-centred nature of the project, WP5 should be closely aligned with the aims of WP1 (User Research), WP2 (Prototype Development), and WP3 (Standards Simplification) to help coordinate communication workflows, distribute surveys, promote recruitment for interviews and testing sessions, and assist in organising focus groups or co-creation events. WP5 can also serve as a conduit for sharing findings across institutional, academic, and professional networks, thus broadening the reach and relevance of the project's results.

8.5.12.1 Specific Recommendations for WP5.

Facilitating Iterative Feedback Collection: WP5 should support ongoing cycles of user consultation by promoting participation in qualitative and quantitative studies (e.g., surveys, interviews, co-design workshops) and ensuring that insights gathered by WP1 are effectively communicated and contextualised for WP2 and WP3. While WP1 remains the lead for research, WP5 can enhance access to participants and help sustain participation over time.

Expanding Outreach and Sampling Channels: recruitment for user research activities should leverage WP5's outreach strategies across multiple platforms, including institutional mailing lists, academic partnerships, cultural sector networks, and multilingual calls via the project's public channels. This will increase the diversity of the user base, especially among underrepresented or less digitally literate groups.

Ensuring Inclusivity in Engagement: WP5 should facilitate accessible communication practices and support inclusive dissemination formats. This includes preparing accessible surveys, multilingual materials, screen-reader-friendly websites, and audio/video summaries of results. These materials should be tailored to the needs of different user groups (G1–G3), including non-users and people with disabilities.

Coordinated Dissemination of Research Outputs: WP5 should develop and maintain public-facing formats for sharing research insights and progress, including infographics,

summary reports, blog posts, and social media updates. It should also support targeted communication with stakeholders and cultural institutions that may adopt or adapt the outcomes of the IMPULSE platform.

Stakeholder Mobilisation and Advocacy: WP5 is in a strong position to build alliances with external partners and cultural institutions. It should capitalise on these relationships to create opportunities for user-centred validation, prototype demonstration, and potential future collaborations that extend beyond the current scope of the project.

8.5.13 Conclusion for WP5 Integration.

WP5's contributions to the dissemination of findings, the recruitment of participants for further research, and the sustained engagement of stakeholders will be critical to the success of the IMPULSE project. By facilitating continuous feedback loops and promoting inclusive and transparent user involvement, WP5 can help bridge the gap between theoretical development and real-world application. This will ensure that the VR platform evolves in alignment with the actual needs and expectations of diverse user communities across varying levels of digital competence and professional contexts.

9 Conclusions

This section outlines the key findings of the study and identifies critical areas where future research is necessary to enhance the IMPULSE VR prototype and ensure it meets the diverse needs of users across different domains.

9.1 Summary of Key Findings

The research conducted as part of the IMPULSE project has provided valuable insights into user interactions, experiences, and expectations regarding the use of immersive VR technology in the context of cultural heritage. The key findings from the participatory workshops, quantitative surveys, and semi-structured interviews reveal several important themes that have implications for the design and development of the VR platform.

1. Usability and Technical Issues: Across all user groups, the most prominent usability concerns were related to system instability, including platform crashes, slow performance, and technical malfunctions. These issues were especially evident during the participatory workshops and surveys, highlighting the need for further optimization and stabilization of the platform before moving forward with additional user testing.

2. User Expectations and Desire for Control: A consistent theme across the data was the desire for increased user agency. Participants expressed a strong preference for greater control over the immersive environment, including the ability to manipulate environmental elements, such as objects, backgrounds, and avatars. This was echoed in both the surveys and the interviews, where users called for features like avatar customization, enhanced spatial control, and alternative movement options (e.g., teleportation and flying).
3. Group-Specific Needs: The analysis of different user groups G1, G2 and G3 revealed distinct expectations. G1 preferred structured, educational content, while G2 sought more creative freedom and artistic expression. G3 focused on technical robustness, emphasized the need for professional tools, such as metadata integration, multi-user functionality, and the ability to curate content effectively. This divergence underscores the necessity of creating a flexible platform that accommodates the specific needs and priorities of each group.
4. Barriers to Immersion and Accessibility: Several barriers to effective VR use were identified, including physiological challenges (e.g., VR sickness, discomfort from headsets), affective concerns (e.g., fear of isolation or disorientation in VR), and cognitive barriers (e.g., the perceived complexity of using VR). Additionally, equipment-related issues, such as the high cost of VR hardware and lack of access to adequate infrastructure, were significant barriers for many participants. Addressing these issues will be critical for ensuring wider adoption and use of VR technologies, especially in educational and cultural contexts.
5. Desire for Enhanced Immersive Experiences: Many users expressed interest in more sensory engagement within the VR environment. Features such as spatial sound, multi-sensory feedback, and the ability to manipulate time and space within the virtual environment were frequently mentioned as key areas for enhancement. These features align with the goal of creating a more immersive and engaging experience, particularly for users involved in creative and educational fields.

9.2 Identifying Gaps and Directions for Further Research

While the current research provides valuable insights into user needs and expectations, several gaps remain, and further research is needed to refine the VR platform and address identified challenges. These gaps suggest multiple avenues for continued investigation:

1. **Long-Term User Experience:** the current study primarily focused on initial impressions and short-term interactions with the VR prototype. Future research should investigate how users engage with the platform over extended periods, particularly in the context of ongoing educational activities, creative projects, and cultural heritage curation. Understanding how users adapt to and evolve their

interactions with the platform will provide insights into the long-term usability and sustainability of the system.

2. **Diverse User Populations:** while the current study covered a range of users, future research should expand to include a broader and more diverse population, particularly those who may have been excluded due to accessibility or physical limitations (e.g., users with disabilities or older adults). Investigating the inclusivity of the platform is recommended to ensure that it meets the needs of all users and can be accessed by a wider audience. While this may not be implemented within the scope of IMPULSE, it can serve as a set of recommendations for future initiatives
3. **Impact of Immersion on Learning and Emotional Engagement:** more research is needed to explore how the immersive nature of VR affects learning outcomes, emotional engagement, and storytelling across different disciplines. Specific focus should be placed on how VR can enhance educational experiences (particularly for G1) and foster emotional connections with cultural heritage (especially for G2 and G3). Longitudinal studies could help assess the effectiveness of VR as a tool for learning and its ability to evoke meaningful, emotional responses from users.
4. **Exploring Multi-User and Collaborative Experiences:** another critical gap lies in understanding the multi-user functionalities and collaborative aspects of VR. While some users expressed interest in multi-user interactions, this feature was not fully realized in the current prototype. Further research is needed to evaluate how real-time collaboration and social interactions within the virtual environment can enhance engagement and learning outcomes.
5. **Technology Adoption and Accessibility:** future research should investigate how to make VR more accessible to users with varying levels of technical expertise, as well as those with specific physical or cognitive impairments. Developing strategies to lower the barriers to entry, including improving affordability and availability of hardware, will be key to achieving wider adoption of immersive VR technologies.
6. **Cultural Sensitivity and Ethical Considerations:** as VR technology becomes more widely used for cultural heritage purposes, further research should address the ethical implications of representing and interacting with cultural artifacts. This includes ensuring that the content and interactions are culturally sensitive, accurate, and inclusive. Additionally, the use of AI in these environments should be ethically considered, particularly in relation to user data and privacy concerns.

10 References

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11 Annexes

11.1 Questionnaire IMPULSE VR Platform Testing prepared for Leuven workshop.

IMPULSE VR Platform testing

The purpose of this survey is to identify the respondent's opinions regarding the scope and quality of functionalities available in the platform and to explore the respondents' opinions on the expected scope of functionalities in the final version of the platform. The survey is anonymous, and you can stop answering at any time. Please note that, because it is anonymous, we cannot delete or edit responses once the survey is complete. The survey should take approximately 10 minutes to complete. There are no right or wrong answers – we want to hear your honest feedback. Thank you for your time and for sharing your knowledge and experience. Please be aware that during the survey, there is a risk of experiencing VR sickness. Symptoms may include dizziness, nausea, headaches, vomiting, and general discomfort. The survey can be stopped at any moment upon the participant's request. However, if you are concerned about the potential for VR sickness, we encourage you to carefully consider your participation in the study.This survey is part of the IMPULSE project. If you have any questions or concerns, please feel free to contact us via https://euimpulse.eu/contact/

* Required

1. Do you agree to participate in the survey "VR Platform testing" carried out as part of the IMPULSE project? *

   Yes

   No

2. How would you assess the platform in relation to the following pair of attributes? *

unpleasant pleasant

3. How would you assess the platform in relation to the following pair of attributes? *

brings me closer to people separates me from people

4. How would you assess the platform in relation to the following pair of attributes? *

simple complicated

5. How would you assess the platform in relation to the following pair of attributes? *

unimaginative creative

6. How would you assess the platform in relation to the following pair of attributes? *

motivatingdiscouraging

7. How would you assess the platform in relation to the following pair of attributes? *

ugly attractive

8. Have you experienced any difficulties importing 2D content while using the platform? If so, which ones? (You may select more than one option.) *
Problems with the supported file format (e.g. the platform does not recognise .svg, .png, etc. files)

Slow loading of the content

Failure to load the content due to too large file size

Technical errors (e.g. platform crashed during import)

Incorrectly imported content (e.g. missing elements, distortions)

No, I have not experienced any difficulties

Inne

9. Have you had any difficulties moving content within the platform environment? If so, which ones? (You may select more than one option.) *
Problems with the precision of the content's movement

Content 'jumped' or changed position not according to my expectations

Lack of clear guidance or visual cues (e.g. no grid display, on-screen cues showing the model's current position or possible directions of movement)

Controller issues (e.g. difficulty using VR goggles or keyboard/mouse)

No, I have not experienced any difficulties

Inne

10. Have you had any difficulties changing the size of the content on the platform? If so, which ones? (You may select more than one option.) *
Lack of precision when changing size (e.g. the content changed size in jumps instead of smoothly)

Limited ways to change scale (e.g. no way to zoom in/out to the right size)

Unclear instructions on how to use features (e.g. no explanation of which gestures or buttons to use to change size; no visual indication of the model's current size)

Technical problems (e.g. platform freezes)

No, I have not experienced any difficulties

Inne

11. Did you have any difficulties moving around the environment? If so, what were they? (You may select more than one option.) *
Problems with steering (e.g. no clear steering instructions)

Poor fluidity of movement (e.g. delays or lag in movement)

Difficulty navigating with respect to objects (e.g. walking into objects, collisions with objects)

Restricted field of vision or difficulty orienting in space

Symptoms of VR sickness (e.g. dizziness, nausea, disorientation)

Controller-related technical problems (e.g. lack of control precision)

No, I did not experience any difficulties

Inne

12. Did you find it easy to use the interface (e.g. VR goggles, controllers, keyboard + mouse) to interact with the platform? *

Very difficultVery easy

13. Please describe any specific problems you faced when using the interface (optional)
14. While using an immersive (VR) environment, have you encountered any difficulties related to any of the following aspects? (You may select more than one option.) *
Difficulties initiating communication with other users.

Unclear or confusing instructions on how to navigate or use the environment.

Uncertainty about what to do at a given moment (e.g., how to complete a task or continue interacting).

Trouble locating specific functions (e.g., what to click, touch, or how to activate certain features).

Challenges navigating through the virtual environment (e.g., moving around, changing perspective).

Emotional or social difficulties (e.g., stress, uncertainty, feeling intimidated when interacting with others).

Difficulty concentrating or understanding the information being presented.

Technical issues that hinder communication (e.g., delays, malfunctioning voice or text interfaces).

No, I did not experience any difficulties

Inne

15. What additional functionalities would you like to see in the final version of the platform? Select up to 3 options that are most important to you. * Wybierz co najwyżej 3 opcje.

Ability to edit the VR environment (e.g. change backgrounds, add/remove elements of the environment)

Ability to personalise your avatar (e.g. choice of appearance, e.g. skin colour, hair, clothes; ability to add accessories such as glasses or hats; choice of gesture animation)

Ability to change the way you move (walking, flying, teleportation - depending on user preference)

Enhanced communication options (e.g. text chat, video chat, indications of emotional reactions such as emojis, nonverbal cues by virtual characters, etc.)

Inne

16. Do you have any additional comments on the use of the platform that you would like to share with us?
17. How did you experience the platform? * Using VR goggles

Using a computer screen (VR desktop)

18. How would you describe your prior experience with VR before participating in this study? *

I had no prior experience with VR (Non-user)

I had limited experience with VR (Beginner)

I use VR occasionally (Intermediate)

I am an experienced VR user (Expert)

11.2 Questionnaire IMPULSE - Needs and expectations of VR users.

IMPULSE - Needs and expectations of VR users

The purpose of this survey is to explore the needs, expectations and experiences of users and potential users of VR. The survey is anonymous. It will take approximately 10-12 minutes to complete. There are no right or wrong answers - we are interested in your personal experience and opinions. Please respond to all questions. Thank you for your participation! Your answers are extremely valuable to us.

This survey is part of the IMPULSE - IMmersive digitisation: uPcycling cULtural heritage towards new reviving StratEgies EU Funded Project: 101132704. If you have any questions or concerns, please contact us at https://euimpulse.eu/contact/.If in the future you would like to take part in an interview or test our VR platform, we encourage you to contact us via the form available on the website. You can also join IMCo, an open community of people involved in the development of immersive technologies. It's a

space to share knowledge, experience and ideas. You can find more information about IMCo here: https://euimpulse.eu/introducing-imco-the-impulse-community-ofpractice/

* Required

1. Do you agree to participate in the 'IMPULSE - VR user needs and expectations' survey conducted by the IMPULSE project? *

Yes

No

Experience with VR

1. Have you ever used VR? *

Yes, on a regular basis

Yes, but occasionally

Yes, once (e.g. during a class or an exhibition)

No, but I would like to

No and I am not interested

2. How often do you use VR technology? * Never

Rarely (once a year or less often)

Occasionally (several times a year)

Often (several times a month)

Very often (weekly or more often)

3. How would you rate your level of expertise in VR? *

Beginner

Intermediate

Advanced

Expert

4. What VR devices have you used? (Select all that apply) *
   - Oculus Rift/S
   - Oculus Quest/Quest 2
   - HTC Vive
   - Valve Index
   - PlayStation V
   - I do not know
   - Inne

5. What VR platforms have you used most often? (You can choose more than one answer). *
   - Spatial
   - VR Chat
   - Meta Horizon
   - Decentraland
   - Open Simulator
   - Roblox
   - Sandbox
   - I am using Unity products
   - I am using WebGL products
   - I do not use
   - I do not know
   - Inne

6. What are your main reasons for using VR? (You can choose more than one answer). *
   - Entertainment (games - including desktop games, films)
   - Education and training
   - Creativity and art
   - Cooperation and teamwork
   - Exploring new technology
   - Inne

7. What difficulties have you encountered when using VR? (You can choose more than one answer). *

Technical issues

High cost of equipment

Physical discomfort (e.g. dizziness, nausea)

Lack of knowledge about VR

Limited social interaction

I have not encountered any difficulties

Inne

8. Briefly describe what you associate your experiences in the VR environment so far with. Name them, give associations. *

Social interactions in VR

10. "Please rate the following statements on a scale from 1 to 7: (1 = strongly disagree, 7 = strongly agree)" *

1 - strongly 4 - hard to 7 - strongly disagree 2 3 say 5 6 agree

I feel like a part of the group in the virtual world.

During interactions in VR, I pay attention to other users.

In VR, I can easily understand other users' intentions and emotions.

Communication in VR feels as natural to me as in the real world.

Collaboration in VR is more engaging than in traditional applications.

Expectations toward VR

11. Which VR features are/would be the most important to you? (Select up to 3) *

Wybierz co najwyżej 3 opcje.

World realism

High-quality social interactions

Intuitive controls and ease of use

Ability to create and be creative

Access to educational and professional content

I don't know / Hard to say

Inne

Interacting with VR elements

(e.g., digital objects, virtual items, parts of the virtual environment, virtual exhibits, 3D objects, visualizations, etc.)

12. Please rate the following statements on a scale from 1 to 7:(1 = strongly disagree, 7 = strongly agree) *

	1 - strongly disagree	2	3	4 - hard to say	5	6	7 - strongly agree
Interaction with virtual elements is intuitive for me.							
Virtual objects help me feel more immersed in the VR world.							
Objects in VR should be more realistic.							

13. Have you previously interacted with digital cultural heritage objects (e.g., digitized books, scanned paintings, 3D models, scans of sculptures, monuments, etc.)? *
    Yes

    No

14. Please describe your experience with digital cultural heritage objects. *

Barriers and Expectations

15. Why don’t you use VR? (You may select more than one answer.)" *
    I don't have the necessary equipment.

    VR is too expensive.

    I don't know how to get started.

    I don't see the value in it.

    I'm not interested in VR.

    I haven’t had the opportunity to try it.

Inne

16. What could convince you to start using VR? (You may select more than one answer.) *
Cheaper and easier access

Improved graphics and immersion quality

More educational or professional content

Easier to use

Inne

Affiliation

17. Status at university * Student

(undergraduate)

Student (Master's degree)

PhD student

Academic teacher

Not applicable

11.3 Interview Guide.

Thanks for your participation in this interview.

Before I start asking questions, I wanted to inform you that the interview will be recorded and then transcribed. The transcriptions will be sent to you for confirmation. You can remove any information that you do not want to be part of the transcriptions. The transcriptions will be anonymized and will be published online in an open data archive.

Do you consent to the start of the recording? (YES/NO)

11.4 Demographic Data.

Please provide the following information by marking the appropriate category:

- Age:
  - 20-30 [ ]
  - 31-40 [ ]
  - 41-50 [ ]
  - 51-60 [ ]
  - 61 and more [ ]
  - I don't want to say my age [ ]
- Gender:
  - Male [ ]
  - Female [ ]
  - Other [ ]
- Education Level:
  - [ ] High School
  - [ ] Some College
  - [ ] Associate Degree
  - [ ] Bachelor's Degree
  - [ ] Master's Degree
  - [ ] Doctorate
  - [ ] Prefer not to say

- Field of studies/ [artists]Artistic specialisation: _____

11.5 Interview Questions.

Question ID	*Questions*	*Notes for interviewers*
Q1: Exposure and Awareness	How would you define *virtual reality*? Can you describe your general familiarity with Virtual Reality (VR)? Have you had any exposure to VR technologies, even if you haven't used them personally?	**Goal**: Gauge basic awareness and indirect exposure to VR technologies. **Possible follow-up questions**: - What have you heard or seen about VR that influences your perception of it?

	[**artists**] How do you incorporate VR/XR technologies into your artistic practice?	- Where do you typically encounter information about VR? **Notes to interviewer**: - What sources of information are mentioned? - Are there any misconceptions or accurate understandings evident? **Possible follow-up questions:** - How do you integrate XR (VR, AR, or immersive experiences) in presenting your artworks? - How does the virtual environment influence your artistic choices compared to a physical studio?
Q2: Perceived Relevance	In your view, how could VR be relevant or beneficial to your studies or teaching methods?	**Goal**: Understand perceived potential uses of VR in academic contexts without prior direct experience. **Possible follow-up questions**: - Can you imagine any scenarios where VR might enhance learning or collaboration? - Are there particular subjects or activities you think would benefit from VR? **Notes to interviewer**: - What are the theoretical benefits they can think of? - Are there any specific academic disciplines they mention?
Q3: Barriers to Adoption	What are the main reasons you have not tried using VR in any form?	**Goal**: Identify barriers or lack of interest regarding VR use.

		Possible follow-up questions: - Is it a matter of access, cost, lack of interest, or something else? - Have you encountered any negative reviews or opinions that influenced your stance? **Notes for interviewer**: - What specific barriers are mentioned most frequently? - Are these barriers logistical, financial, perceptual, or cultural?
Q4: Perception of Technology	How do you generally perceive new technologies (like VR, AR, AI) in terms of accessibility and usability? How do these gaps affect your work? [**artists**] How do VR and XR offer unique opportunities for artistic experimentation that other media do not?	**Goal**: Explore attitudes towards adopting new technologies and specific thoughts on VR's user-friendliness. **Possible follow-up questions**: - Do you feel that new technologies are designed with users like you in mind? - What could make new technologies more appealing or easier for you to try? **Notes to interviewer:** - How do they view technological advancements? - Are there any specific features or support they believe would encourage usage? **Goal**: The aim is to indicate the potential, aptitude, competence and perspective of the application of new VR, XR technologies in art, as well as to highlight the potential for experimentation with and in the immersive environment of artists

		Possible follow-up questions: - - Can you share an example of how using VR or XR has changed the outcome of an art project? - How does the use of XR (VR, AR or immersive experiences) impact on the perception of space and dimension in artworks? - Describe an artistic concept you could realise in VR that would be impossible in traditional or other digital formats. **Notes to interviewer:** How the artist creates immersive space, what the perception of an immersive environment means to him, how he feels this space, how it influences his work, whether it really supports experimentation and interaction with the audience?
Q5: Collaborative Potential	Considering your current methods of study or teaching, how do you think VR could impact collaboration or learning environments? How do you see its potential and challenges?	**Goal**: Elicit thoughts on the transformative potential of VR in educational settings. **Possible follow-up questions**: - What changes to learning environments do you foresee if VR were introduced? - Could VR address any current limitations in your educational experience? **Notes to interviewer**: - Are there positive or negative impacts envisioned? - Do they see VR as a solution or a potential complication?

	[**artists**] Does and how does interaction change in a VR environment when art is experienced by a group (of artists)? Do you think VR changes the way artists and audience perceive and interact with art? Compared to traditional viewing What unique group experiences do you believe VR and immersive installations can provide to artists that other art forms cannot?	

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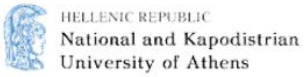

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