IMPULSE

IMmersive digitisation: uPcycling cULtural heritage towards new reviving StratEgies

Deliverable D1.1:

Review of UX Methodology and Tool Proposition

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Contributors	JU; MZ; KUL; UM	**Reviewers**	Zoë Vandenhende (KUL)
		Reviewers	Andrew Pace (MZ)

Author(s)		
First Name	**Last Name**	**Partner**
Monika	Krakowska	JU
Magdalena	Zych	JU
Marek	Deja	JU

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Deliverable leader	Monika Krakowska (JU)	26 July 2024
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Project Coordinator	Żaneta Kubic (JU)	30 July 2024

Executive summary

The Deliverable 1.1 presents an overview of UX methodologies resulting from a scoping review of the available scientific and research literature, as well as from various analysis and exploration activities, a research methodology and a proposal of tools to explore the experiences, behaviours, needs and affective-cognitive factors of different user groups, as envisaged by the IMPULSE project. The report is divided into three main parts, chapters. The first chapter briefly outlines the main objectives of the IMPULSE project, taking into account the subject and aims of Work Package 1, which includes a number of subtasks, including subtask 1.1.2, resulting in the development of a proposal for a methodology for researching users using the final project product. Attention was also drawn to the categories of users, for which adequate research tools were created in this first, key stage of activities, to be implemented at the stage of subsequent subtasks related to the analysis of user experience (UX research). The second chapter presents the process of developing the research procedure, creating the methodology by characterising: (a) the main results of the scoping review and the methods and tools used to study the users of immersive environments across multiple dimensions and disciplines of science and art in the context of the use of digital cultural heritage resources; (b) the activities undertaken in the form of research in action, or team and expert consultations; (c) the initial studies that were carried out as part of participation in the task processes of the CAPHE project (H Communities and Artistic Participation in Hybrid Environments, The HORIZON Europe Program under grant agreement no. 101086391; https://www.caphe.space/) and in collaboration with participants in events created in immersive environments, including artists. In the third part of the report, the final chapter presents the research methodology created, together with a characterisation of the research methods and tools to be used in order to achieve the objectives of the IMPULSE project, in particular concerning the study of user experience and the development of coherent effects of extended storytelling towards vivid users' experience. In addition, possible difficulties and problems that may occur during the implementation of the methodology and the conduct of the research have been taken into account.

Finally, there is an Appendix, which adds appendices, including a scoping review report, diagrams of all developed questionnaires for different user groups, and observation and interview patterns to be taken into account when implementing UX research.

Key words:

experiment, questionnaires, interview, observation, procedure, prototype, report, research methodology, research tools and techniques, scoping review, user experience, user research

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Abbreviations and Acronyms

Abbreviation / acronym	Description
App.	Appendix
CCI	Cultural and Creative Sectors and Industries
DX.X	Deliverable number X belonging to WP X
EC	European Commission
FIG.	Figure
G X (e.g. G1)	Group X (e.g. Group 1)
IMCo	IMPULSE Community of Practice
JU	Jagiellonian University
MUVE	Multi-user Environment
p.	Page
Tab.	Table
UX	User Experience
VR	Virtual Reality
WP	Work Package
WP X	Work Package Number
XR	Extended Reality

1 Introduction

This section of Deliverable 1.1 presents the subject matter and key objectives of the IMPULSE project, taking into account the aims of WP1 and Subtasks, both 1.1.1 and, most importantly, Subtask 1.1.2, whose priority was to develop a methodology for user research and user experience in immersive environments.

Given the tasks required to achieve the main aim of the project, their intended scope was incorporated into Work Package 1 (WP1) and Subtask 1.1, as well as a supporting element, labelled subsequent sub-task 1.1.2. The overarching aim behind subsequent sub-subtask 1.1.2 was developed on the basis of a critical analysis of the literature and a scoping review conducted for the project, as well as a variety of activities, including preliminary studies, undertaken by the partners of each Work Package. The aforementioned studies will serve as a preliminary foundation for the actual preliminary studies that have been proposed in accordance with the IMPULSE framework. This initial stage is for the evaluation and validation of the proposed methodologies and the IMPULSE research procedure, small-scaled studies will be conducted concurrently with the implementation of the prototype under development at a subsequent phase of the project. The research methodology that emerged from these empirical and conceptual explorations will discern the needs, expectations, beliefs, socio-cultural impulses, embodiment and use of technology, together with the dynamics of engagement in domains of virtual heritage facilitated by virtual reality (VR). Thus, the methods detailed in the research procedure and the quantitative-qualitative analysis of the results carried out in the subsequent stages of the project will contribute to conceptualise and update the prototypes while providing recommendations tailored to the needs of the public actors entrusted with the digital preservation of cultural heritage. These directives will be based on insights derived from the conditions, expectations, requirements, behavioural patterns, motivational frameworks and experiences gathered from the three main cohorts of users surveyed. Thus, the methodology used to study the experiences of users using digital resources in MUVE/metaverses will implement the process of their application in the didactic, creative and commercial dimensions.

1.1 IMPULSE Project - résumé

The overarching goal of the IMPULSE project is to develop innovative and multifaceted solutions and methodologies for the digitisation and accessibility processes of the collections that make up digital cultural heritage. These efforts aim to facilitate their innovative use but also reuse, to address the challenges of interoperability between platforms and to improve access to pre-existing digitised cultural heritage materials in new contexts, in particular in the metaverse. At the same time, the project aims to develop pioneering standardisation protocols and adapt the legal framework to contemporary changes and creative dynamics in education, the arts and the CCSI

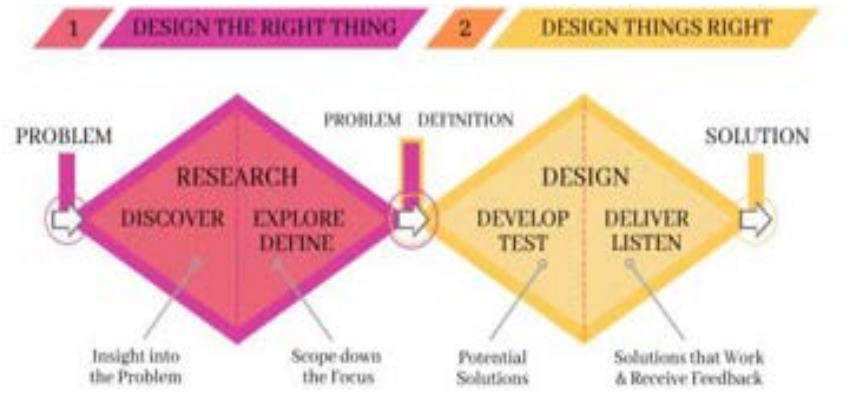
sector (IMPULSE project proposal, 2023). The goal of the IMPULSE project is to be achieved through a set of specific, measurable, achievable, realistic and time-bound (SMART) specific objectives, which include:

- Promoting solutions that expand the scope and consequently the number of artefacts and objects that can be presented using XR technology to recreate objects, as well as expand the possibilities for new, uses of digital cultural heritage and the creation of multi-layered narratives for different user groups, including underrepresented communities, cultures.
- Identification and development of technological solutions that will enable effective and efficient re-use, accessibility and presentation of already existing digitised cultural heritage content in new contexts and immersive environments, including educational, teaching and artistic and creative dimensions.

IMPULSE enable cross-fertilisation between researchers, artists, heritage practitioners, CCSI representatives, entrepreneurs, local institutions, companies and other relevant stakeholders through a profiled IMPULSE Community of Practice, and relevant tools and channels such as the IMPULSE Hackathon and Acceleration & Mentoring Hub, to facilitate effective dialogue, co-creation and capacity building in immersive digitisation.

All these tasks are among the priorities behind the promotion of new ways and forms of education, art and creative experiences within the framework of European immersive digitisation, enabled by the diversity of audiences, actors and in correlation with different economic sectors. In addition, the project envisages research, evaluation and prioritisation of the needs (in particular, the objective is to ascertain the specific information needs) and experiences of diverse stakeholders in order to identify the characteristics, conditions, behaviours, experiences, recognition of cognitive-affective processes of these users, both passive and active, in order to adapt the project outcomes to the transformation of immersive environments. It is a synthesis of specific requirements into the design of research and innovation policy activities that strengthen immersive digitisation capacities, aiming to develop a new understanding of the metaverse, defined here as a user experience that includes embodied immersion in a multi personal, persistent online virtual world together with other relevant elements and that has the potential to become a suitable venue for the presentation of digital cultural heritage and other key elements. For this, it is necessary to diagnose first of all the needs, motivations and requirements of the audience in terms of their interest in interacting with cultural heritage in a virtual environment. The application of methodological principles such as Agile Development, Design Thinking and Future Literacy (IMPULSE Proposal, p. 8) allowed the implementation of an interactive, cyclic process of implementing conceptual-theoretical guidelines, creative-practical ways of developing methods and research tools, taking into account not only the needs and requirements resulting from the identification of user criteria with regard to the use of new forms of experience in immersive environments, but also the development of effective methods for the identification of user behaviour and information needs, as well as the creation of user experiences.

Fig. 1. Visualisation of the iterative research-empirical process in the IMPULSE project.



Source: (IMPULSE Proposal, p. 9)

Figure 1 highlights the key role of research, both within the specific WP1 task package and as a whole, cyclical and systematic process of diagnosing and clarifying relationships, linkages, and defining conditions in the process of creating user experience.

The iterative nature of the IMPULSE research is particularly evident in WP1 and its associated subtasks, as well as in the process of creating the prototype. This includes the creative and imaginative activities conducted on the virtual platform, such as those involving artists and CCSIs, as well as the creative utilisation of digital heritage. In terms of the technological aspects of the implementation of the research and the creation of the prototype, the iterative process of its creation will be concluded at the stage of the creation of the final version of the prototype, subject to evaluation. This will be done in accordance with the IMPULSE initiative, which has set out two versions of the prototype platform (in line with the guidelines set out in WP2).

Through a set of multifaceted and diverse activities in the IMPULSE project, which was divided into individual overarching tasks, the focus was on documenting, assessing and prioritising the diverse needs of stakeholders and users in the different sectors of immersive digitisation. The IMPULSE project has adopted a defined strategic plan to achieve its stated intentions, which it has differentiated from individual goals and intentions, which it has hierarchised into six work packages (WPs). These are indicative not only of the adopted dimensions of research and practical activities, but also profile the progression, evolution of activity patterns, principles and adopted standards of project implementation.

Thus, the IMPULSE project aims to explore the research field as well as the diverse and multifaceted issues that shape the space of immersive user experiences. It is also intended to serve as a specific way of implementing and disseminating new forms

of education, art and creative modes of experience within the framework of European immersive digitisation. The initiative, based on expertise, practice and mutual learning opportunities, allows the formation of research and innovation capacities to optimise the interplay and activities between art and science, culture and technology, taking into account immersive digitisation, contributing to functioning in the dynamically shaping digital transformation.

1.2 Objectives of the Work Package WP 1

The aim of Work Package 1 (WP1), entitled "Extended Storytelling Towards Vivid User Experiences," which spans the 36-month duration of the project and serves as one of the foundational elements of IMPULSE, is to provide a pivotal module guiding the entire initiative. This module underpins the whole project, and its research is both essential and a priority not only for the individual Work Packages but also for the successful creation of the prototype.

Within the framework of the project, research procedures, methodologies, and methods of analysing user experiences will be developed. The results of these activities will be applied in UX research to identify user requirements and behaviours in virtual environments related to digital cultural heritage. Furthermore, it will present digital heritage archives to researchers, artists, and scholars through augmented reality artworks and game-like experiences. This will disrupt dominant narratives and represent marginalised cultures and communities by embedding hidden stories, creating rich, diverse, and multi-layered narratives to engage a broader audience with the presented topics and themes.

The task encompasses the following specific objectives:

- Identifying and defining the information needs of selected user groups involved in creating and utilising virtual environments in the context of exploiting digital cultural heritage resources and perceiving creative virtual environments. Information needs in information science, one of the social sciences, are broadly and diversely defined as: 1. knowledge gaps or information gaps (Dervin, 2000). This occurs when there is a discrepancy between an individual's internal and external reality, leading to a desire to attain complete knowledge to find the sense and logic of the world (Savolainen, 2005). This can manifest as 2. anomalous states of knowledge, characterised by the perception of the discrepancy between the desired state of knowledge and the current state of knowledge (Belkin, Oddy, Brooks, 1982). It can also manifest as a 3. need to obtain answers to questions pertaining to the environment, digital systems, and other areas (Taylor, 2015). This can be understood as 4. an emotional state during the multi-stage process of acquiring information (Kuhlthau, 1993). Moreover, the perception, awareness and expression of the need by the individual

result in the undertaking of a range of behaviours, including those related to the acquisition of information (Taylor, 2015).
- Introducing techniques to engage audiences in new ways of utilising digital heritage resources, facilitating immersive experiences in metaverse environments through multifaceted UX research.
- Creating socially engaged experiences in XR technologies to challenge and reframe dominant narratives, as well as exploring the methods and possibilities for representing marginalised social cultures.
- Presenting innovative and progressive applications of digital cultural heritage resources.
- Defining collections within the digital environment.
- Offering solutions that expand the scope and contextuality of objects presented, perceived, and utilised in new virtual environments.
- Focusing on underrepresented communities and cultures by uncovering hidden histories and cultural memories.

1.3 Objectives of the Task 1.1

Within the framework of the overarching Task 1.1 entitled UX Research, conducted by the Jagiellonian University (UJ), multifaceted and diverse UX research is carried out in collaboration with partners representing the universities and institutions of Katholieke Universiteit Leuven (KUL), University of Bologna (UNIBO), University of Malta (UM), National and Kapodistrian University of Athens (NKUA), Clust-ER Create (C-ER) and K8 Institut fuer strategische Aesthetik GGMBH (K8).

The study, using mixed methods and techniques, aims to identify the needs and behaviours of a sample of users from the groups surveyed in Impulse (G1 = general group of university students and academics, G2 = artists, art students and teachers, G3 = CCI representatives) will be included in the study. In addition, non-users will be included, defined as individuals who do not actively use VR but are aware of its existence, as well as those who do not use VR due to a lack of knowledge and competence. The initial two groups (G1 and G2) can be further categorised into two distinct subgroups. The first subgroup comprises active users (in accordance with the established terminology, users in this subgroup are designated as experts. It will proceed to further subdivide G2 into non-users and users, while within the user category, we will also distinguish between experts), which includes artists and individuals who engage actively with immersive environments. The second subgroup, in contrast, encompasses passive users. Those are not involved in the creation and dissemination of virtual environments in the context of the popularisation of digital cultural heritage. The aim is to identify their needs, expectations, beliefs, social motivations, embodiment and acceptance of the technology and engagement with virtual heritage environments using VR. The analysis will include the skills and competences of both users and non-users, as well as the reactions evoked by the tool and the proposed personifications of virtual environments generated

by the institutions (avatars). Research trials, involving random and self-selecting groups, will be conducted by UX support groups and quality control teams on a diverse audience.

For the key tasks on which the subsequent tasks and deliverables will be based, outputs implemented throughout WP1, as well as other packages, including those related to the creation of prototypes, are envisaged to be realised through research, multi-faceted, undertaken using mixed methods and selected research techniques. The task of these analyses, undertaken iteratively, systematically and through permanent refinement of research tools, is to identify in depth the needs and behaviours of users (from G1, G2, G3, and experts selected from G1 & G2) and non-users (selected from G1 & G2) of immersive environments: the virtual multi-user environment (MUVE) in the context of the popularisation of digital cultural heritage. The goal is to identify needs, expectations, beliefs, social motivations, embodiment and acceptance of technology and engagement in virtual heritage environments using VR and thus achieve new knowledge, practice in the context of creating interdependent immersive spaces with a digital cultural heritage resource that is correctly adapted, replicating conditions and elements correctly interpreted in terms of user experience.

1.3.1 User groups as audience and actor categories in UX research in the IMPULSE project

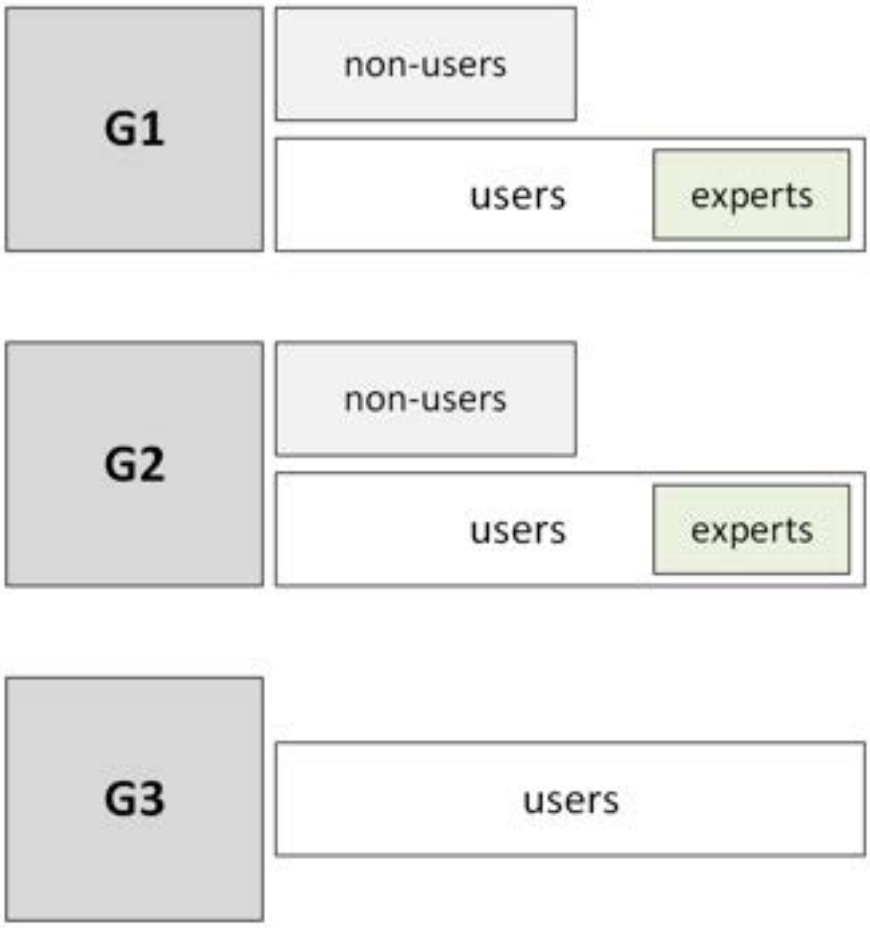
It is necessary to indicate and highlight the relevant aim of the project and the specific tasks undertaken in the framework of WP 1.1. It is essential to identify and emphasise the principal objective of the project and the particular tasks undertaken within the context of WP 1.1. The project's core objective is to develop prototypes and recommendations for public institutions responsible for the digitisation of cultural heritage, based on an understanding of the expectations, needs and behaviours, as well as the experiences, of users from selected and surveyed groups. These will be differentiated into three overarching groups: (1) students, researchers, and university academics from different disciplines; (2) artists of different specialisations, art schoolteachers; and (3) representatives of selected industries from the creative industry (e.g. filmmakers, scriptwriters, computer game developers, etc.).

The user experiences research will also allow, through the analysis of the questionnaires, to select a subset of the overarching groups of students and academics and artists art students and teachers as a potential non-user group. This sub-group are users who do not use immersive environments, who are passive participants in these spaces (as they may use them unconsciously) or who do not use immersive environments due to lack of knowledge about VR, MUVEs or lack of desire, motivation, competence and skills to use them.

The findings and recommendations resulting from the research and scientific (as well as technological) work of the project will provide insights not only into the reasons why users want (or do not want) to use digital content in XR, but also into strategies for increasing its use, and for enhancing its efficacy, efficiency, and creativity.

The research conducted in WP1, particularly with regard to UX in VR, will concentrate on the categorised core groups resulting from the project assumptions. Furthermore, the two principal groups, G1 and G2, will be subdivided into additional subgroups, namely those comprising internal non-users and experts. Figure 2 below illustrates the visualisation adopted in the project for the categorisation of users surveyed in IMPULSE. This categorisation is divided into three main groups and subcategories, resulting from the classification based on qualitative analysis within the main groups. Additionally, G1 and G2 have been divided into subgroups of users and non-users, as well as experts.

Fig. 2. The adopted categorisation of IMPULSE users divided into groups.



Source: Self-authored, 2024

These principal groups with selected sub-groups are described below and include:

- **Group 1 (G1)**: This group comprises students and academic teachers, academics from different university departments and institutes selected in all IMPULSE partners academic environments, such as those from the Jagiellonian University in Krakow. The group of users in question can be described as a general and principal one, which may be further diversified and require further subdivision. This will be based on the characteristics of this group (G1), as well as the identification of such users who already have some experience with VR, immersive environments, as well as very active users who are involved in their use, if only in the teaching process (as this dimension is crucial in this group) and the creation of content. Concurrently, the G1 group may also comprise individuals who do not utilise such technologies, as defined on page 17. These individuals are also crucial for the project, as they must be identified and their needs, expectations and motivations in experiencing immersive environments explored. This overarching group of users (G1) will include additionally within those users who engage creatively with immersive environments (e.g. use VR environments for didactics and create content) there are two sub-groups: experts and non-users. Selected individuals who express a willingness to participate in subsequent stages of the project will be included in both the user and non-user groups. From groups of users from G1, G2 & G3, who agree and express an interest in participating will be invited to participate in research using the prototype (an experimental form based on using resources within the immersive environment of the prototype and performing specific tasks according to the stages of project development and prototype creation, along with completing surveys and possibly using retrospective think-aloud protocols). It is now necessary to provide an overview of the methodology in order to facilitate comprehension of the research procedure as a whole. Given the current stage of the IMPULSE tasks, this preliminary description will focus on the key elements of the methodology, highlighting the aspects that should be taken into account in the selection of respondents for the study. A group of experts may be selected on the basis of an analysis of completed questionnaires or with the use of convenience sample method. The experts in this subgroup of users are defined as highly active and proficient users of virtual environments, capable of not only creating such environments but also their content. They possess extensive experience in utilising immersive spaces and have teaching experience, having either used or are currently using virtual environments for educational purposes. Those who are engaged in the utilisation of virtual environments for the learning process (within the context of higher education), and who are established users and creators within the research community, may be invited to participate in the subsequent phase of the study, wherein they will utilise the prototype to explore the metaverse user experience. Furthermore, they must be willing to participate in the experiment.

  The primary aspect to be explored within this group is the educational and pedagogical perspective, examining the potential for integrating and applying

immersive environments and digital cultural heritage into teaching and learning processes. A prototype intended for didactic use within this group, utilising contextual layers, will facilitate the examination of ownership within institutional collections and narratives.

- **Group 2 (G2)**: This group includes artists of various specialisations, as well as students and teachers from art schools. As with the preceding cohort, this group constitutes a general, principal grouping of users, which may also be diverse and thus necessitates further subdivision. This will be based on the characteristics of this group (G2), as well as the identification of such users who already have some experience with VR, immersive environments, as well as users demonstrate high levels of activity, those who are involved in VR or metaverse use, if only in the creative, artistic process (because this dimension is crucial in this group) and the creation of content. Concurrently, the G2 group may also comprise individuals who are not users of the technology in question. These individuals, as defined on page 17, are also crucial for the project, as they can provide insights into the needs, expectations and motivations of those who do not currently utilise immersive environments, particularly in the context of artistic activities. G2 will then be divided into two sub-groups of experts and non-users, similarly to G1. After the first phase of research, based on the results of the questionnaire, a group of experts will be selected that will include artists, students and academics who actively use VR and engage with immersive environments, create their work in such spaces and share their immersive experiences in virtual environments. The second sub-group will include non-users selected through a survey. The latter group of non-users, a subset identified through the questionnaire, consists of actors that means users, those who do not use VR due to a lack of (often unacknowledged) knowledge about such environments, a lack of competence, or a lack of willingness or motivation to use the metaverse.

  Furthermore, as in G1, it is possible to select within G2 a group of experts from within this group on the basis of an analysis of the completed questionnaires and using the convenience sampling method. The term "expert" is defined as a highly active and proficient user of virtual environments, including those who create such environments and their associated content. These individuals possess extensive experience with immersive spaces and are established users and creators within the artistic community. They may be invited to participate in the subsequent phase, utilizing the prototype to examine user experiences within the metaverse, and are willing to engage in the experimental process.

  Various dimensions of experiencing immersive environments will be investigated within this group, including the creative aspects of perceiving, creating, and utilising digital cultural heritage resources, both in metaverse, as well as with the use of the prototype and selected digital heritage content. The inquiries will focus on the potential of using prototypes in unconventional artistic contexts. Artists will employ the IMPULSE prototype in their creative processes through the implementation of artistic research and speculative methods, intellectually interpreting and reinterpreting information and resources to engage

performatively with assets in metaverse worlds. A particularly interesting approach to studying this user group will be speculative methods, which aim "to imagine or create futures or conditions that may not yet exist, to provoke new ways of thinking and to focus on specific ideas or issues" (Ross, 2017).

- **Group 3 (G3):** As with previous cohorts, this group represents a general core group of users, which may also be diverse in terms of the specialties and industries that this group represents. These include, for example, computer game developers, screenwriters, game music, and others. The selection of users for the study within this group (G3) will be based on collaboration with the IMPULSE Community of Practice (IMCo), the convenience sampling method, and general familiarity and accessibility to recognized individuals in the specialty and industry. The group is comprised of individuals representing the creative and commercial sectors. This group is of primary importance and its selection is guided by the project's objectives. It has been assumed that this is a highly diverse and specialised user group (G3), consisting of professionals who utilise virtual reality (VR) but do not necessarily employ digital heritage resources in this environment. This assumption is also implicit in the project's objectives, where the commercial dimension as it relates to the group representing cultural heritage institutions (CCSI) and the identification of opportunities for the utilisation (as well as re-use in creative way) of a variety of digitised cultural heritage objects in the creation of immersive environments is made clear. The group is constituted by professionals who are proficient in their respective fields and who will be included in the research. These may include, for example, computer game developers or filmmakers. It is assumed that this group, in line with the subject matter of the project and its stated objectives, constitutes a sector that does not make sufficient use of or indeed make use of digital heritage content at all. Furthermore, it is assumed that this group does not use these resources optimally. However, it is possible that this sector could become one that actively uses and transforms digital heritage content in creative ways. The research will employ interview methods and focus groups with representatives of these industries, who will also be selected using the convenience sample method. This will enable the identification of their motivations, expectations, needs and ways of experiencing the metaverse. This group encompasses CCSI organisations and networks, freelancers, and designers. Research within this user group aims to reframe the mental model, as well as the mental and cognitive representation, of those within CCSI, particularly concerning new understandings and methods of utilising digital cultural heritage. Identifying the needs and expectations of users in this group will be crucial for the proper development of standards for storing, using, and creatively reusing these resources, especially in the context of prototyping new immersive environments. Representatives of CCSI, freelancers, and designers will use IMPULSE to explore methods to facilitate the integration of existing digital resources into metaverse environments, through co-creation based on exemplary sets of open cultural data available, for instance,

on Europeana (https://www.europeana.eu/pl), with various constructive approaches to resource integration.

The research will examine all these groups and sub-groups perceptions of virtual environments, identify their potential applications for these users, and, crucially, incorporate knowledge about their needs, motivations, and ways of perceiving and understanding new technologies, including metaverses. It will also assess the likelihood of their engagement with digital cultural heritage and identify potential barriers and issues that may lead to avoidance, abandonment, or a lack of immersion and experience in virtual environments.

The project and the user research carried out adopted a definition of non-users, according to which these are people who do not use new information technologies, products or services because they are not familiar with them, do not have knowledge about them or do not perceive the environment and facilities offered as appropriate, adequate or accessible. Therefore, a non-user is an individual who does not use new technologies, including different products or services, despite their knowledge or lack thereof. Non-use of new technologies by an entity defined as a non-user can be attributed to several reasons, including a lack of acceptance of new technologies, a lack of specific needs for their use, inappropriate experiences resulting from the use of new technologies, and a lack of knowledge about new technologies. Additionally, non-use of new technologies may be related to affective dimensions such as resistance, aversion, fear, and other negative emotions. The term 'non-user' also encompasses individuals who are disregarded or inaccessible to the field's interests (Rabello, 2023). The project includes a group of potential and future users, specifically those in heritage contexts where XR apps would be applicable, but who currently lack the knowledge to integrate such approaches into their work. This is a crucial distinction between the current users, comprising the G1, G2, and G3, as well two subgroups: experts and non-users, and the experts from G1 and G2, who were incorporated into the comprehensive research. Additionally, there is a need to consider the potential future users, who would require a compelling reason to utilize XR or other digital heritage resources in XR. This could be for educational, teaching, artistic, creative, or commercial purposes.

1.3.2 Structure of Task 1.1

The research undertaken as part of Task 1.1 will encompass an assessment of the skills and competencies of current and future or potential users and non-users, as well as creators. It will also examine the reactions elicited by the tools used and the proposed personifications of virtual environments generated by institutions (e.g., interactions and responses to avatars and objects, resources). Stratified, random, and self-selecting sample studies will be conducted by UX support groups and quality control teams. These studies will be carried out on a diverse group of participants. The groups identified

in the project documentation, which have been previously described, include: 1) students, including doctoral candidates, and academic teachers (G1); 2) artists and academic teachers from art schools (G2); 3) the creative industries (including computer games, film, animation, and performance (G3).

The entire task has been divided into sub-tasks, which will be undertaken in a compatible, transparent, and iterative manner throughout the project's duration.

These sub-tasks are divided into seven parts as follows:

- Task 1.1.1 (months 1-3): Critical analysis of literature and scope review. At this stage, exploratory (diagnostic) qualitative and quantitative research will be conducted to identify research methods and analyse users and non-users, along with their interactions with VR using digital cultural heritage resources.
- Task 1.1.2 (months 3-6): The objective is to develop research techniques for three overarching, categorised and differentiated user groups in accordance with the project's objectives, designated as G1, G2 and G3, as well as two sub-groups (experts and non-users) that can be scaled within G1 and G2. For further details, please refer to subsection 1.3.1. The proposed methodology and procedures will allow for the examination of active and potential future users of virtual worlds and the identification of their knowledge, competencies, motivations, and ways of experiencing immersive spaces.
- Task 1.1.3 (months 7-15): User research: preliminary studies before prototype development. At this stage, the requirements and information needs, behaviours, and practices of users in immersive and virtual environments will be identified, along with their competencies and expertise, such as software knowledge, terminology, and tools. The findings will be integrated into the prototype development process. The UX research will be iterative preliminary, allowing for verification and modification based on preliminary and pilot study results, and will be conducted within selected target groups.
- Task 1.1.4 (months 16-18): Correlation with research conducted in various WPs. This stage involves compiling and analysing the results of research conducted concurrently across all WPs to diagnose the significant requirements, expectations, and behaviours of different users.
- Task 1.1.5 (months 16-20, months 29-35): Collection, selection, evaluation, and interpretation of research results. This task includes the compilation of results, construction of personas, statistical and qualitative analysis of surveys, and production of UX diagrams (designing). Additionally, data collection will focus on educational and didactic factors—ideas for art schools' teachers and professional digital art trainers on promoting the assimilation of new users into VR. Internal reports will be created for processing within various WPs.
- Task 1.1.6 (months 21-34): UX research (final phase, after prototype development and implementation). This task involves testing the usability and functionality of the technology and metaverse prototypes using digital heritage resources. Additionally, the quality of the prototypes will be evaluated.
- Task 1.1.7 (months 20-36): Compilation of all relevant educational and didactic data. At this stage, instructions and guidelines will be developed for activating art

schools' teachers and digital art trainers to promote the immersion of new users in VR. Concurrently, principles concerning the information needs and behaviours of users will be established. A crucial element of this task will be knowledge dissemination and transfer, including the co-creation of scientific publications, hackathons, conferences, and workshops.

1.3.3 Objective of the subtask 1.1.2

While this document mainly highlights the results of subsequent sub-task 1.1.2, it is important to point out the important role and combination of both the activities undertaken in sub-task 1.1.1 and the activities carried out in WP 2 (TECH), WP 3 (STAND), WP 4 (LEGAL WP), WP 5 (DISS WP). The creation of a library of resources in Zotero by all the teams of partners participating in the project, the search for interrelationships between WPs, the discussions, the creation of a database of questions, the clues that have been taken into account both in the scoping review process and have contributed significantly to the development and preparation of a set of methods and techniques that will form the methodological basis for any research carried out in analysing the experiences, needs, motivations, cognitive-affective aspects of all users in the different groups to be analysed. Hence, the key results of the scoping review have been included in the document, as a starting point for the development of the user research methodology and the activities that have been carried out during the process of creating this extremely difficult, multifaceted, but also compatible with the stated objectives of the project, user experience exploration scheme.

The IMPULSE project represents a clearly defined conceptual framework, whose realisation, construction, and implementation are systematically organised through iterative methodologies, encompassing continuous improvement alongside exploratory analyses and actions. This endeavour is divided into six distinct work packages, each outlining a primary objective while leveraging the actions, outcomes, and insights from all associated tasks within the project to support its execution. Among the early stages in these work packages is Subtask 1.1, focused on user experience (UX) research, and subsequent sub-task 1.1.1, which involves a critical review of literature and scoping review, included within WP1, the EX-STORY activities.

IMPULSE initiative seeks to challenge existing narratives by showcasing the diversity and multidimensionality of phenomena related to behaviours and experience dimensions while promoting immersive environments. Furthermore, it aims to include marginalised cultures and communities by integrating hidden stories, thereby creating complex, diverse, and multi-layered narratives intended to engage a broader audience with the presented topics and themes.

2 The Process of Creating the Methodology and Procedures for User Research

This chapter will set out the procedure for developing and creating the research methodology. In accordance with the roadmap and task implementation, the methodology should be validated through the preceding proper research phase. It is anticipated that the preliminary research phase will entail the utilisation of methodologies and instruments by all project partners. The subsequent actual research phase will employ the prototype, which will be conducted in two phases: the first phase will entail pilot research utilising the prototype, and the second phase will entail testing and implementation at various stages of the research process, where feasible. Each of the methods, as well as the research phases, can be modified and improved during the subsequent phases, starting from the preliminary studies, as well as a result of diverse and often changing conditions, also taking into account the characteristics of particular user groups, whose experiences, including needs, information practices and behaviour, activities, perception, affective-cognitive predispositions will be diagnosed.

2.1 Scoping review main conclusions

The subchapter will describe the main conclusions that were drawn after the scoping review and thematic analysis. The full text of the report of this activity and part of research belonging to subsequent sub-task 1.1.1, which is also a prolegomenon for the development of the research methodology can be found in Appendix 5.1 (p. 73).

2.1.1 Process scoping review and thematic analysis

Qualitative and quantitative exploratory (diagnostic) research to identify research and methods used in the analysis of users and their interaction with VR using digital cultural heritage resources.

The development of user research methodologies in the IMPULSE project would not have been possible without a thorough evaluation of the available and applied methods, techniques, and research tools for various types of users, not only in the context of experiencing immersive environments but also in utilising digital cultural heritage resources. Previous analyses conducted across different disciplines, using diverse methods, highlighted the necessity of creating a research tool and procedure that can undergo continuous evaluation, verification, and improvement at every stage of the project, particularly in relation to the development and use of a multi-user virtual environment (MUVE) prototype that exclusively utilise digitised cultural heritage content, encompassing a range of formats including e.g. audiovisual material. The perspective

of an environment applicable in educational and didactic processes, as well as a space for the creative activities of artists and a tool for the creative industry, has also allowed for the use of the scoping review as a means to identify various approaches and possibilities. These insights have become essential to integrate into the research process in the next phase of the IMPULSE project.

The scoping review constituted the initial task undertaken within WP1 and involved conducting exploratory qualitative and quantitative research with the aim of identifying the research methods and analyses employed in the investigation of the user experience with virtual reality, particularly in the context of utilising digital cultural heritage resources. The scoping review became a form of knowledge synthesis through a systematic and iterative approach to identifying and synthesising existing or emerging user experience research in the literature. The choice of a scoping review also allowed for mapping the scope and nature of the literature and identifying specific gaps within it. This approach was instrumental in constructing an analytical framework related to the research problems and areas addressed by the IMPULSE project, through exhaustive processes of searching and acquiring information. This supported the synthesis of knowledge, the identification of concepts, terms, procedures, as well as research methods and techniques (Tricco et al., 2018). The analysis was based on the PRISMA 2020 flowchart for systematic reviews and meta-analyses (Page et al., 2020).

The research was developed based on a group library created within the IMPULSE project, named HORIZON_IMPULSE in Zotero. The library aimed to collect, classify, and share an extensive resource concerning the issues and research areas related to the specific research groups within the project. Consequently, the library was divided into folders corresponding to the main work packages in the IMPULSE project related to research. The different sub-folders have been named according to the acronyms of the individual WPs: Dissemination, Ex-story, Legal, Standard, Tech. During the literature analysis and scoping review, subfolders were added: Screening (containing all publications selected for critical analysis and review), Screening Additional Searching (containing all publications found during the scoping review), and Trash (where mainly duplicate publications not included in the analysis were moved). The expansion of the library through systematically gathering relevant resources related to the project's subject matter was essential.

The multi-layered overarching aim of the project, combined with the literature gathered during the collection, search and review stages, helped to expand the objective in subsequent sub-task 1.1.1 and broaden the scope within which the analysis was conducted. As a result, the focus has shifted to a synthetic, multifaceted and interdisciplinary study of the phenomena, features and contextual factors related to research on user experiences in virtual environments using digital resources, including those relating to cultural heritage, and their implementation across disciplines and domains, meeting the needs of different user groups as well as non-users. Achieving

the set overarching objective required embedding it in the broader context of the user experience in virtual environments, taking into account diverse but selected aspects and contextual factors, and recognising the interdisciplinary dimension of the overall subject matter.

Consequently, additional specific tasks were formulated, including:

1. Determining the most appropriate research methodologies for user experience research in immersive environments.
2. Identifying the areas and domains in which previous research has been undertaken.
3. Recognizing the goals and intentions of research conducted in this area, as well as the dimensions in which such research was conducted.
4. Incorporating diverse technologies associated with virtual environments.
5. Identifying various user groups among which VR experience research was conducted.
6. Recognizing different aspects related to VR experience.
7. Diagnosing the plethora of methods used to study users and their experiences in immersive environments.
8. Capturing diverse terminologies.
9. Attempting to identify ways of studying the needs and behaviours of users in immersive environments.

The 201 full texts selected were then subjected to thematic analysis using the MaxQDA software (the thematic analysis tool is a qualitative data analysis tool for which a licence was purchased for JU) by three independent researchers. The software allows for the incorporation of resources selected during the current information and literature acquisition, which will be used during the project and will address methodologies for studying user experience and behaviour in immersive virtual environments. MaxQDA allows for efficient research, various types of analysis and continuous improvement at each stage of the project. The material was divided numerically, and deductive-inductive coding was used. Deductive coding was applied using expert knowledge (domain-specific from project partners involved in user research in technical, information and social sciences) as well as knowledge developed by experts in user experience research. The critical analysis and scoping review started with an analysis and verification of the existing Zotero HORIZON_IMPULSE library. The use of Zotero library resources for IMPULSE included resource verification, during which duplicate bibliographic descriptions and full texts were removed, resource availability was checked, and efforts were made to locate full texts.

Meanwhile, during the thematic analysis conducted in MaxQDA, due to the expanded scope of the analysis undertaken and the scoping review broadening the scope and focus of the VR experience research, a fourth researcher conducted a search for publications in Web of Science and Scopus databases.

A full report of the scoping review process and the results of the critical literature analysis and thematic analysis undertaken can be found in Appendix 5.1 (p. 73).

2.1.2 Scoping review results

Scoping review has identified a number of research procedures that can be used when studying VR users. Among them, methodologies and methods were distinguished. When categorizing individual procedures into either of these two groups, the declarations of the authors of the analysed publications were followed.

The methodologies were assigned 28 sub-codes with different levels of detail. At the general level, the authors of the analysed publications used quantitative, qualitative, mixed methodologies, among others. Empirical research was also used, as well as analytical, iterative methodology, phenomenological approach and triangulations. Of the more specific methodologies noted were grounded-theory, Living Lab, Research by Design methodology, Rovina Paradigm, User Centred Design, user-centred innovation approach, and Whittemore & Knaff methodology, among others. The aforementioned methodologies were merely illustrative examples of those discussed in the context of the D1 study. They were included as a result of the scoping review and were employed in the analytical and other UX studies that fell within the scope of the thematic analysis. It is recommended that these methodologies be considered for use in the subsequent stages of the IMPULSE study. As the reports being prepared are documents that will evolve as the work in IMPULSE progresses, it is appropriate to revisit the question of using additional research methods, as well as methodologies, once the activities undertaken by WP1.2 and WP1.3 and their broader understanding based on the emerging prototype have become established. The continuous improvement of our knowledge and understanding of the requirements will enable us to consider appropriate and optimal methodologies for eventual implementation.

In the context of IMPULSE, both the wide range of possible methodologies use, and triangulation of methods are noteworthy. The multitude of methodologies identified in the scoping review process demonstrates the intricacy of research in regard to information requirements, expectations, and the experiences of diverse users of VR (and VR-like technologies). Concurrently, it offers considerable flexibility in designing research within this domain. On the other hand, the triangulation of methods and the possibility of combining different methodologies, especially quantitative and qualitative research, in a single research project allows for a multidimensional understanding of the studied fragment of reality. In addition, due to the research objectives of IMPULSE and the specifics of the user groups under study, this approach enables efficient organization of the research tailored to the specific research objectives and the possibilities and limitations of the research (e.g., the stationary availability of the subjects to organize empirical research in the VR studio, the characteristics of the collected research material and the possibility of its analysis).

The code denoting research methods was even more extensive, as it counted 213 sub-codes arranged at different hierarchical levels of the code book. In a single project it would have been impossible to apply all of the listed methods to study VR users and immersive environments, so on the basis of scoping review an analysis and selection of methods optimal for the goals and capabilities of the IMPULSE project was carried out. Among the methods were both general, universally applicable ones (e.g., field studies, observation, interview) and those specific to user experience research (e.g., various variants of user studies and design methods).

A number of physiological methods, e.g. ECG (electrocardiography), EDA (electrodermal activity), EEG (electroencephalography), were rejected in the context of the designed research procedure, due to the lack of availability of specialized measurement equipment, difficulty in interpreting the results, and inconvenience to the subjects. The only one of the physiological methods that was initially considered for use in IMPULSE was eye-tracking. As a result of discussions in WP1 and consultations with WP2, this procedure was also rejected due to technological limitations (i.e., using eye-tracking in a study of VR users would have meant purchasing and designing experiences only for selected models of VR goggles).

The results of the scoping review certainly benefited the development of the survey questionnaire. This is because the code book included many types of questionnaires and scales. The code describing the questionnaires was the most elaborate with further sub-codes, which were then reviewed during the development of the tool proposals used in IMPULSE. Many of the identified methods came in different variants; this was the case with experiments and interviews, among others.

In addition to methods and methodologies, the results of the scoping review focused on the areas/disciplines in which the research was conducted, the research objectives, the technology and the diverse groups of users. Furthermore, the components of the VR experience, as well as the dimensions in which the research was conducted, were taken into account during the critical analysis of the literature and in the thematic analysis. The latter two categories facilitated the subsequent development of observation schemes. This is since they addressed issues such as immersion, navigation in VR, VR perception and embodiment, motivation to use VR, and behavioural, cognitive and emotional aspects, among others.

A full list of codes with their explanations can be found in the Appendix 5.1 (p. 98) to the scoping review.

2.2 Team consultation as a form of research in action in the development of research methodology

The individual stages of process development, from the realisation of the scoping review to the creation of the proposal presented here, the activities undertaken, the analyses and the knowledge transfer were based on the form of action research. Additionally, it should be emphasised that all partial documents, presentations, reports and proposals for structuring the research methods and tools were available throughout the duration of subsequent sub-tasks 1.1.1 and 1.1.2 carried out so far and were hosted on Microsoft Teams in WP1. Ex_Story. Thus, it has been possible to view these resources, as well as to comment, suggest other or additional solutions, and make suggestions.

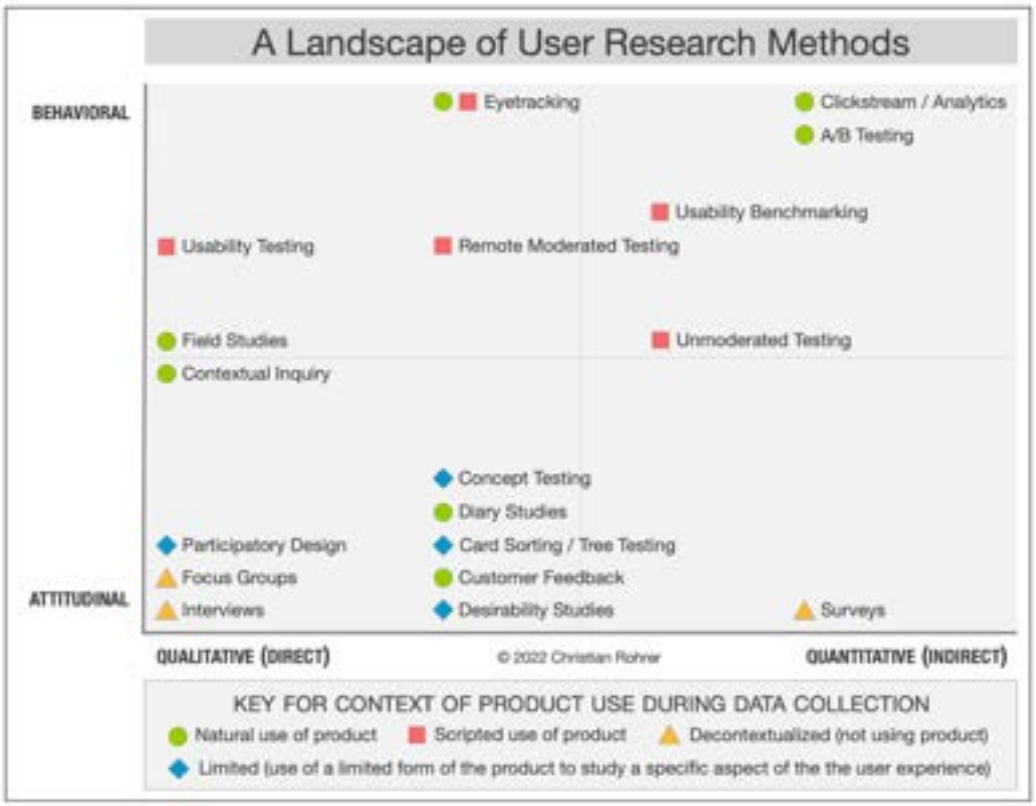
Ongoing consultation, reports on ongoing critical analysis of the literature, correction of questions, assumptions, use of expert knowledge, theoretical and empirical support for partners who learn more and more through experience (including making mistakes) in a self-reflective spiral of planning, acting, observing, reflecting, replanning, etc. Collaboration between group members as a critical community, people reflect and improve their work, strongly integrate their reflection into their actions (Altrichter et al., 2002).

The core objective of action research is the resolution of the identified problem (Drummond & Themessl-Huber, 2007), a process that, like the subject and aims of the IMPULSE project, is not approached in a simplistic manner. The research and empirical activities undertaken during the individual tasks of the project constitute diagnostic action research, in which the problem is diagnosed, and solutions are generated collectively. The objective is to arrive at solutions that are as acceptable as possible to all partners cooperating on the problem situation. Furthermore, such research processes afford the opportunity for learning by doing, which is founded upon the transfer of mutual experience, knowledge, and information. Similarly, the IMPULSE project is a continuous, reflective process of exploration. Action generates knowledge, and collective information practices facilitate the transformation of empirics in a specific context through mutual dialogue, interaction and action. This form of process, based on dialogue, varied interactions and action, enhances the outcomes of the tasks and situational understanding and reflection (Kemmis, Nixon & McTaggart, 2017).

The modus operandi of employing a range of research methods and tools should be oriented towards optimising change and developing the appropriate product, prototypes and new insights related to digital cultural heritage in an immersive environment, thereby enhancing the comprehension of user experience (Greenwood, 2018).

During the thematic analysis and scoping review, as well as during the initial phase of developing the research methodology in IMPULSE a compilation of the most commonly used UX research methods within a three-dimensional framework with the following axes was used: 1. Attitudinal vs. Behavioural, 2. Qualitative vs. Quantitative and 3. Context of Use is illustrated in Figure 3. The diagram was developed by NNgroups, a company founded by UX researchers Jakob Nielsen and Don Norman, which employs a team of UX experts dedicated to providing sound recommendations and practices in UX, user experience design and research.

Fig. 3. Proposed by NNgroups the scheme of categorisation and types of research methods used in UX research.



Source: Rohrer, 2022

Furthermore, an important aspect became the categorization of immersive technologies and virtual worlds proposed by the National and Kapodistrian University of Athens and the Spatial Media Research Group.

The categorisation was presented by the NKUA at the plenary meeting on 1 March 2024 and included a number of key characteristics and examples drawn from the metaverse, MUVEs and virtual worlds. This formed the basis for the creation of an extract from the codebook utilized during the scoping review. During the scoping review process, the technology codes were also discussed with the NKUA (WP2). It should be noted

that different immersive technologies and virtual worlds vary in their functionalities and in the way they are experienced by the user. The distinction provided by the NKUA facilitated, among other things, the identification of the dimensions of observation that are worthwhile for the users of each technology, as well as the suggestion of sections, questions and answer options in the research questionnaires.

An additional source for the development of the methodology was a preliminary proposal to apply specific social research methods in the context of different users from preliminary (on this stage of realisation of IMPULSE) G1, G2 and G3 and taking into account the sub-groups of non-users and experts. These groups initially included: pre-G1) students, postgraduates and young researchers and academics; pre-G2) artists and art schools; pre-G3) representatives of the creative industries (games, film, animation, performance etc.). Furthermore, this aspect was taken into account in the development of the methodology and the selection of research methods and tools. This was a preliminary version of the proposed distribution of users within the key and overarching preliminary groups G1, G2 and G3. It is based on discussions and proposals from the team involved in the IMPULSE research methodology plan. As part of the activities and discussions that took place, four social research methods were initially selected in the context of the user groups, which could be adapted to the different types of users from the overarching and main groups (preliminary G1, G2 and G3). The approved and definitive categorisation of all user groups, developed in the latter stages of the project, together with a description of their characteristics, is included in subchapter 1.3.1 (p. 18).

A meeting of the research team from the JU partners was held internally. The process of developing the vision and defining and refining the project objectives, as well as highlighting the relevant stakeholders, dimensions, and the necessity for verification and experimentation with the prototype, is of great importance. A research gap was identified through a scoping review of the literature on the context in which users experience immersion and interact with digital cultural heritage objects. The review highlighted the need to consider the temporal aspects of user behaviour, including the time at which decisions are made and reactions to the various elements that contribute to the immersive environment. The questionnaire categories and scales that could be useful for implementation in the questionnaire preparation using the experimental method were identified. In addition, questionnaires were created for general users representing a group of students and academics (G1), artists, and art schools (G2). Finally, questionnaires were designed additionally for the sub-group of non-users. The revision of the research methods also applied to CCSI (G3), which, due to their sector-specific nature, require the utilisation of methodologies and instruments distinct from those employed in the administration of questionnaires. Given the particularities of their commercial sector operations and potential reservations about participating in questionnaire-based research, this group was deemed suitable for user experience research employing interview and focus group techniques. These methods facilitate a more precise, non-schematic collection of data for analysis, elucidate certain aspects, and expand a certain way of perceiving and experiencing,

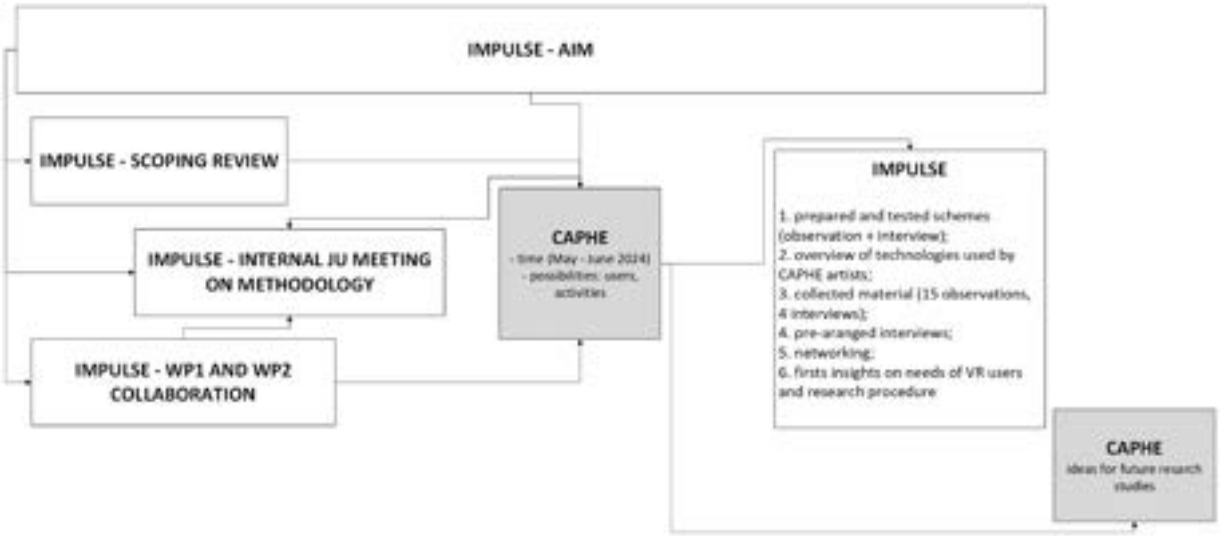
which will be crucial for user experience research in immersive environments. Furthermore, if the group required the use of a questionnaire, it would primarily be based on open-ended questions due to the specificity of G3 and the objectives of researching this user group. Written answers would require a significant investment of CCSI specialists' time, which is a valuable resource. It was thus necessary to devise interview protocols for G3 and to consider the potential use of observation as a method for eliciting expectations and needs when working in a creative and immersive environment.

2.3 Preliminary initial studies within CAPHE project

This stage in the development of the procedure, schemes, verification of feasible, previously proposed and resulting from the critical analysis of the literature, methods and possible project tools were a milestone in developing research methodology in the IMPULSE project.

Initial studies within the CAPHE project (Communities and Artistic Participation in Hybrid Environments, The HORIZON Europe Program under grant agreement no. 101086391; https://www.caphe.space/) were conducted in Italy, in May and June 2024. The objectives of this initial study and the procedures used were driven by the objectives of the IMPULSE project, on the one hand, and the opportunities offered during the CAPHE mobility, on the other. The links between the IMPULSE and CAPHE projects in terms of the development of the research procedure are shown in Figure 4.

Fig. 4. Visualisation of CAPHE project elements compatible with the IMPULSE project and the development of a UX research methodology.



Source: Self-authored, 2024

During the mobility, four main activities were performed, bringing together researchers and artists (including musicians, dancers, sculptors, directors) working in XR environments. These included a research conference, the VR Opera Gianni Schicchi, workshops and the XR Festival.

2.3.1 CAPHE events used in the preliminary study

Participation in two CAPHE events was used to develop and shape the research methods in the preparation of the UX research methodology. These were the Enhancing Artistic Experience in Hybrid Environments conference and the XR Festival in Florence.

The Conference Enhancing Artistic Experience in Hybrid Environments (CAPHE, 2024) was held from 15.05 to 17.05.2024, at the Conservatorio Giacomo Puccini in La Spezia, with remote participation possible. Topics of presentations addressed, among others, the relationship between the physical environment and the VR environment, and the application of VR and AR technologies in selected artistic and educational projects.

Another of CAPHE's events was the opera Gianni Schicchi, which ran simultaneously with the conference in La Spezia. The opera premiere took place on 17.05.2024 at the Conservatorio Puccini with live streaming to Spatial (CAPHE, 2024a). The premiere was preceded by rehearsals: both separate rehearsals for the VR team (director and users moving avatars representing characters from the opera) and the musicians, conductor and all the technical staff, as well as combined rehearsals for both teams.

Then, in Florence from 20.05 to 10.06.2024, at the Opera Network seat, at the Accademia di Belle Arti, at the Conservatorio Cherubini and at the Cattedrale dell'Immagine, workshops were carried out on, among others, video mapping and immersive video art, immersive and interactive storytelling, AR sculptures exhibition, creation of hybrid Artwork Prototype and exhibition, modelling and Augmented Reality using 3D elements, extended reality and 3D data visualisation systems applied to cultural heritage, costume design in metaverse for hybrid performance.

The final event of CAPHE's mobility was the XR Festival in Florence running from 11.06. to 17.06.2024 (CAPHE, 2024b). The XR Festival consisted of hybrid exhibitions (physical space in Oratorio Santa Croce al Tempio + Spatial), an AR Tour and another VR Opera, this time Orfeo & Lwanda. During this second VR opera, live motion capture using haptic costume and Rokoko Studio software was used, as well as participatory costume design using VR and AI.

The main aim of the CAPHE initial studies was to explore the needs of VR users in the context of enhancing/stimulating the quality (creativity) of creative processes. This indicates that the CAPHE project's objectives are in accordance with those of IMPULSE, particularly with regard to the examination of G2 and the identification of requirements, expectations, motivations, and user experiences among this category

of selected categories of IMPULSE users. Additional objectives were to test the pre-developed research procedure and tools and to obtain information on the XR technology used by CAPHE artists (at the request of WP2). The research in Italy focused on one of the user groups considered in IMPULSE, i.e. artists using VR, creators as well as the experts. This was a priority for mobility with CAPHE because of accessibility to this group.

2.3.2 Planning and implementation of initial studies in CAPHE

The alignment of objectives related to investigating the needs and user experience in G2 within IMPULSE permitted the conduct of initial studies within CAPHE. This allowed for the development and preliminary verification of the proposed methodological approaches, which will be applied during the main phase of the project. In addition, the refinement of interview and observation protocols, which form part of the methodological toolkit for IMPULSE, will be undertaken.

On the basis of the scoping review, three general schemes were developed for the research procedure to be conducted with CAPHE (see Table 1). The choice of the scheme to be implemented depended on the possibilities available during the mobility (e.g. events planned in CAPHE, availability of artists and materials prepared in parallel in IMPULSE). In the end, it was possible to implement the most realistic option, an intermediate plan with 15 observations and 4 interviews. All the interviews carried out were a continuation of the observations, following the technique of contextual inquiry.

Tab. 1. General scheme of the research procedure for CAPHE initial studies.

Plan minimum	**Intermediate plan** (most realistic)	**Maximum plan**
observation	some **observations** some **individual interviews** some **contextual inquiries** (individual interview + observation)	**contextual inquiries** (individual interview + observation) + **maybe questionnaires** to test (must be something for laptop, because printouts are unlikely to be done in the field)

observation scheme + photos (phone camera)	**observation scheme** with a semi-structured **interview scenario** + photos (phone camera) + recording of the interview (voice recorder)	**observation scheme** with a semi-structured **interview scenario** + photos (phone camera) + recording of the interview (voice recorder) + survey questionnaires

Source: Self-authored, 2024

Conducting the CAPHE initial studies required the preparation of research tools, i.e. observation and interview schemes, optionally also a user survey questionnaire.

The starting point for the development of the observation schemes were the dimensions identified in the scoping review and the discussion during the methodological internal meeting of the UJ team on 7.05.2024. Based on these, it was decided to include the following elements in the observations:

1. Type of VR experience (what was it, e.g., opera rehearsal, VR opera, costume sewing workshop, etc.).
2. Environment (e.g. Spatial)
3. VR user interactions with objects and other users
    a. Communication with other users (does it occur and if so, what is it like)
    b. Additional information, contextual information, menus, tool selection, etc.
    c. The type of objects and the ways to interact with them (are they present and, if so, what kind - e.g., you can move a vase, you can pour paint on a sculpture, etc.).
4. Cutting off the user from stimuli from the physical world and reactions to this cutting off
5. Movement - how users are moving in physical space (can they move and is the space limited in some way, do they have to move, do they have a choice) and in VR (e.g., teleportation, walking, choice) and what technical tools are used for this movement (the goggles alone? controllers? pads? with vibration – such as in games, where vibration in the pad can alert you of danger? treadmills?) – this movement is related to (1) motion sickness and (2) freedom in artistic creation

The next step in developing the observation scheme was to browse the available frameworks for notetaking during observations. Among others, Spradley's 9 Dimensions (Space, Actors, Activities, Objects, Acts, Events, Time, Goals, Feelings), AEIOU (Activities, Environments, Interactions, Objects, Users) and AX4 (Atmosphere, Actors, Artifacts,

Activities)[5] were analysed. Due to the previously identified observation elements, it was decided to use Spradley's 9 Dimensions framework. The adaptation of this framework is shown in Table 2.

Tab. 2. Idea of adapting Spradley's 9 Dimensions framework to the initial study conditions during CAPHE mobility and IMPULSE objectives.

Original version of dimensions	Adjustment of dimensions to CAPHE/IMPULSE
space - layout of the physical setting; rooms, outdoor spaces, etc.	**VR space** - (1) general level e.g. spatial, single VR, multi-user VR; (2) details of the virtual setting e.g. classroom, concert hall on the beach, amphitheatre *finding the right level of detail: how much do we need?* **"reality" space** – indoors? (where?), outdoors? (where?)
actors - the names and relevant details of the people involved	**actors** – users with VR goggles – who? how many? e.g. musicians (1 + 3, over 7), opera singers (2), dancers (2 + 3), conductor (1), audience (0, over 7?)
activities - the various activities of the actors	**activities:** 1. communication between VR users - does it occur? if so, how do VR users communicate? 2. use of information and virtual tools by VR users - does it occur? if so, in what ways, with what tools, with what information and when? is the use of tools and information easy/intuitive, does it require focus and time, does it cause users problems to the extent that users repeat the action or abandon the idea of the activity? 3. interactions with objects, e.g. lifting a vase, pouring paint on a sculpture, zooming in or rotating an object in space, touching piano keys, waving a baton, stopping at an object, no interaction with objects other than viewing them according to a script (as in the Van Gogh exhibition) 4. VR user's mode of movement:

	• in VR space - 1. walking, 2, flying, 3. teleportation, 4. 'rollercoaster', 5. (others? - < additional modalities to be entered>); • in physical space: 1. moving (walking, bending, jumping, etc.) in a designated space, without the use of additional equipment; 2. moving on a treadmill or with the help of other equipment; 3. no movement other than, for example, moving the head and turning on a chair • other activities – <indicate which (insert)>
objects - physical elements: furniture etc.	**objects in VR** – objects in VR - what is available? e.g. sculptures? paintings? musical instruments? paints? brushes? <other objects – insert here>? other elements of the world that can be interacted with, e.g. benches, chairs, stairs, doors? **objects in "reality":** VR goggles? controllers? pads? haptic gloves? treadmills? steering wheels? moving seats? regular chairs/seats?
acts - specific individual actions	**acts** – *is this dimension necessary if we have activities and time?*
events - particular occasions, e.g. meetings	**events** - type of VR experience e.g. VR opera, rehearsal for VR opera, lecture, conference paper, costume sewing workshop
time - the sequence of events	**time** - to link with activities / acts and actors + objects
goals - what actors are attempting to accomplish	**goals** - ideally in relation to needs and barriers – to be specified, if possible, during the interview
feelings - emotions in particular contexts	**feeling** - to be specified, if possible, during the interview
	(added dimension for initial studies) cutting off, immersion, embodiment - how does it occur? which of the user's senses are cut off from the outside world and redirected to VR? what are the reactions of the VR user? (this is more for an interview, if possible)

Source: Self-authored, 2024

In addition to interpreting the individual dimensions and proposing a preliminary dictionary of responses (to facilitate the note-taking process), the following modifications to the framework were made: 1. the ACTS dimension was removed, due to the anticipated specificity of the observations (rather short events of up to about two hours); 2. CUTTING OFF, IMMERSION, EMBODIMENT dimension was added, which is linked to the IMPULSE study objectives; 3. the order of the dimensions was changed to better match the observed phenomena and conditions during the study; 4. initial elements identifying the individual observations were introduced (observation code, observation start and end time, date and observation point information). During the observations, notes were kept by hand to ensure smooth operation regardless of the field conditions in which the research was conducted. The handwritten notes were then retyped electronically. The written texts were supplemented by photographs, video recordings or screenshots. Some of the materials described in the observations were also accompanied by publicly available links, e.g. to the VR Opera scene in Spatial. A full scheme of the observation can be found in Appendix 5.4 (p. 154).

The second research tool that was essential during the preliminary studies was the interview scheme. The starting point for its development were the results of the scoping review, the IMPULSE objectives and the discussions within WP1 and the collaboration with WP2. Furthermore, it was assumed that the optimal research procedure for the conditions offered by CAPHE would be contextual inquiry, so the interviews were to be preceded by previous observations of the individual artists' work.

The first version of the interview scheme covered two basic questions to elicit the basic requirements for WP2 in order to create a prototype:

1. What kind of VR platforms (e.g. Spatial) and tools (e.g. VR goggles) are you using in your work?
2. From your perspective: what are the advantages and disadvantages of those VR platforms and tools that you mentioned in terms of your artistic needs?

General questions were followed by specific questions relating to previous observations. Using the example of the interview related to the opera Gianni Schicchi, this was as follows (in brackets were details or examples of the paths of additional questions depending on the respondent's narrative):

1. Are Spatial ways of expressing emotions of the characters enough for you? (If yes - which features are the most useful to express e.g. sadness, being angry etc. If no, do you have any idea of VR tools or features that would allow for better expression?)
2. Do you want to access any additional information or tools directly from the VR environment? (for example, was tracking the libretto using a separate program and splitting the screen during the rehearsal enough for you, or would you prefer to have the text somehow displayed right away in Spatial?)

3. Did you feel immersed in your character during yesterday rehearsal? (What do you think mostly led to this immersion (e.g. other people in the back room, the music from YouTube, the libretto, the Spatial environment, something else)?)
4. Is moving the avatar in Spatial the way it was practiced during yesterday's rehearsal easy for you, and do you see any way to improve the VR user experience in terms of immersion and artistic creation? (e.g. using pads or computer mouse)
5. From your perspective as a musician, how do you feel about the possible sound deformation that can happen when creating an opera in VR?
6. Can you imagine anything that would discourage you from using VR?

The second and final interview scheme was augmented with suggestions sent by WP2. It consisted of five main questions on VR platforms and tools, their advantages and disadvantages, ways of interacting in VR with heritage objects, the difficulties with importing 2D or 3D objects into VR and the size of the VR environment. The questions posed to experts and artists during the interview process have been collated and presented in the document entitled 'Interview Protocol'. This document can be found in Appendix 5.3 (p. 148).

The results of the initial studies carried out by the CAPHE project include:

1. testing observation schemes.
2. developing and testing interview schemes for artists.
3. collection of empirical material: 15 observations, 4 interviews with artists working in XR environments, and pre-arranging further interviews and making contacts that may be useful when recruiting participants for IMPULSE research.
4. insights into the IMPULSE-applicable research procedure:
    a. considering conducting research in the native languages of the respondents due to greater freedom of expression.
    b. including in the interview schemes the possibility to change the order of questions and to modify, add or omit certain questions depending on the respondent.
    c. considering the possibility of 'written interviews' (some CAPHE artists have expressed a willingness to respond in the form of written statements).
    d. comments on observation schemes:
        i. The TIME dimension is difficult to complete during live observation; it will be easier to complete based on recordings.
        ii. the FEELINGS and GOALS dimensions should be completed/verified during the interview, if such an interview is possible.
5. initial insights into VR user needs and behaviours:
    a. avatar issues (e.g. limited ways of showing emotions in Spatial, difficulties with costume import and live motion capture, abandoning the VR goggles in favour of communication with the other artists working on the opera, cultural differences).

b. lack of certain functionalities important for artistic and didactic projects, e.g., the inability to follow the libretto text (original and translation) during a VR opera in Spatial.
c. technical issues with sound during live VR performances and combining a costumed avatar with scenography and live motion capture of the dancer's movements, as well as sound and live streaming.
d. mimicking the physical world in a VR environment (gravity, doors, windows, walls, stairs, etc.) with the goal of grounding the user in something familiar to them.
e. not associating the artist using VR with the VR end user (How to empower artists?).

- Overview of technologies used by CAPHE artists working in XR environments (additional objective at WP2 request) presented in Table 3.

Tab. 3. Technology and software used by artists in CAPHE based on initial studies interviews and observations.

Technology or software	What it was used for
Spatial	Opera Gianni Schicchi, opera Orfeo & Lwanda, XR Festival exhibitions – GALERIA KONKRET AR.T
VRChat	Alternative environment for Orfeo & Lwanda opera due to a problem importing an avatar into Spatial; however, it turned out that the avatar file size was too large for VRChart
Metaverse	For case VR Meditation https://www.lajetee.it/-/medinitaly2/
Rokoko Studio and haptic costume	Live motion capture for the Opera Orfeo & Lwanda
MoCap System	Live tracking gestures
Marvelous Designer	Used to create the final costume for the avatar
Midjourney	Creation of the costume for the opera: collecting sketches and assembling into one design, using Midjourney
Blender	Preparation of files for VR (e.g. changing the properties of the costume and avatar layers)
Unity	From ITA9: "Why did they choose Unity? Answer: complex solution, but provides various outputs, e.g., to browsers, to applications, to WebGl; allows control of the development process; enables work on the interface and backend ("the interface links our vision"); ability to export from Unity to various devices, e.g. Mac, Windows, Linux, dedicated server, Android etc."
Unreal Engine	For case VR Meditation https://www.lajetee.it/-/medinitaly2/

Webgl	For case AI in my brain https://www.lajetee.it/-/ai-in-my-brain/
Shadertoy	For case AI in my brain https://www.lajetee.it/-/ai-in-my-brain/
Html5	For case AI in my brain https://www.lajetee.it/-/ai-in-my-brain/
Sound Ambisonico	For case AI in my brain https://www.lajetee.it/-/ai-in-my-brain/
Reality Capture	Photogrammetry
VR goggles	
VR goggles used with controllers	
Desktop VR	
Projectors	
Interactive table	Interactive exhibition at the Museo Galileo in Florence
Photoshop	To create a mask for video mapping
Visual studio 2019	Coding, used for extended reality and 3D data visualization systems applied to cultural heritage
Adobe Illustrator 2023	Used for extended reality and 3D data visualization systems applied to cultural heritage
Adobe Premiere 2023	Used for extended reality and 3D data visualization systems applied to cultural heritage
Autodesk Maya 2023	Used for 3D in extended reality and 3D data visualization systems applied to cultural heritage
Adobe After Effects	To make animation for video mapping
Whatchout/ Pandora's Box or Resolume Arena	To manage live performance
Codecs	Video mapping: choosing the right codec is very important in the context of the software we use; it also needs to be working in real time and to sync audio and video
Computers	Powerful computer with good graphics cards (desktop rather than laptop)
Right cables	Video mapping: to send the signal between computer(s) and projector(s)

Source: Self-authored, 2024

3 Methodology of user research in the IMPULSE project - characteristics

This section of the document outlines the fundamental assumptions, methodology, and approach employed in the examination of all user groups considered within the IMPULSE framework. This encompasses the heterogeneous user groups within the overarching categories of G1, G2, and G3, in addition to the two subgroups selected from G1 and G2: non-users and experts, which are classified within both G1 and G2. The research methodology employed in the IMPULSE project is based on a mixed-methods approach, incorporating both quantitative and qualitative techniques. The adopted perspective and interdisciplinary framework will also facilitate the development of a comprehensive, complementary, and interdisciplinary understanding of immersive environments, as well as the utilisation of digital cultural heritage resources explored across various contexts and by diverse user groups. This will involve identifying the conditions and characteristics associated with experiences in the metaverse and multi-user virtual environments.

It is important to note that the proposed user research methodology is a construct derived exclusively from critical analysis of the literature, collective expert discussions, and scholarly considerations, which also incorporate the voices of practitioners. The proposed experimental phase in the research process represents an idea conceived prior to the development of various prototypes, with its credible validation expected to occur in subsequent phases of the IMPULSE project, once specific tools for immersion and the utilisation of digital cultural heritage are made available.

The methodological proposal is intended to explore selected dimensions of immersive environment experiences and to identify informational needs and practices within virtual worlds, necessitating an evaluation of the usability of the proposed research methods and tools. In the initial studies conducted as part of the CAPHE project, only two methods—interviews and observations—were partially validated, which nonetheless allowed for the integration of certain findings into the methodology development process for IMPULSE, as well as their inclusion in created tools such as questionnaires.

Furthermore, the IMPULSE project employs, as intended, the principles of inclusive design as a methodology, both in its own development processes and in the strategies to be implemented in the workshops.

Similarly, the project aims to integrate diverse perspectives, voices, narratives, and access points within digital heritage collections. It is imperative to prioritize addressing disability in technology, as it serves as a gateway to vast knowledge and the development of competencies in a multitude of environments, including traditional and immersive ones. It is acknowledged that there are additional physical, embodied aspects of the user experience that extend beyond considerations of immersion, which must be addressed in conjunction with the technical and social elements in IMPULSE. In adapting

the research method to encompass these aspects and contexts, it would be preferable to utilise interviews and focus groups in lieu of an extended questionnaire, as they will facilitate a more effective and comprehensive capture of the pertinent issues. Similarly, a retrospective think-aloud protocol method will prove more efficacious than a questionnaire, which will facilitate the uncovering of the cognitive and affective aspects related to the fundamental issue. The optimal methodology for recognising and describing these aspects will be to combine the user and non-user groups in focus group interviews.

Thus, the proposed methodology for investigating user experiences in immersive environments serves as a foundational framework for extensive analyses and the adaptation of tools, as well as the incorporation of novel methods for analysing needs, motivations, and behaviours. This approach encompasses iterative prototyping processes and considers the social, affective, and cognitive dimensions that shape VR experiences.

In the experimental phase of the study, up to 50 selected participants (10-12 individuals from each four group) representing G1, G2, G3, and experts will engage in exploratory activities. It is anticipated that between 100 and 200 users will respond to the questionnaires distributed to the total number of participants from all users' groups, primary from G1 and G2, as well subcategories of non-users, and experts.

The initial sample size estimates are applicable to all user groups (G1, G2, G3, and selected from G1&G2 category of experts) to be studied in each IMPULSE partner country, where VR user experience research with the prototype will be conducted. This could result in a total number that is multiplied by the number of countries or institutions represented by the partners.

Furthermore, it is important to note that the selection of research participants representing G1, G2, G3, non-users, and experts will take into account cultural differences, gender, and disabilities in accordance with the assumptions set forth by IMPULSE.

The research results will be subjected to both quantitative and qualitative analysis. In regard to quantitative data analysis, we will utilise Bayesian statistics in conjunction with the Bootstrap method, which entails repeatedly sampling with replacement from the sample in order to estimate results. Similar statistical methods will be employed in the analysis of time series data, which includes the examination of decision-making and interaction times with the prototype. Furthermore, nonlinear estimation with permutations will be employed in the statistical analysis.

3.1 User research methods - proposal

The methods identified through the critical analysis of existing literature and the subsequent scoping review were further verified and refined. These included

an analysis of the structure, questions, and dimensions explored through the lenses of user experience in the specific context of an immersive environment, taking into account the nuances of such an environment as well as the various aspects and modalities of user engagement.

The selected methods are currently being employed in ongoing empirical research on user experience in virtual reality. These methods address three core aspects: perceptions, user interactions, and engagement with objects and other users in virtual environments.

It is imperative that considerations pertaining to gender and other pertinent factors are given due attention in the context of the IMPULSE project, with a particular focus on individuals with disabilities within the groups that will engage in user experience research within MUVEs.

To effectively use this methodology, we need to embrace human diversity. Accessibility, meaning usability by people with the widest range of capabilities, extends to the elderly, rural residents, and those in developing countries. Accessibility benefits everyone, even those without disabilities. Despite efforts to establish inclusive design guidelines on the internet, especially in web design, the majority of digital objects remain largely inaccessible. The diversity of disabilities and varied access devices complicates universal design. Including elderly respondents is essential, as they often integrate multiple disabilities, creating a midpoint for inclusiveness. This is a compromise approach since part of our cohort comprises professors who may use virtual reality for teaching.

The research procedure will allow for the continual proposal and utilisation of alternative methods, such as eye-tracking, throughout its implementation and the realisation of its various stages. The exclusion of the eye-tracking method from this document at the development stage was a result of the lack of information available regarding the technology used in the prototype, the capabilities of the prototype, and the required equipment (e.g., goggles) to be used in conjunction with the prototype. This information was not available at the time of proposal of the research methodology. The eye-tracking method will be employed in conjunction with WP2 to ascertain the viability of the prototypes. Moreover, its incorporation will be substantiated by the outcomes of Subtasks 1.2 and 1.3. Furthermore, should the technology become available in the VR lab at UJ and at all participating partner institutions, the procedure can be incorporated into the research with the prototype without any changes to other procedures. At the present time, the utilisation of some methods, e.g. eye-tracking is not a viable option, predominantly due to technological constraints. However, it is intended to continue to monitor this issue on an ongoing basis and to employ information on pertinent technological requirements through the use of interviews, for example, with G3 or G2 users.

The research process is primarily based on an experiment, with the additional method of survey being employed to analyse both quantitatively and qualitatively (using closed and open-ended questions) selected dimensions of users' experiences in VR, their preferences, needs, motivations, and affective and cognitive factors that shape and verify

these experiences. The questionnaire will serve two purposes: firstly, to identify the aforementioned elements, and secondly, to categorise users and select potential participants for the experiment. It is important to note that questionnaires will be tailored to the specific user group to which each individual user belongs.

The research process will be based on a number of methods and techniques, which will be employed in the five designated user groups. These are the three overarching groups G1, G2, and G3, as well as the two subgroups, non-users and experts, belonging to both G1 and G2. The proposed research employs the following methods like an online survey questionnaire (hosted online using the appropriate, optimal tool selected by IMPULSE partners) has been designed for G1, G2, and non-users.

The survey method employed in G1 and G2 will be used to analyse both quantitatively and qualitatively (using closed and open-ended questions) selected dimensions of users' experiences of VR, their preferences, needs, motivations, and affective and cognitive factors that shape and verify these experiences. The questionnaire will serve two purposes. Initially, it will be used to identify the aforementioned elements. Secondly, it will be employed to categorise users and select potential participants for the experiment. Furthermore, it will permit the identification of additional subgroups, namely non-users and experts, within these two groups. Those who provide their email contact details may, upon consent, participate in subsequent stages of the research. The general questionnaire (“Questionnaire_General_VRexperience”, see Appendix 5.2.1, p. 123) is designed in such a way that, subsequent to the initial question, participants who select the option "never" [used VR] will be presented with the non-users' version of the online questionnaire.

The experimental format, described as an experiment, was conducted among a selected group of users, identified through questionnaires and the convenience sampling method. The participants primarily represented users from G2, but also included members of groups G1 and G3. The experiment, conducted in a laboratory setting (specifically, a room equipped with the necessary technology and VR headsets), is designed to assess the efficacy of the prototype developed within the IMPULSE framework. The experiment will be based on scenarios that have been meticulously crafted during the prototype creation and content verification phase. The questionnaires that have been proposed include sample scenarios that will be adapted to align with the functionality of the prototype. These will be employed in the two relevant phases of the pilot studies at the stage of actual user experience research. These proper scenarios will encompass tasks that users will perform during their interaction with the immersive environment offered by the prototype. Concurrently, as an exploratory study of interaction methods and the virtual environment experience, a specially prepared questionnaire for the experiment participants (“Questionnaire with experiment and prototype usage”, see Appendix 5.2.3, p. 137) will be administered. The present iteration of the scenarios included in the questionnaires serves as a preliminary point of discussion concerning the issues that should be taken into account in the research and the inclusion of prototype functionalities that are aligned with the research objectives.

The questionnaire will be divided into sections: pre-experiment questionnaire, experiment questionnaire (with prototype), and post-experiment questionnaire. It will be used accordingly in the respective phases of the experiment (before, during, and after its completion).

The research will employ a combination of interviews and focus groups, which will be developed in accordance with the forms presented later in the document. The participants will be primarily drawn from G3, but also from G2. Furthermore, the selection of email contact will permit the implementation of these methods in accordance with the appropriate scheme among users from G1&G2 and non-users. Interviews and focus groups will be conducted with non-users, again with their consent. For non-users from G1 and G2, as well as some other users, who possible have the knowledge about VR, and it is possible for them to use the immersive environments and create the content with digital heritage objects usage, the proposal is based on the General Non-Users (G1 & G2) Interview Questions form (see Appendix 5.2.2, p. 132).

During the experimental phase of research involving the prototype, the observation method will be utilised to study selected users from G1 and G2. It will also be employed in the user experience research within G3.

3.1.1 Surveys (Questionnaires)

According to the findings from the scoping review conducted in the initial three months of the IMPULSE project, which analysed and synthesised a range of literature and content on methodologies for studying users of immersive environments, it was identified that surveys and questionnaire studies are widely utilised. These methods offer substantial versatility across various research fields, including survey-based and experimental research, providing structured frameworks for systematic data collection and both quantitative and qualitative data analysis. In the research process, they will serve as tools for gathering and documenting information on issues and research objectives relevant to the IMPULSE project.

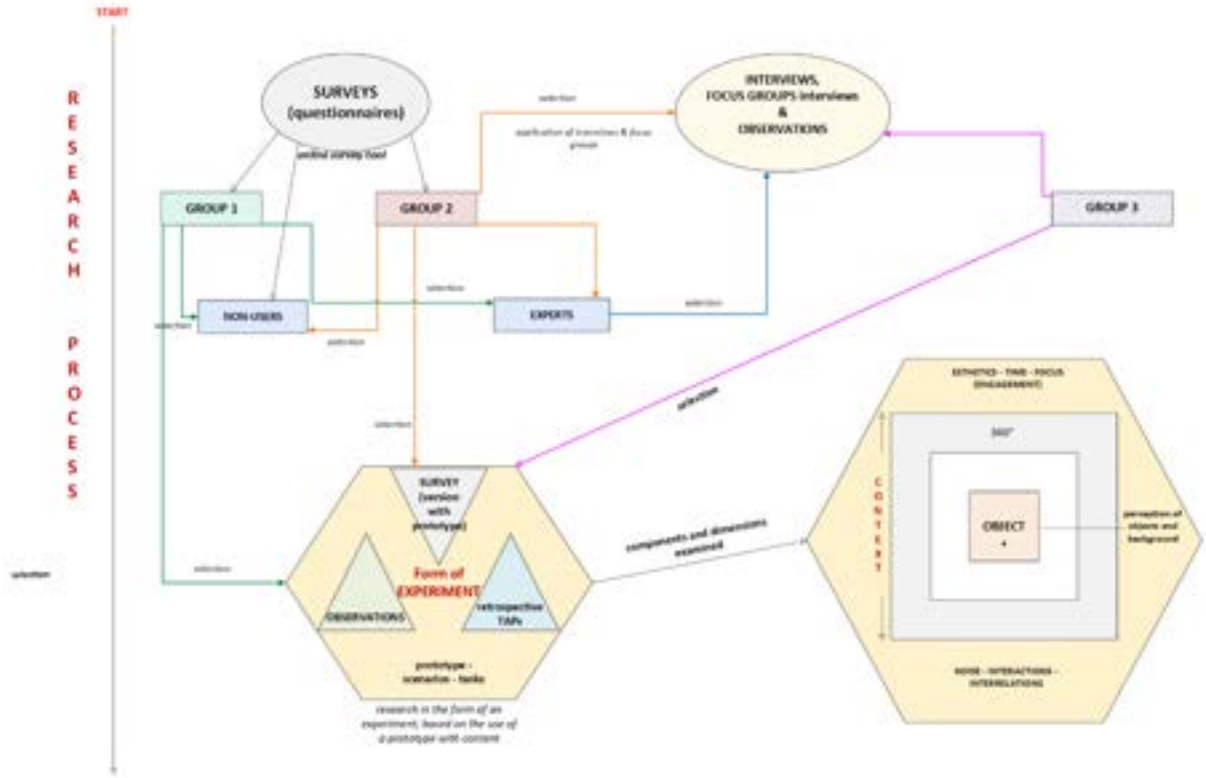
Additionally, a collaborative effort among all project partners has resulted in a repository of questions designed to support various tasks and objectives across different Work Packages (WPs). This repository aims to assess familiarity with immersive environments, technologies, and tools used in virtual spaces, as well as to identify needs and explore the potential applications of VR.

Three distinct types of survey questionnaires will be developed for three user groups, each aimed at diagnosing different aspects of user experience and identifying opportunities for utilising immersive environments in creative, educational,

and interactive contexts involving avatars or objects. It is acknowledged that young users, in particular, frequently engage in learning and communication within digital or virtual environments without full awareness or knowledge of their use. Even inadvertent use, learning, or communication in such environments can provide insights into specific experiences within virtual environments and contribute to shaping preferences for utilising digital cultural heritage in immersive settings.

The complete proposed procedure is illustrated in Figure 5.

Fig. 5. Visualisation of the research process with attention to key data collection methods and tools.

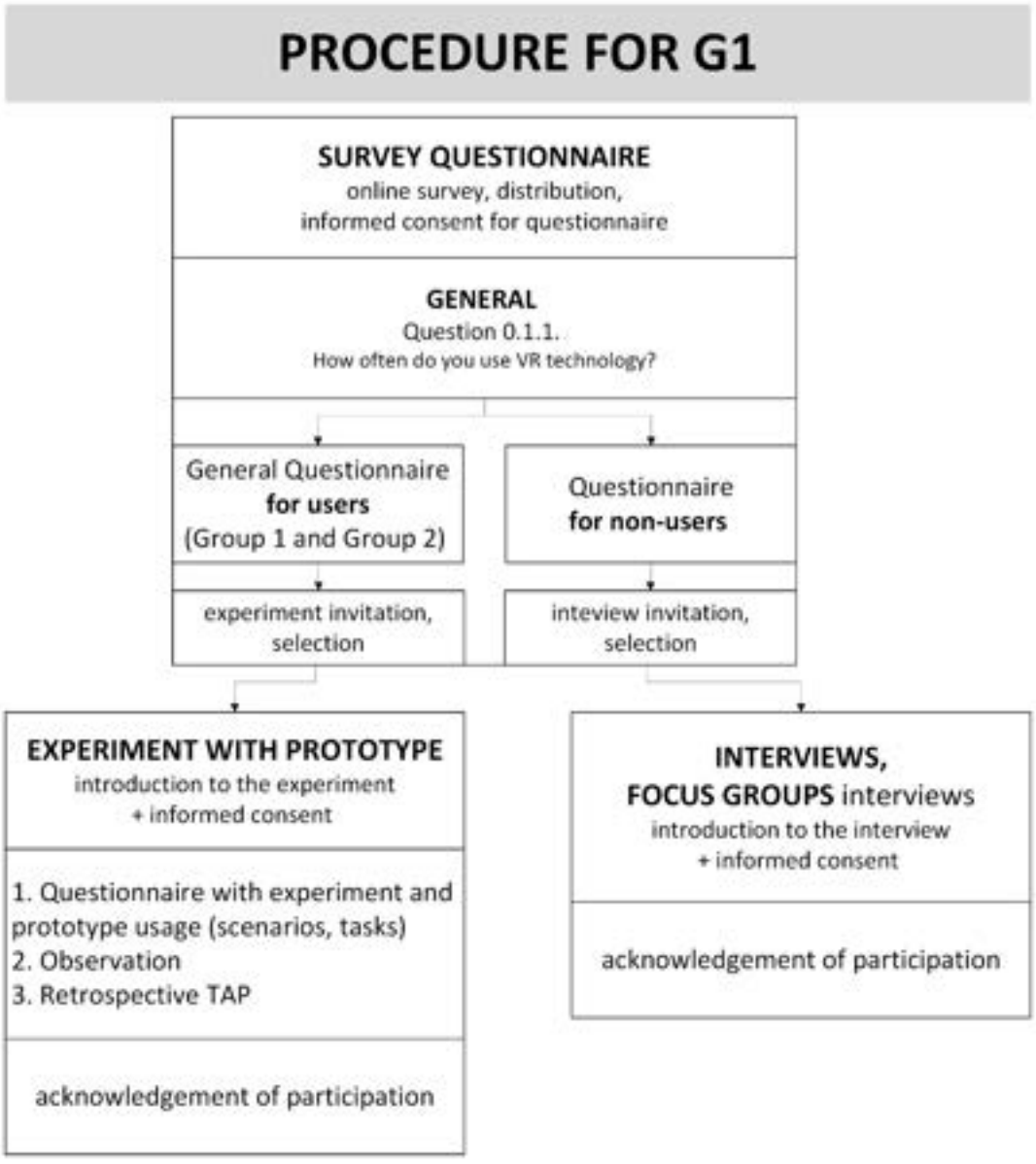


Source: Self-authored, 2024

While Figure 5 visualises the general research process and the use of specific research methods and tools, the following diagrams refer to the research process that will be applied to the individual groups G1, G2, G3, as well as to selected sub-groups of G1 and G2, namely experts and non-users.

Figure 6 illustrates the constituent elements of the research procedure for G1, which is primarily based on survey methods, experiments, as well as interviews and focus groups. The general questionnaire for this group will be used as the basis for the selection of both expert and non-user subgroups. Once consent and willingness to participate have been obtained from the experts, an experiment will be proposed to them. A distinct questionnaire will be provided for non-users who indicate in their responses that they do not utilise and are not conversant with virtual environments.

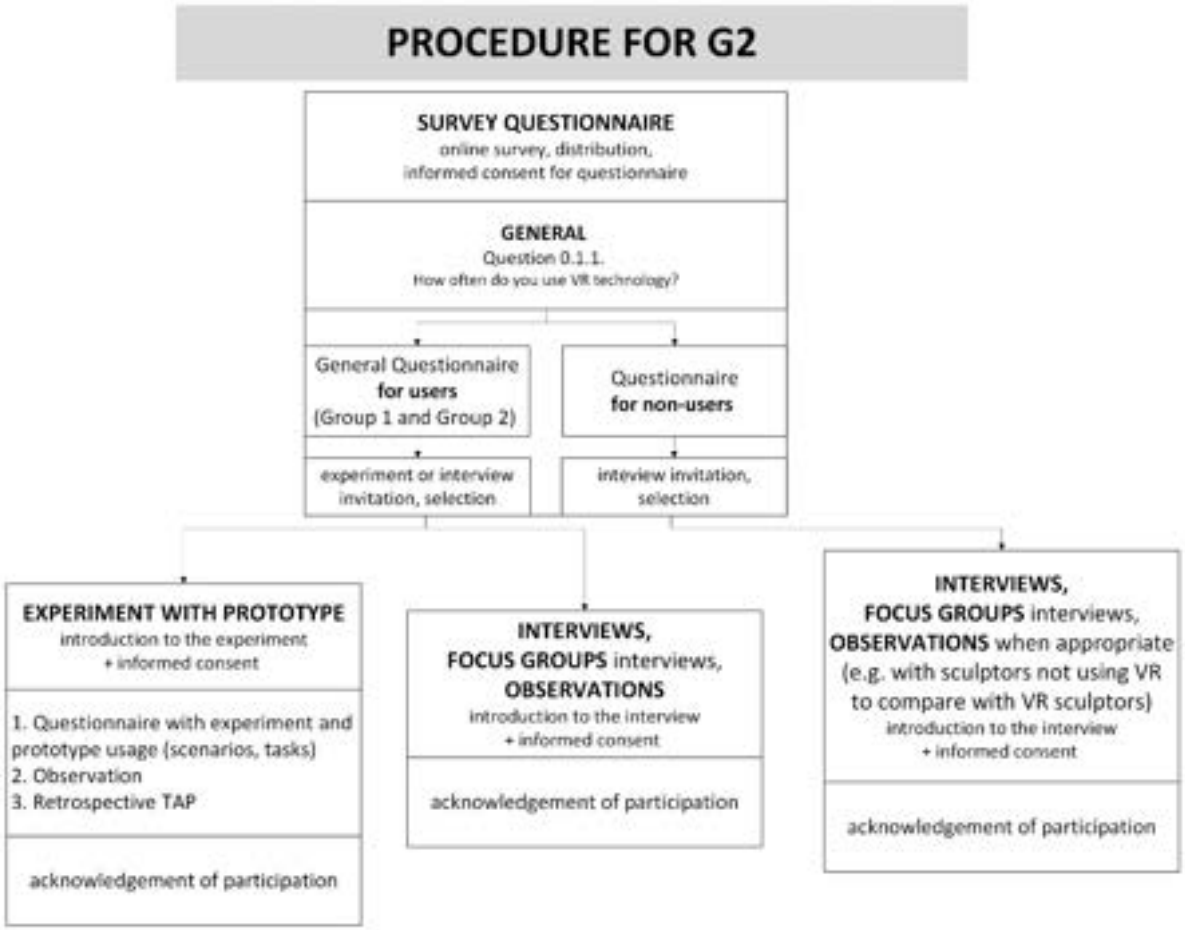
Fig. 6. Visualisation of the research process for G1



Source: Self-authored, 2024

The research procedure for G2, as illustrated in Figure 7, is analogous to that of G1. It commences with a comprehensive questionnaire. As with G1, G2 will be divided into two categories: experts and non-users. The questionnaire will be divided into two versions for the specified user groups, based on their responses regarding the use or unfamiliarity with VR technologies. Subsequently, the group utilising immersive environments, upon furnishing their contact details, will be further categorised into the expert cohort and the active user cohort from G2. These individuals will then be invited to participate in the subsequent stage of research, which will entail an experiment involving a prototype. Concurrently, interviews and focus groups with experts can be conducted. Should the selected non-user group provide their email contact and indicate their willingness to participate in subsequent research phases, interviews (non-user scheme, see Annex) and focus group interviews may be conducted.

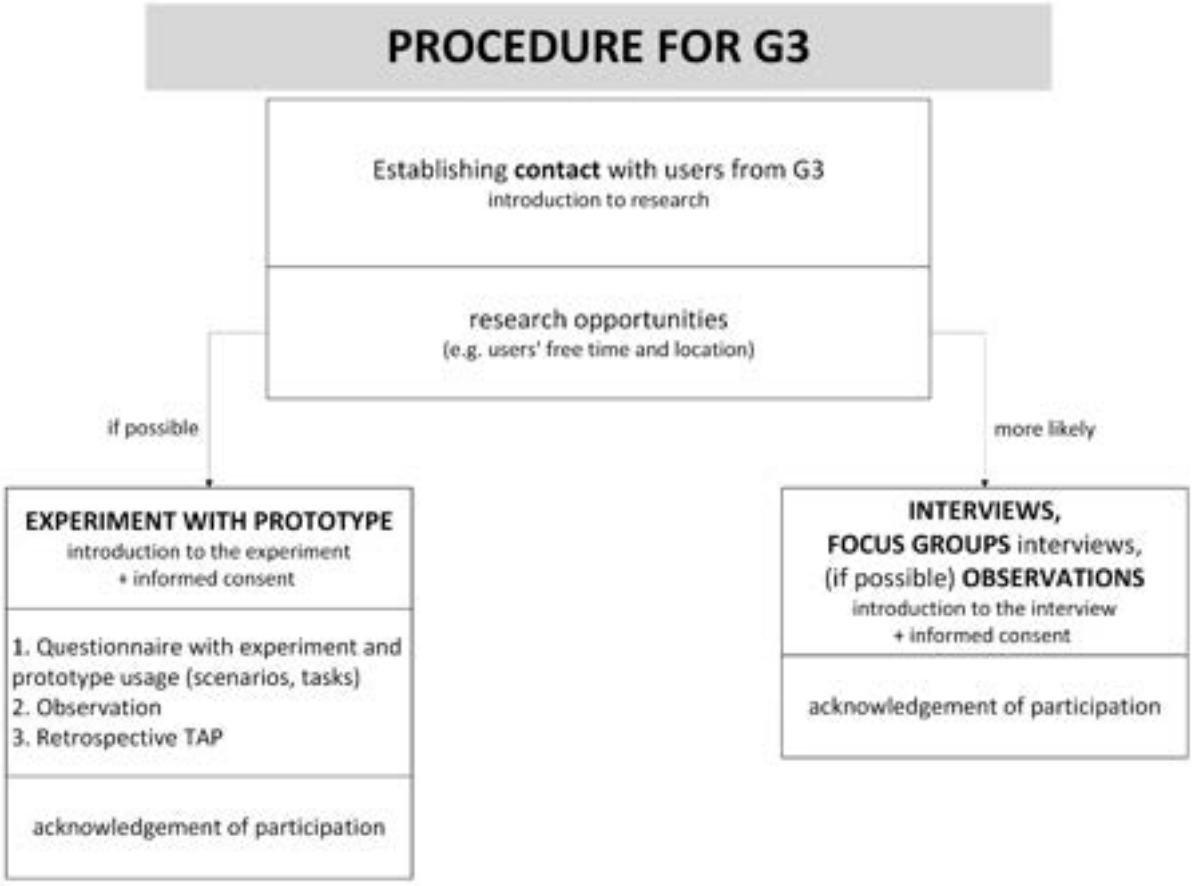
Fig. 7. Visualisation of the research process for G2



Source: Self-authored, 2024

Figure 8, in turn, presents the research procedure plan exclusively for Group G3. In the case of this particular group, the survey technique will be excluded from the research procedure plan. It seems likely that a greater quantity of qualitative material will be obtained from interviews and focus groups, as well as observations of the participants' information practices and interactions in an immersive environment. The recruitment of research participants in Group G3 will be conducted through the convenience sampling method and by disseminating information about the research, which will be linked to invitations for interested users from various industries operating within CCSI. The research methods employed for this group are based on interviews and focus groups. It is assumed that this form of research will facilitate a more comprehensive understanding of user experiences in immersive environments, allow for the refinement of questions, elicit detailed responses, and facilitate inquiry into other aspects that may be indicated by interview participants. The G3 group is comprised of users with a high degree of diversity, representing CCSI. A questionnaire designed for this group would be of a very general nature and could prove to be time-consuming, as it would rely heavily on open-ended questions. It is therefore recommended that interviews and focus groups be used as the preferred method. Those users from G3 who are willing and interested in participating in research involving experiments and the use of IMPULSE prototypes will be invited to take part in this research phase. Furthermore, this phase incorporates the survey technique, the observation method, and potentially the retrospective think-aloud protocol.

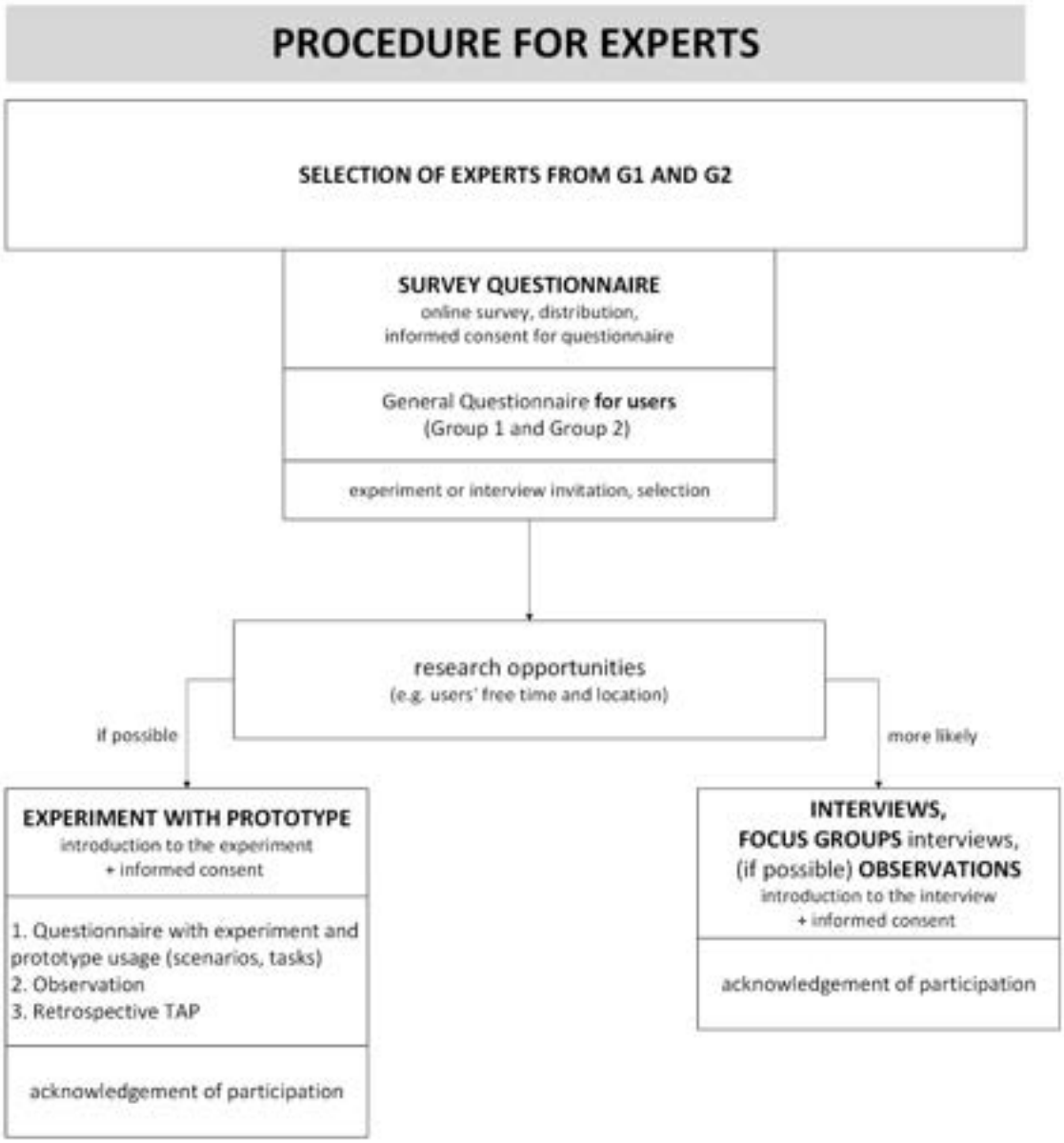
Fig. 8. Visualisation of the research process for G3



Source: Self-authored, 2024

The research procedure for the group of experts selected from G1 and G2, that is visualised on Figure 9, based on the analysis of questionnaires will include both experiments and a combination of interviews, focus groups, and observations. In the initial phase of the procedure applied to this group, the survey questionnaire will serve two purposes: firstly, to select participants for the expert group, and secondly, to identify participants willing to engage in the subsequent stages of user experience research conducted in the form of experiments. In this case, it will be necessary to provide an email contact in the final question of the questionnaire and to give the appropriate consents. The research procedure will include both experiments, in light of the prototype's construction and subsequent verification of its functionality and applicability in the context of virtual worlds and cultural heritage resources within two proper pilot studies, and interviews, focus groups, and observations. The latter will be conducted with the selected users, who will be contacted via email to invite them to participate in the research. Furthermore, if feasible, the observation method will be employed during artistic and creative practices, interactions, and experiences in immersive environments that are utilised in the course of artistic activities.

Fig. 9. Visualisation of the research process experts



Source: Self-authored, 2024

3.1.2 Experiment

Following the verification of users through quantitative and qualitative analysis using survey questionnaires, an experiment utilising the prototype developed within the project is planned. In this phase of the research, the participants should represent G1 and G2, as well as G3 and experts, which have been selected in a fair manner, considering cultural differences, gender, and disabilities in accordance with IMPULSE's assumptions. The involvement of the participants in this particular aspect of the study

is contingent upon their active engagement with virtual reality (VR), the creation of immersive environments, a demonstrated expertise in the field or a representation of the creative computerized simulation and interactive entertainment (CCSI) industry. They should be artists, students and academics, as determined by the analysis of the initial questionnaire (general) and the acquisition of email addresses to contact the participants, as well as the invitation to take part in the experiment and the corresponding consents to participate in the experiment. It is anticipated that the entire experimental process will be recorded using a range of technologies and methods, including MS Teams and transcription tools, cameras, recorders, voice tracers and immersion recording.

An additional tool at this stage of the research will be a specially constructed survey divided into three parts: 1) pre-experimental phase; 2) during the experiment phase; and 3) post-experiment phase. The pre-experimental phase involves preparing participants for the study, checking technical settings of devices and prototypes, and completing the initial section of the questionnaire with general questions to identify basic user needs and experiences.

The during-experiment phase signifies the period of prototype testing and research trial execution, where participants will use goggles and undergo immersion into a virtual environment. During this phase, participants will complete sections of the questionnaire and perform designated tasks according to predefined activity scenarios and immersion experiences using the prototype. This phase aims to identify selected dimensions that will be assessed through various types of questionnaires commonly used in studies of users in immersive environments, as identified in the scoping review, along with appropriate scales for quantitatively evaluating hierarchy and compliance levels. Detailed questionnaire categories and scales used in constructing the survey are outlined in subsection 3.2.2 (p. 85).

Proper scenarios and tasks will depend on the prototype's capabilities and content. At this juncture, two pilot studies—one to refine the prototype and another to validate the tool for rigorous testing with the final, correct prototype—will be conducted. The findings from these studies will serve as the foundation for IMPULSE. The attention will be given to the timing of task completion by participants, as well as mitigating any factors that could disrupt immersion and the proper experience of the prototype environment. It is planned to remove the goggles after each task for participants to complete the questionnaire. There is also the possibility of developing a tool for completing surveys in the immersive environment. However, challenges may arise with the option of survey completion by the experiment conductor; presenting questions and responses to participants could not only lengthen the experiment but also lead to misunderstandings or concerns arising from answering questions aloud.

The questionnaire completion element during the experiment (clearly, this has been subjected to preliminary investigation, with modifications made according to the outcomes of the pilot studies) is crucial stage for verification during preliminary studies and evaluation by participating partners. Subsequently, after completing the experimental phase and switching off the prototype or when participants exit the immersive environment, the third part of the survey questionnaire is envisaged. This section includes specific scales analysing selected dimensions, feelings, reflections, and post-experiment states, providing retrospective insights into experiences during the experiment and immersion phase.

The experiment serves as a tool to diagnose and understand human interaction with immersive environments and digital cultural heritage objects, and it is considered a type of behavioural experiment (Aguilar et al., 2024). It will be understood as a verifiable and modifiable concept aimed at repeatable and scalable experimental actions using VR environments. It will consist of a prototype-based proposal, focusing crucially on exploring the context in which immersion and user experience occur.

For the organisation of the entire experiment, which requires a prototype (or in the preliminary phase may rely on available immersive worlds and cultural heritage objects usable for testing the adopted methods and tools), it is necessary to develop individual elements ensuring the quality, correctness, and reliability of the experiment.

Essential aspects to be developed within the research (including questionnaire utilisation and experiment execution) include:

1. Management Plan: This encompasses participant acquisition, immersion process, incentivisation of participation (considering possible lack of adequate payment or other incentives), as well as progress monitoring.
2. Documentation: This involves a registration plan, location of procedure execution, experiment protocol, consent forms (e.g., for recording).
3. Infrastructure: Preparation of recording equipment, access to the prototype, prototype content, equipment for both experiment conductors and participants, and ensuring suitable network connectivity (fast internet connection) and other local equipment.
4. Data Collection: This includes experiment content, scenarios, tasks, scoring systems, experiment flow, data collection methods, and integration of various experiment elements.
5. Data Management: Assembly of experiment data, infrastructure data, sensor data, and data pre-processing involving anonymisation procedures.
6. Data Analysis: This encompasses data inspection, validation, editing, visualisation techniques, and statistical and quality assessments.

The series of experiments (the aforementioned procedures were conducted during the preliminary studies and the verification of the prototype, as well as during the actual pilot studies) with the prototype will not only be repeatable but will also require adjustments after the prototype's deployment, including checks and verification during stages of refinement. A complete experimental procedure may not be necessary

at that point; instead, the focus will be on testing selected elements identified during preliminary studies or those not functioning correctly, as well as addressing any technological difficulties (such as usability and functionality issues with the prototype or equipment), and addressing personal reasons (such as interruptions due to psychophysical problems or participant non-attendance due to unforeseen circumstances). Scenarios will be tailored to match what is envisaged in the prototype, its functionalities, and user experiences. Feedback and evaluation of results from studies (related to these aspects) after testing the initial prototype version should be planned.

Therefore, it is crucial to collectively develop tasks, scenarios, procedures, and necessary information for applying the prototype in the experiment.

It is also essential to integrate efforts aimed at developing data collection procedures with other partners and WP2, and to utilise a universally accepted data management plan. Additionally, developing and refining the experiment protocol after preliminary studies and during proper pilot studies (2 phases of VR platforms evaluation) with prototype creation and deployment will be vital. For preliminary studies, which are also part of this methodology and research process, leveraging available VR technologies and platforms used in other projects, such as CAPHE with accessible content (e.g., Spatial), will be considered.

3.1.3 Interviews

In relation to categorising participants in the research process during the analysis of results from the first type of questionnaire and identifying categories such as users, experts and non-users from all studied groups, interviews have been planned for implementation. In G3, these will be prioritised given that it is a highly specific, creative user group that, due to time constraints, the nature of their work, and the need for prompt action, may not complete the survey questionnaire. A more efficacious methodology for elucidating preferences, necessities, expectations, modes of experiencing immersive environments, and identifying the optimal utilisation of digital cultural heritage objects would be to employ interviews and focus groups. The schema for in-depth interviews, along with a potential set of questions for selected participants willing to participate in the study, utilising this method, has been included in Appendices 5.3 (p.148) and 5.4 (p.154).

The interview method has also been incorporated into the research methodology schema, visualised in Figures 5-9, as an additional component among the methods planned for application across the user from G1, G2, G3, non-users and experts. Alongside surveys and experiments, it constitutes one of the primary methods for obtaining qualitative data. Interviews will be conducted, similar to the initial studies carried out in the CAPHE project, even before the prototype is developed. This is to gather insights into the capabilities, preferences, and experiences of users, particularly concerning the technologies used and immersion experiences in virtual environments.

Participants will include active users of these spaces, experts, artists, students, or academic teachers with qualifications and experience in XR applications. Interviews may also be used during the prototype testing phase to refine conditions, characteristics, and motivations of user experiences, and to gain a deeper understanding of needs, expectations, and potential for utilising metaverse and digital cultural heritage.

3.1.4 Focus groups interviews

For experts and users recruited using convenience sampling, a non-random sampling method (Galloway, 2005), participants are chosen based on the researcher's easy access (temporally and spatially) and the likelihood of their willingness to participate (due to personal acquaintance or knowledge of their qualifications, competencies, and experience, which is crucial in the Creative and Cultural Industries sector and for artists with specific specialisations). Additionally, this recruitment method for focus group studies and interviews can be instrumental in capturing a range of attitudes, opinions, and initial hypotheses that can be rigorously tested in subsequent stages of research.

An interesting approach would be to combine users from G1, G2, G3, experts and non-users in the focus groups interviews sessions. Bringing together these two groups, observing their communication processes, knowledge transfer, perceptions, and understanding of the metaverse and immersive vs. traditional worlds would provide significant dynamics in focus group interviews. Questions would be broad, and expectations would involve comments and references to insights gained during discussions, shaping or deepening the knowledge of users and non-users.

For groups of artists and experts, the targeted method would be focussing group interviews, conducted either face-to-face or online (using platforms such as Microsoft Teams or Google Meet). Questions used in these interviews should be based on schemas developed after initial studies in CAPHE or questions designed for general interviews with users and non-users from Group 1.

Furthermore, conducting initial analyses and studies with various specialists and users experienced in the metaverse and other virtual environments at different stages f the IMPULSE project will allow for modifications and additional questions. These could expand knowledge about needs, experiences, perceptions of immersive environments, and the utilization of digital cultural heritage resources. The iterative approach to project management, including research processes and continuous refinement of user research methodologies, will enable cyclic verification and the development of a framework for studying UX in the metaverse, adapting to rapidly evolving XR technologies.

The scheme for focus groups interview is available in Appendix 5.3 (p. 148).

3.1.5 Observation

The observation method is designed to address three key areas: firstly, the reactions of VR users during the experiment; secondly, the ways in which artists react and experience VR when carrying out their creative work using immersive environments; and thirdly, the reactions and behaviours of students and academics when enabling immersion, both when using the prototype and, for example, during teaching activities using VR.

The objective of the observation is to identify the factors that contribute to the experience of immersion in metaverse. This will be achieved by monitoring the behaviours, reactions and interactions undertaken by participants during their immersion in a virtual environment using prototypes, as well as during their use of other immersive environments. This will include observations made during the preparation of participants for the experiment, during the experiment itself and after the experimental study has concluded.

The term observation can also be used to describe research conducted within a group of artists and CCI representatives, during which the participants' reactions and interactions with digital cultural heritage objects in an immersive environment, behaviour and activities during artistic performances, and other forms of artistic activity are monitored. In the latter case, we intend to integrate observation as extensively as possible into the contextual inquiry procedure, which also encompasses the option of posing questions during the observation or conducting a subsequent interview. Obtaining such direct, oral information from the respondents will facilitate the verification and supplementation of the observations made during the observation.

The results of the observations will permit the correlation between the data collected, recordings, transcriptions, questionnaires and the results produced by the observations to be verified. A comprehensive overview of the various stages and elements to be considered during the observation process can be found in Appendix 5.4 (p. 154).

3.1.6 Additional methods: Think-aloud protocol

An additional method that is feasible for the project and will be a complementary element of the experiment, as well as the questionnaire to be used during this phase of user research, is the think-aloud protocol. This method will require the use of the prototype under development. The method will be implemented following the completion of the tasks and immersion in the prototype environment. It will serve to complement the analysis of the forms of perception, the perception of this environment, the activities undertaken by the user during the experiment, as well as their emotions and their specific narration of thoughts.

Think-aloud protocol (TAP) comes in three versions: simultaneous, retrospective and co-discovery based on the conversation of the participants. In the IMPULSE project, a retrospective version is being considered, which would involve verbalisation of the user's thoughts, actions and feelings while watching a recording of a previously performed task or set of tasks. In the simultaneous version, the verbalisation is done while the activity is being performed, so the simultaneous version would affect the subjects' immersion. In the retrospective version, there is no such impact on immersion, but the duration of a single test is increased. However, it still is necessary to test the retrospective version of the TAP during the pre-testing of the research procedure, including the estimation of the time of a single study and the determination of the order of the procedures used (TAP versus questionnaire survey completed after the experiment).

3.2 The IMPULSE project research tools

The following represents an overview of the fundamental tools, questionnaires, interviews and observations that serve as the basis for the proposed user experience (UX) research methodology. It also serves as a foundation for the ongoing examination of specific tasks, the formulation of assumptions and the delineation of various facets of user experience within the metaverse.

3.2.1 Survey questionnaires

The online survey questionnaires, provided by all WP1 partners using appropriate tools in collaboration with WP5, have been meticulously developed to align with the user categorisation framework within the IMPULSE project. This framework differentiates between four categories of users: G1, G2, experts, and non-users. Consequently, different questionnaires have been designated for each of these categories. They function as instruments to investigate predetermined domains concerning needs, experiences, stimuli, behaviours, and information practices, while also encompassing affective and cognitive dimensions. These questionnaires aim to uncover the individual mental models (mental representations) of immersive environments held by users, enabling precise adjustments not only to prototype content but also fostering a comprehensive understanding of the conditions and components influencing virtual space experiences and interactions within immersive frameworks alongside their co-participants and objects.

The included questions serve as foundational elements for identifying users and non-users. Furthermore, they serve as the initial phase for identifying factors influencing the inactive engagement with immersive worlds or their rejection and non-

utilisation, as well as highlighting inhibiting determinants such as lack of motivation, knowledge, or skills.

The questionnaires have been tailored for:

a) general user cohort representing the project's primary user groups: students, academic teachers, artists, and students and teachers from art schools.

b) selected group of participants involved in the experiment, primarily targeting Group 2 comprising artists (including selected students or academic teachers from Group 1 with experience in using immersive environments who have expressed willingness and consent to participate in this segment of the study).

c) non-users identified through specific questions in the general questionnaire and directed to a dedicated form tailored for this subset of participants.

It was decided that users representing G3 would not be included in the survey questionnaire due to the specific nature of their work and activities, as well as the individuality of the CCSI sector. For this group, alternative research methods, as outlined in the methodological proposal, are to be employed.

The structure, sections, and specific questions for all types of proposed questionnaires are detailed in the Appendix 5.2 (p.123).

3.2.1.1 General Questionnaire

This questionnaire is designed for users from G1 and G2. These comprising students and academics (G1), encompassing general, exploratory, and educational/didactic dimensions and artists, students and academic teachers from art schools (G2). It is anonymous, with no requirement to provide an email address, allowing for potential invitations to participate in future research experiments involving prototypes.

The questionnaire will be disseminated across universities and art schools, as well as within the artistic community. It is applicable not only to Group 1 but also to Group 2, serving as an exploratory survey in addition to those used for targeted groups (utilising a convenience sampling method).

Selected elements, types of questionnaires, and scales (described in subsection 3.2.2, p. 85) are incorporated within this survey, which are also reflected in the questionnaires intended for experiment participants and non-users.

This questionnaire primarily focuses on educational and didactic aspects, exploring user experiences, perceptions of VR technology, immersion, and various dimensions related to VR tool preferences. It comprises 7 sets of closed and open-ended questions, categorised into sections that address overarching aspects of user experience dimensions in VR.

Key dimensions include interfaces, space, and immersion, encompassing team identification, presence in VR space, immersion, hedonic quality, and identification. Additional dimensions cover actors, relating to awareness, social interaction in VR environments, objects, and user emotions.

Open-ended questions are included to determine the most important features in a creative VR space (e.g., ease of use, collaboration tools, realistic rendering) and to describe experiences interacting with digitalised cultural heritage objects.

The demographic section includes questions about age, gender, education level, and field of study/discipline. Providing an email address enables the selection of interested users to participate in the prototype testing phase.

The online survey questionnaires have been developed with great care and attention to detail in order to align with the user categorisation framework that has been established within the context of the IMPULSE. The questionnaires have been constructed with the specific intention of being applicable to G1, and with the requisite modifications, to G2. Additionally, they are designed to be suitable for experts and non-users.

The complete questionnaire, detailing all dimensions and questions, can be found in Appendix 5.2.1 (p. 123).

3.2.1.2 Questionnaire with prototypes developed by WP2 and experiment stage

This particular questionnaire has been designed for users who have been selected based on the results of the general questionnaire for G1 and G2. It also includes chosen representatives from the experts' group and also G3 who have expressed a willingness to participate in this phase of the research, as well as those selected through the convenience sampling method. It has been constructed based on various types of questionnaires and scales identified during the scoping review, with the aim of ensuring the inclusion of diverse dimensions of experiences in immersive environments.

The survey is divided into 12 sections, categorised according to the analysed dimensions and aspects of user experience within immersive environments.

Additionally, the questionnaire is structured into stages: pre-experiment, during experiment, and post-experiment, each containing relevant questions that verify and explore the dimensions analysed during the experiment, while also introducing a new aspect—avatar embodiment.

The Pre-Experiment Questionnaire section comprises 9 recognition questions, both closed and open-ended. Questions cover general information about VR experience,

including frequency of use, digital competencies in VR usage, and the type of equipment used. The subsequent set of questions focuses on artistic tools preferences, their types, frequency of usage, motivations for using VR environments in artistic work, and the influence of XR on perception of space and dimensions in artworks. Open-ended questions inquire about expectations from the prototype and the VR environment to be used, as well as any potential concerns about using VR technology.

In the experimental phase, another section of the questionnaire, titled "Experiment Questionnaire (with prototype)," is based on preliminary, sample scenarios and tasks dependent on the construction and content of the prototype. The first of 6 sets of questions focuses on system usability evaluation and consists of 9 closed-ended questions. Subsequently, the questionnaire is divided into 5 sections covering different dimensions.

The dimension concerning space and immersion, utilising elements from CCPIG, iPQ, and AttrakDiff-2, is sample scenario-based and task-oriented, comprising 22 closed-ended questions. This dimension addresses three aspects: team identification (5 closed-ended questions; agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements), immersion (9 closed-ended questions; agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements), and hedonic quality identification (8 closed-ended questions rated on a scale from 1 to 7).

The subsequent dimension concerns actors and is constructed around a sample scenario and task, comprising 6 closed-ended questions assessing awareness (agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements).

The fourth dimension pertains to the object and is similarly contingent upon a sample scenario and task. This is employed to investigate the user's emotional response to the metaverse environment and the prototype (as a product). It consists of 12 closed-ended questions (agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements).

The fifth dimension related to actions is based on another sample scenario and task. Its objective is to analyse activities during immersion in the metaverse environment, consisting of 10 closed-ended questions (agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements).

The final part of the experiment involves utilising the last section of the questionnaire, administered after the immersion phase without goggles, following the completion of all preliminary sample scenario-based tasks.

Similar to the questionnaire section administered during the experiment, this part includes dimensions focusing on:

a. Interface, examining consequences of use (6 closed-ended questions; agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements),

b. Space and immersion, addressing presence in VR space (7 closed-ended questions; agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements),

c. Actors and social action (8 closed-ended questions; agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements),

d. Objects, with questions probing Interaction with the object and hedonic quality stimulation (5 closed-ended questions; scale 1-7),

e. Actions, alongside recognition of psychophysical demand and pragmatic quality (6 closed-ended questions; scale 1-7).

In this section of the questionnaire, a dimension on avatar embodiment has been added, addressing:

a) Body ownership (5 closed-ended questions; agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements).

b) Agency and motor control (4 closed-ended questions; agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements).

c) External appearance (12 closed-ended questions; agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements).

As part of the final aspect to be analysed, two open-ended questions have been included, concerning the most important features in a creative VR space and previous interactions with digitalized cultural heritage objects before participating in the experiment.

Additionally, demographic questions regarding age, gender, education level, and artistic specialisation have been included in this last part of the questionnaire.

The full questionnaire with all dimensions and questions can be found in Appendix 5.2.3 (p. 137).

3.2.1.3 Non-users' questionnaire

Questionnaire entitled “Non-Users Questionnaires (General)” is dedicated for G1 - students and academics as well as G2 – artists, artistic schools' students. It is anonymous, without prototype.

In addition, participants can be selected for the study through interviews and focus groups by providing their email address and expressing their willingness and consent to participate in subsequent stages of user experience research.

Questionnaire will be displayed for you to complete if you answer negatively to the question on the use of VR. It is possible to ask questions without a specific task or sample scenario.

It is to be disseminated in universities and includes group 1 and art schools/art environment for group 2, as an exploratory survey, in addition to the questionnaire used in the target groups (convenient sample = non-random sampling method).

The survey questionnaire is predicated on the assumption that, despite having been identified as non-users, individuals may, on occasion, utilise a range of digital immersive technologies (e.g. online gaming), engage in communication through the use of new technologies (e.g. Discord), participate in collective learning in a digital environment and interact with other users within that space. Furthermore, it is possible that they may utilise digital cultural heritage, albeit unconsciously and without being aware of the source, for instance, within the context of a digital library. It can be reasonably deduced that they may become potential active users of the metaverse.

The questionnaire has been designed for use with students and university teachers (scholars) and artists, students at the art schools and the teachers from the art schools. The questionnaire is also divided into individual sections, each containing questions relating to a specific aspect of the general experience in cyberspace. These sections include six closed questions with a multiple-choice format and two open questions. The first of these open questions relates to the use of gaming environments in the learning process, while the second concerns the use of computer games for collaborative learning or teaching.

In addition, the questionnaire includes three questions on tool preferences. These questions are also closed, with a multiple-choice format, and include two open-ended questions on the following two topics: (a) expectations of a gaming environment for group work and (b) concerns of using an online gaming environment for communication.

The questionnaire was then divided again into sections related to specific dimensions, based on sample scenarios and tasks addressing various aspects. The first dimension focuses on interface and explores consequences of use (5 closed-ended questions; agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements). The second dimension pertains to the concept of spatial immersion. The concept is subdivided into the following aspects: team identification (5 closed-ended questions; agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements) and hedonic quality and identification (with 8 closed-ended questions; scale 1-7).

The dimension related to actors focuses on social action and comprises 8 closed-ended questions (agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements).

On the other hand, the Avatar embodiment dimension addresses external appearance and response to external stimuli. It is assumed that users may have experience with avatars from online computer games. This part includes 1 closed-ended question (agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements) and two open-ended questions concerning the most important features in a virtual online game space and the affective dimension of interactions during taking a break and playing with teammates.

The final part of the questionnaire includes 4 demographic questions, covering age, gender, education level, and field of study or discipline.

The full questionnaire with all dimensions and questions can be found in Appendix 5.2.2 (p. 132).

3.2.2 Impulse questionnaires scales

The scales used in the experiment design aim to evaluate six aspects of a MUVE VR environment prototype, which is intended for artists and art students. In Section 1, the interface is assessed using fragments from two scales: the System Usability Scale (SUS) (Cecotti, 2022) and the Measurement Components model of User Experience (meCUE) (Minge et al., 2016, 2017). The System Usability Scale (from SUS) provides a global view of subjective assessments of usability, allowing participants to evaluate various aspects of the VR interface, such as ease of use, integration of functions, and confidence in using the system. Questions are adapted to focus on specific features of the VR environment, including menu navigation and environment settings. The meCUE questionnaire measures the consequences of using a product, focusing on the emotional and evaluative responses of users. Participants rate their agreement with statements regarding their likelihood of using the VR environment frequently, emotional engagement, and overall satisfaction. In Section 2, space and immersion are evaluated using fragments from three scales: 1) Competitive and Cooperative Presence in Gaming Questionnaire (CCPIG) (Hudson & Cairns, 2014), 2) Igroup Presence Questionnaire (IPQ) (Schubert et al., 2001), and AttrakDiff-2 (Dupont et al., 2019; Hassenzahl et al., 2003; Souza et al., 2023). The Team Identification subscale from CCPIG measures the sense of belonging and social connection within a team in a cooperative environment. Participants assess their awareness of and connection with other team members within the VR space, reflecting on social interactions and team dynamics. The IPQ measures the sense of presence experienced in a virtual environment. Participants evaluate their sense of reality, immersion, and awareness of the virtual environment compared to the real world. This helps in assessing how convincingly VR space simulates a real-world experience. The Immersion subscale from CCPIG measures the depth of immersion and presence in the virtual environment. Participants rate statements related to their sense of being in virtual space, their awareness of the real environment, and their overall captivation by the virtual world. The Hedonic Quality - Identification (HQ-I) subscale

from AttrakDiff-2. Participants use a scale to indicate their perceptions of various qualities of the virtual environment, such as professionalism, style, and captivation. In Section 3, the artists' agencies in the virtual environment are assessed using the CCPIG scale. The Awareness subscale measures awareness and interaction with other participants in the virtual environment. Participants reflect on their awareness of others' actions, goals, and the mutual influence within the virtual space. This helps in understanding social dynamics and interaction awareness. The Social Action subscale assesses the social behaviours and contributions within a team. Participants evaluate their sense of contribution, the help received from the team, and the impact of their actions on others. This scale helps in gauging the cooperative aspects of the VR experience (Hudson & Cairns, 2014). In Section 4, objects within the VR environment are evaluated using the meCUE and AttrakDiff-2 scales. The User Emotions subscale from meCUE measures the emotional responses elicited by interacting with objects within prototype (Minge et al., 2017) in the VR environment. Participants rate their emotional reactions, such as exhilaration, frustration, and relaxation, while interacting with virtual objects. This provides insights into the emotional engagement with VR content. Interaction with Objects subscale from AttrakDiff-2 (Hedonic Quality - Stimulation) assesses the hedonic quality of stimulation provided by interacting with the cultural heritage objects. Participants evaluate the creativity, boldness, and innovation of virtual objects on a scale. In Section 5, actions performed within the VR environment are assessed using the NASA-TLX, AttrakDiff-2, and Flow Short Scale (FSS) (Cecotti, 2022). The Psychophysical Demand subscale combining NASA-TLX and AttrakDiff-2 (Pragmatic Quality) measures the mental and physical demands of tasks within the VR environment. Participants rate the mental and physical effort required, the clarity and structure of tasks, and their overall stress levels. This helps in assessing the workload and usability of VR interactions. The Flow Short Scale (FSS) measures the experience of flow during activities. Participants evaluate their sense of challenge, absorption, and smoothness of activities, familiarizing researchers with the engagement and flow state achieved during the VR tasks. Section 6, which is optional, assesses avatar embodiment using a scale developed by (Gonzalez-Franco & Peck, 2018) in a review study. This section measures the sense of embodiment and control over the avatar in the VR environment. Participants reflect on their sense of body ownership, agency, and response to external stimuli.

3.2.3 Interviews and focus groups

The interview scheme applies to both the structure of questions intended for the users represents the expert group (selected from G1 and G2), artists (G2), and representatives of various industries in the CCSI (G3), and deals with specialized insights deep into the experience of immersion, the use of virtual environments and the potential of implementing digital cultural heritage resources in creative work.

Questions will be modifiable according to the type of participants, their artistic specialization. In addition, the implemented questions for non-users can be used in focus groups, when juxtaposing both one type of users, active and creative users

of the metaverse, and people who are not active participants in immersive spaces and create art or produce artistic creations without using VR (in a traditional way), but also those who use digital cultural heritage objects without using VR (and its implementation into artistic work). The interview scheme for this group (G2 and G3) is therefore applicable to the focus interviews.

It may also be appropriate to conduct interviews and focus groups with the non-users' group, selected from G1 and G2, in order to gain further insight.

Interview structure for experts and artists, also in focus group, it consisted of five main questions on VR platforms and tools, their advantages and disadvantages, ways of interacting in VR with heritage objects, the difficulties with importing 2D or 3D objects into VR and the size of the VR environment. In addition, a question to non-users about their reasons for not using VR was provided. The interview schema concludes with questions that are specific to the subject, which are based on previous observation or information obtained about the respondent. The full interview scheme can be found in Appendix 5.3 (p. 148), whereas only the main questions from the general pool for all respondents are presented below:

- What kind of VR platforms (e.g. Spatial) and tools (e.g. VR goggles) are you using in your work?

Additional questions relate to the type of VR most commonly used, the hardware used, participation, immersion and use of metaverse environments, multi-user gaming environments, and the mode of interaction that is preferred by the user.

1. From your perspective: what are the advantages and disadvantages of those VR platforms and tools that you mentioned in terms of your artistic needs?

In addition, questions will relate to the usefulness of virtual environments in creative work, speciality, industry, the possibility of implementing metaverse to accomplish tasks, preferences of VR aspects and emotional approach to VR, and possible problems and inconveniences in using VR.

2. Do you use VR mainly to inspect cultural heritage content (or other types of content) or do you also interact with / transform / manipulate the content? If you interact with the content, what type of interaction do you usually engage in?
3. Do you notice any issues related to importing 2D / 3D content onto VR platforms and/or VR development software / tools?
4. What is the average size (area) of the virtual environments you usually enter? (e.g. room-sized, building-sized, more expansive)?
5. (additional) *[IF NOT USING VR] Why have you not been interested in using VR up till now? [not applicable if the audience are VR experts]

In addition, the resulting interview scheme is intended for a group of users to identify the potential of the educational dimension of the metaverse environment, the use of digital cultural heritage resources for teaching purposes, it is also intended for a possible group of artists who are attempting to use immersive technologies

in creative work, to check the potential that such an immersion environment brings, and perceptions about the use of digital heritage. The group will include student users as well as academic staff and artists.

The investigation of the perceptions associated with the various dimensions of VR, including those related to creativity, immersion, and educational elements, will facilitate the verification of the ways in which this technology is understood, perceived, and experienced in terms of immersion.

The structure is based on four demographic questions (relating to age, gender, education level and field of studies or artistic specialisation) and five main questions on specific aspects, particularly related to didactics and, in the case of artists, to the creative use of VR. In the table (available in Appendix 5.3.2, p. 150), the questions posed to the artists are highlighted in colour.

The group of questions included those that relate to the following dimensions and objectives:

1. exposure and awareness, which goal is gauge basic awareness and indirect exposure to VR technologies.

2. perceived relevance, which goal is to understand perceived potential uses of VR in academic contexts without prior direct experience.

3. barriers to adoption that should identify barriers or lack of interest regarding VR use,

4. perception of technology which goal is to explore attitudes towards adopting new technologies and specific thoughts on VR's user-friendliness. In the case of a group of artists, 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.

5. collaborative potential which goal is to elicit thoughts on the transformative potential of VR in educational settings.

Each of these questions is accompanied by a series of more specific, guiding questions. With regard to the dimension pertaining to exposure and awareness, the subsequent questions seek to ascertain the definition of the virtual environment, the extent of familiarity with it, the utilisation of VR technologies in any capacity, and, in the case of artists, the incorporation of VR technologies in artistic and creative work. The dimension related to perceived relevance will be identified through a question that primarily concerns the relevance of VR technologies in education or training (the potential for using VR in teaching methods), enhancing learning or collaboration, as well as the beneficiary aspect of VR in education (e.g. in specific disciplines) or creative activities. The question on barriers will seek to identify the principal reasons for the non-use of VR, rejection of VR, and the lack of acceptance of VR technologies in teaching or artistic work.

A further question will be posed in order to ascertain perceptions of new immersive technologies, the view of technological advancements and possible aspects that could enhance the use of VR in both teaching and artistic work. Artists should indicate the distinctive possibilities for artistic practice and experimentation.

In the context of evaluating the potential for collaboration, it is essential to identify the ways in which virtual reality (VR) could influence collaborative workspaces and learning environments, as well as to understand the perceived benefits of the metaverse among users. In the context of artists, it will be important to gain knowledge of the interactions and possible ways in which the immersive environment can be experienced collectively. This will enable us to recognise changes in the way artists and audiences perceive and interact with art, as well as to gain unique group experiences. Do you believe that VR and immersive installations can provide artists with benefits that other art forms cannot?

The complete interview schedule for G1, G2, G3, can be found in Appendix 5.3 (p. 148). Interview scheme for non-users (selected from G1 and G2) can be found in Appendix 5.3.2 (p. 149).

3.2.4 Observation schemes

The observation schema primarily pertains to experiments and other events, including public ones, utilising VR technology.

The observation schema includes details such as the date, observation point, observation code, and the start and end times of the observation.

Subsequently, the data collected pertains to the event type, including the following categories: a) the type of VR event, e.g., VR opera, VR performance, VR museum exhibition; b) preparation for the event or activities related to the event; c) lecture; d) conference presentation; e) workshop. The specific elements and types of events may be added as required, depending on the circumstances and the nature of the event in question.

Further information pertains to the space in which the event is held, encompassing the type of virtual reality (VR) space and its general level of sophistication. This includes spatial, single-user, multi-user, and other forms of VR. Furthermore, additional details encompass aspects of the virtual environment, including, for example, a classroom, a concert hall situated on a beach, or an amphitheatre. Furthermore, consideration is given to the real-world space in question, including the type of room and location, for example, whether it is outdoors.

Another element of observation concerns the users representing specific artistic disciplines, artists. The group designated as G2 may comprise a variety of individuals,

including musicians, vocalists, dancers, conductors, audience members, and other relevant parties, similar in composition to the group of artists who participated in the CAPHE initial studies. The types of participants are determined solely from these initial studies and tool verification during conferences and XR events within CAPHE. Types of actors can be modified and added as necessary based on the observed event.

The observation schema also considers the context of observers without VR goggles.

This part of the schema includes elements for gathering information about objects in VR, such as sculptures, paintings, musical instruments, paints, brushes, landmarks, and other interactive elements in the world, such as benches, chairs, stairs, and doors. Additional types of objects can be freely added. The second part of the observed elements pertains to objects in reality, such as VR goggles, controllers, pads, haptic gloves, treadmills, steering wheels, moving seats, regular chairs or seats. Individual observed elements can be added as needed.

The next dimension concerns actions. The observation schema includes elements that researchers should pay attention to and gather relevant data on. These include the occurrence of communication between users and the manner of communication in VR. It examines whether there is a process of using virtual information and tools by VR users, which tools and information are used, and when. Additionally, the observer needs to ascertain whether the use of tools and information is easy/intuitive, requires concentration and time, or presents such problems that users repeat actions or abandon their intended actions.

Other aspects to observe include interactions with objects, such as lifting a vase, pouring paint onto a sculpture, zooming in or rotating an object in space, touching a piano, conducting with a baton, stopping at an object, or not interacting with objects beyond observing them according to the sample (used during preliminary studies) or proper (used during pilot studies) scenarios. The manner in which users move in the virtual environment is crucial, including walking, flying, teleporting, experiencing a rollercoaster ride, and others. Movement in physical space pertains to moving (walking, bending, jumping, etc.) within a designated space without using additional equipment; moving on a treadmill or using other equipment; or no movement other than, for example, moving the head and turning on a chair.

The observation schema includes time to link with activities or acts and actors and objects in the context of consecutive or simultaneous events.

The recording structure is constituted of a number of elements, which can be broadly classified under the following headings: The aforementioned structure comprises a series of interconnected elements, including actors, activities, objects, and actors. This intricate

network of relationships can be further delineated as follows: (2) actors – activities – actors – objects.

Description scheme is: <actors> - <activities> <actors><objects> - - (2) <actors> - <activities> - <actors><objects>.

Furthermore, the observation may encompass dimensions pertaining to disconnection, immersion, embodiment, and the manner in which these phenomena occur, including the identification of which of the user's senses are detached from the external environment and redirected towards the virtual reality (VR) domain. Furthermore, it is possible to observe the reactions of the VR user, which is recommended for further exploration during interviews, if feasible.

Furthermore, additional dimensions pertaining to objectives and sentiments were incorporated into the assessment of activities and temporal elements. These should be subjected to scrutiny during an eventual interview.

The complete observation scheme is available in Appendix 5.4 (p. 154).

3.3 Potential problems and barriers to conducting research

During deliberations on research methods and tools, as well as during initial studies in CAPHE, significant difficulties, obstacles, and issues arose due to various conditions or factors often beyond the control of researchers or participants.

Among the most critical issues to consider when using the proposed methods and tools, as well as conducting preliminary studies, are:

Organisational problems, including, for example:

- Insufficient time intervals between experiments,
- Inadequate number of researchers to conduct studies within specified time frames,
- Lack of VR laboratories, appropriate equipment, and space for conducting studies, including interviews, experiments, and observations,
- Limited access to VR laboratories due to scheduling conflicts with educational activities,
- Inadequate number of participants,
- Recruitment challenges,
- Lack of prepared language versions for specific participant groups from partner countries of the project,

- Withdrawal of consent to participate in the study or incomplete informed consent forms for participation and use of research outcomes,
- Overly extensive questionnaire or excessively long duration of interviews, including focus group interviews.

Technical issues, including:

- Equipment failures,
- Inadequate internet connectivity (reliable Wi-Fi and wired connections, especially if participants outside VR goggles use desktop computers),
- Insufficient testing of research equipment (from VR goggles to voice recorders and cameras for recording studies),
- Data loss (it is essential to establish where and how research data will be stored, backup copies, and data security measures to prevent unauthorized access, including sensitive data),
- Technical problems during questionnaire completion.

Behavioural and psycho-social issues, such as:

- Participant boredom and reluctance,
- Psycho-physical problems during experiments (including visual and motor disabilities),
- Sudden onset of symptoms like motion sickness in participants,
- Issues arising from mismatched equipment and digital resources with user preferences,
- Inappropriate way of selection of user groups for specific stages of the research process (for example, this may result from an erroneous analysis of the questionnaire results, the failure to reach a particular user group, an inadequately conducted questionnaire dissemination process, and other factors)

Communication barriers, such as:

- Inadequate researcher conduct (leading responses, rushing, creating a nervous atmosphere).

It will be necessary to develop remedial procedures, consider potential issues, and reconsider the ways in which specific methods and tools are used, along with the development and implementation of prototypes envisaged in the IMPULSE project. Furthermore, preliminary studies serve twofold purposes: firstly, to corroborate the proposed methodology and secondly, to identify any potential issues that may arise during the research process. These preliminary studies also facilitate the identification of challenges pertaining to technology, equipment, participant numbers and organisational issues. Additionally, they assist in the identification of contextual issues and deficiencies in the developed research procedure, experiment and other

aspects of the study. A process of continuous improvement will be implemented to address potential issues that may arise during the preliminary studies and the subsequent main studies, as well as proper pilot studies. This will ensure the smooth and effective conduct of user experience studies within the IMPULSE framework.

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5 Appendices

5.1 Scoping review report

Prepared for subsequent sub-task 1.1.1

Date of preparation and submission: 2024-03-31

Project number: 101132704

Project name: **IMPULSE, IMmersive digitisation: uPcycling cULtural heritage towards new reviving StratEgies**

Call: HORIZON-CL2-2023-HERITAGE-01

Topic: HORIZON-CL2-2023-HERITAGE-01-03

Type of action: HORIZON Research and Innovation Actions

Granting authority: European Research Executive Agency

Report on the conducted literature analysis and scoping review

(WP 1 (EX-STORY): Task 1.1: Subtask 1.1.1)

Identification of research and methods applied to the study of users of immersive virtual environments (virtual reality) and interaction with digital cultural heritage resources.

Authors:

Monika Krakowska (subsequent subtask 1.1.1 leader)

&

Marek Deja, Paloma Korycińska, Magdalena Zych

Jagiellonian University in Krakow

Introduction

The primary or rather overarching objective of the IMPULSE project is to devise innovative and multifaceted solutions and methodologies for the digitalisation processes and accessibility of collections comprising digital cultural heritage. These endeavours aim to facilitate their innovative (re)utilisation, tackle interoperability challenges among platforms, and streamline access to pre-existing digitised cultural heritage materials within novel contexts, notably the metaverse. Simultaneously, the project seeks to pioneer pioneering standardisation protocols and align legal frameworks

with contemporary transformations and creative dynamics in education, art, and CCSI (Project IMPULSE proposal, 2023).

Taking into consideration the tasks instrumental in achieving the principal aim, their intended scope has been duly incorporated within Work Package 1 (WP1) and Task 1.1, as well as its subsidiary element, denoted as Subtask 1.1.1. Their overarching objective is twofold:

to discern the exigencies, anticipations, convictions, sociocultural impetuses, embodiment, and technological embracement, alongside the engagement dynamics within virtual heritage domains facilitated by Virtual Reality (VR).

to conceptualize and actualize prototypes whilst furnishing recommendations tailored for public entities entrusted with the digital preservation of cultural heritage. These directives shall be predicated upon the discernments derived from the expectations, requisites, behavioural patterns, motivational frameworks, and experiential insights gleaned from the tripartite user cohorts under scrutiny.

Both the results and guidelines aim to provide answers regarding the essential conditions for using digital resources in MUVE/metaverses, as well as possibilities for improving their didactic, creative, and commercial applications.

Aim of research

The IMPULSE Project constitutes a delineated conceptual framework, the instantiation, construction, and deployment of which have been systematically orchestrated through iterative methodologies, involving perpetual refinement alongside the conduct of analyses and exploratory endeavours. This undertaking has been delineated into six distinct work packages, each delineating a primary objective whilst leveraging the activities, outcomes, and reconnaissance of all interrelated tasks within the project to bolster its attainment. Among the preliminary stages within the work packages lies Task 1.1, centred on User Experience (UX) Research, and Sub-task 1.1.1 addressing a critical literature review and a scoping review, encapsulated within the domain of WP 1, EX-STORY activities. This package aims to harness UX research to discern the exigencies and behavioural proclivities of users within virtual realms of cultural heritage in the digital sphere and to inaugurate digital heritage repositories for scholars, artists, and researchers through augmented reality and gaming-based experiences. This initiative seeks to disrupt prevailing narratives by elucidating the diversity and multidimensionality of phenomena pertaining to behaviours and experiential dimensions, whilst fostering immersive environments. Moreover, it endeavours to encapsulate marginalised cultures and communities by embedding latent histories, thereby crafting nuanced, diverse, and multi-faceted narratives with the aim of engendering broader audience engagement with the presented thematic and motifs.

Methodology

The initial task undertaken in the execution of WP 1 intentions was to conduct exploratory qualitative and quantitative diagnostic studies aimed at identifying research and methods

used in the analysis of users and non-users' interactions with virtual reality using digital cultural heritage resources. This was accomplished through critical literature analysis methods and scoping review. The scope review is a form of knowledge synthesis that employs a systematic and iterative approach to identify and synthesize existing or emerging literature on a given topic (Mark & Thomas, 2022). Choosing scoping review also allowed for mapping the scope and nature of the literature, as well as identifying certain gaps in the literature. It was also a way of building the analysis framework related to the issue and research area addressed by the IMPULSE project through exhaustive processes of information search and retrieval, which also supports knowledge synthesis, identification of concepts, terms, procedures, and research methods and techniques (Tricco et al., 2018). The analysis was based on the block diagram of Systematic Reviews and Meta-Analysis, PRISMA 2020 for systematic reviews (Page et al., 2020).

The study was developed based on the group library created within the IMPULSE project named HORIZON_IMPULSE in Zotero. The library aims to gather, classify, and share an extensive resource on issues and research areas relating to individual research groups within the project. Therefore, the library was divided into folders concerning the main task packages in the IMPULSE project related to research: Dissemination, Ex-story, Legal, Standard, Tech. During the literature analysis and scoping review, subfolders were added: Screening (containing all publications selected for critical analysis and review), Screening_Additional searching (containing all publications found during the scoping review), and Trash (to which mainly duplicate publications not included in the analysis were moved).

The Zotero library was established at the beginning of the project, and email addresses and usernames of public and closed membership users of the group library were systematically collected. Consistently since 27th February 2024, based on the established goals of individual work packages, a collection was developed to achieve the objectives in Sub-Task 1.1.1 creating a Zotero library (link: https://www.zotero.org/groups/5342666/horizon_impulse) and resource building - permanent creation throughout the project's duration. It is worth noting that the form of conducting a publicly accessible group library allows for continuous collection of resources, which means that during the execution of individual project tasks, participants have the opportunity to input various types of resources, which form the basis for continuous literature analysis, which constantly changes through the implementation of new projects and user experience research in virtual environments, including in the field of cultural heritage.

The multi-layered overarching goal of the project, coupled with the literature amassed during the collection, retrieval, and review stages, contributed to the expansion of the objective in subtask 1.1.1 and the broadening of the scope within which the analysis was conducted. Consequently, the focus shifted towards a synthetic, multi-faceted, and interdisciplinary examination of phenomena, features, and contextual factors associated with research on user experience in virtual environments utilizing digital resources, including those pertaining to cultural heritage, and their implementation across various disciplines and domains, catering to diverse user groups as well as non-users. Achieving the specified overarching goal necessitated embedding it within

the broader context of user experience in virtual environments, considering diverse yet selected aspects and contextual factors, and acknowledging the interdisciplinary dimension of the entire subject matter. Consequently, additional specific tasks were formulated, including:

- Determining the research methodologies for users in immersive environments and user experience in virtual spaces.
- Identifying the areas and domains in which previous research has been undertaken.
- Recognizing the goals and intentions of research conducted in this area, as well as the dimensions in which such research was conducted.
- Incorporating diverse technologies associated with virtual environments.
- Identifying various user groups among which VR experience research was conducted.
- Recognizing different aspects related to VR experience.
- Diagnosing the plethora of methods used to study users and their experiences in immersive environments.
- Capturing diverse terminologies.
- Attempting to identify ways of studying the needs and behaviours of users in immersive environments.

Method of resources selection for critical analysis

A critical analysis and scoping review were initiated by analysing and verifying the existing Zotero library HORIZON_IMPULSE. The utilisation of Zotero library resources for IMPULSE involved the verification of the resource, during which duplicate entries were removed, resources were checked for availability, and efforts were made to locate full texts. Additionally, the range of publications in general was also checked. Finally, the 201 publications were included in the Zotero subfolder named "Screening" for analysis. The chronological scope of the analysed literature spans from 1988 to 2024. All publications are in the English language.

All resources designated for analysis were allocated among 3 researchers who employed MaxQDA software for both qualitative and quantitative analysis. MaxQDA was chosen for its availability under a license held by the researchers' home institution, the Jagiellonian University in Krakow. Additionally, it offers flexibility, continuity, and facilitates ongoing research iterations. Furthermore, the use of a single tool streamlined teamwork and refined the analysis process. Moreover, the software allows for the inclusion of resources selected during the ongoing acquisition of information and literature, which will be utilized throughout the project's implementation and will pertain to the methodology of researching user experiences and behaviours in immersive virtual environments. MaxQDA enables smooth conduct of research, various types of analysis, and continuous improvement at every stage of the project's duration.

Meanwhile, during the thematic analysis conducted in MaxQDA, due to the expanded scope of the undertaken analysis and the scoping review broadening the scope and topic of VR experience research, a fourth researcher conducted a search for publications in the Web of Science and Scopus databases.

Additional searching

The queries entered to Web of Science by Clarivate have been refined according to up-bottom logic, departing from the broadest ones and successively narrowing the research scope by addition, removal or modification of query terms or filters. The first widely sweeping query was composed as follows:

TS=(((VR OR "virtual reality" OR XAR OR "higher education" OR "virtual worlds" OR metaverse) AND (experiment OR observation OR interview) AND (affective OR behaviour OR spatial OR cognitive OR psychological OR need) AND (sickness OR barriers OR efficacy OR learning OR improvement))) OR AB=(((VR OR "virtual reality" OR XAR OR "higher education" OR "virtual worlds" OR metaverse) AND (experiment OR observation OR interview) AND (affective OR behaviour OR spatial OR cognitive OR psychological OR need) AND (sickness OR barriers OR efficacy OR learning OR improvement))) OR TI=(((VR OR "virtual reality" OR XAR OR "higher education" OR "virtual worlds" OR metaverse) AND (experiment OR observation OR interview) AND (affective OR behaviour OR spatial OR cognitive OR psychological OR need) AND (sickness OR barriers OR efficacy OR learning OR improvement))) OR KP=(((VR OR "virtual reality" OR XAR OR "higher education" OR "virtual worlds" OR metaverse) AND (experiment OR observation OR interview) AND (affective OR behaviour OR spatial OR cognitive OR psychological OR need) AND (sickness OR barriers OR efficacy OR learning OR improvement)))

Although fully relevant to the research objective, the query proved to be too large and generated over 6000 results, a volume which was impossible to review and classify thoroughly. More restricted choice of applied terms and filters was required. The final version, tested for relevance, pertinence and results' number acceptability, came out as follows:

(((TI=(VR OR "virtual reality" OR XAR OR "virtual worlds" OR metaverse OR immersive OR augmented OR "head mounted display")) AND AB=("cultural heritage" OR museum OR "cultural artifacts" OR "cultural collections" OR "cultural assets")) AND AB=(experiment OR observation OR interview OR "user stud*")) AND AB=("cognitive *load" OR barriers OR sickness OR needs)

Once the results transferred to Zotero and then, to MaxQDA software, full texts and records with abstracts (in case full text was not available) were automatically scanned for the presence of a dozen of keywords aimed at extracting information about research methods utilized to inspect and gauge VR users' behaviours and needs, in various contexts. In addition to methods, techniques, protocols and measurement discovered beforehand in previously gathered corpora of scholarly literature, the search results obtained from Web of Science indicated at least three new avenues pertaining to the field of medicine, i.e. VR distraction (VRD), VR hypnosis (VRH) and avatar therapy, cooccurring frequently with the notion of cognitive load or cognitive overload. This discovery

motivated supplementary research both in Web of Science and in PubMed, using the queries:

A) Web of Science:

(TI=(VR OR "virtual reality" OR XAR OR "virtual worlds" OR metaverse OR immersive OR HMD OR "augmented reality" OR "VRET")) AND TI=("anxiety score" OR "anxiety scale" OR HAM-A OR sickness OR "cognitive *load")

B) PubMed:

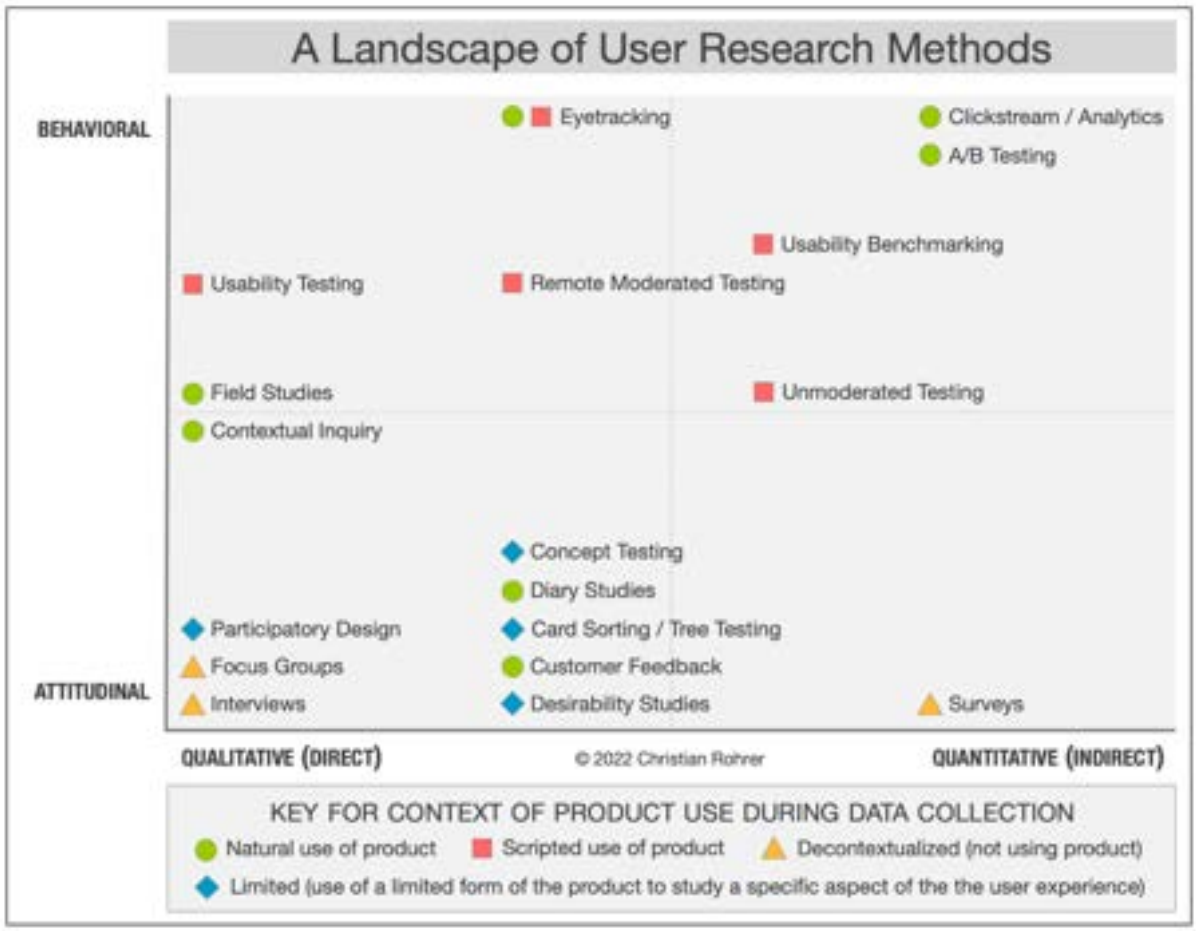
(VR[Title] OR "virtual reality"[Title] OR XAR[Title] OR "virtual worlds"[Title] OR metaverse[Title] OR immersive[Title] OR "head mounted display"[Title]) AND (anxiety[Title/Abstract] OR "cognitive load"[Title/Abstract] OR sickness[Title/Abstract] OR "anxiety scale"[Title/Abstract] OR "anxiety score"[Title/Abstract]) Filters: Abstract, Free full text, Full text, Randomized Controlled Trial, Systematic Review, in the last 5 years Sort by: Most Recent

In research literature thus collected, there were numerous highly EBM rated papers (randomized controlled trials, including programmatic RCT, metanalyses and systematic reviews) summarizing scientific findings on the utility of virtual reality (VR) as an effective and straightforward non-pharmacological approach to alleviate pain, reduce peri-procedure anxiety and tremor, support symptoms soothing in psychiatry (especially in patients with experience of schizophrenia) and in addiction therapy as well to diminish cognitive or affective load in subjects with experience of neurodiversity. These preliminary reconnaissance shows the interest of including medicine in the scoping review encompassing all the areas of present or predicted application of VR in human-centred activities.

Thematic analysis

The thematic analysis conducted in MaxQDA was carried out by three independent researchers. The material was divided numerically, and deductive-inductive coding was employed. Deductive coding was applied using expert knowledge (domain-specific, from project partners involved in user research in technical and information and social sciences) as well as knowledge developed by experts in user experience research. In this case, a compilation of the most commonly used UX research methods within a three-dimensional framework with the following axes was used: 1. Attitudinal vs. Behavioural, 2. Qualitative vs. Quantitative and 3. Context of Use is illustrated in Figure 1. The diagram was developed by NNgroups, a company founded by UX researchers Jakob Nielsen and Don Norman, which employs a team of UX experts dedicated to providing sound recommendations and practices in UX, user experience design and research.

Fig. 1. User experience research methods in 3-dimensional framework.



Source: Rohrer, Ch. (2022). When to Use Which User-Experience Research Methods. *NNgroup, Nielsen Norman Group*. Retrieved from: https://www.nngroup.com/articles/which-ux-research-methods/ (30 April 2024)

An additional source for the creation of codes for deductive coding was the initial proposal of social survey methods in the context of the different user and non-user groups that were selected in the project. These groups included: 1) students, postgraduates and young researchers and academics; 2) artists and art schools; 3) representatives of the creative industries (games, film, animation, performance etc.). Figure 2 presents the selected four social survey methods in the context of the user groups and types of users that were also selected (Tomanek, 2024).

Fig. 2. Survey Methods vs Target Groups draft.

Source: Tomanek, K. (2024). Available at: https://teams.microsoft.com/v2/

Furthermore, an important aspect became the categorization of immersive technologies and virtual worlds proposed by the National and Kapodistrian University of Athens and the Spatial Media Research Group. This categorization emerged from a presentation discussed during the Impulse Plenary Meeting on 1st March 2024 by Dimitris Charitos (accessible at: https://teams.microsoft.com/v2/). In a later stage of coding and code verification, consultation and review of the correct application of parent and child codes for virtual environments, VR, Virtual worlds, MUVEs, CVEs, and key names of popular applications were required.

Coding

Based on these expert materials, knowledge, and established research objectives, an initial codebook was developed, containing the primary and secondary codes. Through thorough engagement with the text, reading, and familiarity with full texts, inductive coding was employed, progressively adding new codes in accordance with the individual interpretation of the text by the three researchers conducting thematic analysis in MaxQDA. This process involved selecting excerpts related to specific predetermined primary and secondary codes. This facilitated capturing the complexity and richness of qualitative data, as well as recognizing the multitude of methods, procedures, and forms of user research organization and their user experience (UX) in virtual

environments. The adopted logic and methodology of content analysis, as well as the application of inductive coding, also aim to prepare the groundwork for intensive, often innovative, and multifaceted explorations of the designated three user groups, their behaviours, needs, and experiences in immersive virtual spaces, which will be planned and conducted in later stages of the project.

The code set was continuously updated, verified, and supplemented. Ultimately, the following codes were classified as overarching: aim of research, area, dimension, methodology, methods, organization of research, technology, users, and VR experience. Additionally, it was decided to specify embodiment, citation (content referred to in the state of research or discussion of the results), needs, terminology, tips for using VR/AR/XR, and VR therapy as overarching codes. Each overarching code is further subdivided into deductively-inductively defined sub-codes (secondary codes), which are then subdivided into additional tertiary codes. For example, codes related to the area include secondary codes, which are further divided into tertiary codes: for instance, Area > archaeology > archaeological sites, cultural heritage > digital heritage, or historical accuracy, historical authenticity, or tourism, and likewise design > fashion, furniture design, interior design. Among the secondary codes related to users, examples include codes for artists, children, creative industry, experts, students, teachers, and others, which are also subdivided into lower-level codes (e.g., creative industry > design professionals, film/movie creators, game creators, performance creators, VR or MUVE creators). It is noteworthy that in some cases referring to overarching codes such as methodology, methods, dimensions (in which the research was conducted or the authors of the analysed publications referred to the identified dimensions, perspectives identified in previous research, and which are important planes of VR experience research), or technology constitute very elaborate code trees with numerous sub-codes, including names of specific methods, techniques, scales used in questionnaire research, technologies, applications, names of specific virtual worlds and applications. Additionally, when reading the code tree and the number of codes present at this stage of thematic analysis, it is important to note that not all publications and resources subjected to coding yielded codes, necessitating continuous analyses related to key objectives and user groups, as well as methods for studying VR experience.

During the process of inductive-deductive coding by individual researchers, which was subsequently integrated, refined, verified, and supplemented, a total of 482 codes were generated. Additionally, MaxQDA obtained 6798 codes based on keywords and field designations from the bibliography, which were directly imported from the Zotero library. The final, comprehensive list of codes and their categorization is located in the Appendix to Scoping review report (p. 98).

It should be noted that the codes utilized and selected at this stage may continue to be verified and updated following any consultations and feedback that arise during the project implementation and will be addressed by the team participating in WP1 and individual tasks.

In addition to inductive coding, lexical coding was employed in MaxQDA by using alternatives for specific selected codes (e.g., area > museums, area > cultural heritage,

methods > diary method, methods > contextual inquiry, methods > desirability studies, methods > field studies) according to specified instructions, such as diary "feedback study" "feedback studies" "elicitation study" "elicitation studies", "contextual inquiry" "participant observation" "on-site study", "desirability studies" "desirability study" "desirability survey" "desirability research" "desirability toolkit" "desirability testing". Additionally, automatic coding was applied for selected codes, facilitated by the MaxQDA program.

Results (in selection)

This section delineates chosen outcomes derived from the thematic analysis and coding conducted through MaxQDA. It is imperative to underscore that the lexicon employed in this project necessitates additional scrutiny and elucidation. Standardising and solidifying the overarching terminology utilised within the project holds paramount significance for advancing user research initiatives. The absence of elucidation and definition identified during the literature review underscores the imperative for this endeavour.

Due to the nature of Task 1.1, which primarily entails the determination of research and methods utilised in analysing the interactions of users and non-users with virtual reality (VR) through digital cultural heritage resources, the scope of this objective has been broadened to extend beyond cultural heritage, incorporating various domains and research methodologies concerning user experience (UX). Consequently, an initially adopted definition of user experience, as established by Don Norman and Jacob Nielsen, has been preliminarily embraced. Furthermore, the inductive coding employed also encompassed terminology relating to dimensions of experiences, behaviours, and interactions within virtual environments. The term "user experience" comprehensively encapsulates all aspects of an end-user's engagement with a company, its services, and its products (Norman & Nielsen, 1998). However, further clarification and expansion of this definition are deemed necessary.

Given the substantial number of codes and the complexity of the code tree structure, the majority of findings have been visually represented below.

As an example, Figure 3 depicts a tag cloud delineating the coded themes, highlighting the codes that occur most frequently, surpassing 10 instances.

Fig. 3. Tags cloud of coded themes (coded above 10 instances).

Source: Self-authored, 2024

For comparison, Figure 4 depicts a considerably less legible, overall tag cloud representing the entirety of applied codes, the complete code tree, during the process of coding and thematic analysis. Throughout this process, the most frequently occurring themes were recognized, addressing areas encompassing overarching codes such as aim of research, organization of research, methods, methodology, domain, dimension, users, needs, technologies, VR experience, as well as citation, embodiment, terminology, tips for using VR/AR/XR, and VR therapy.

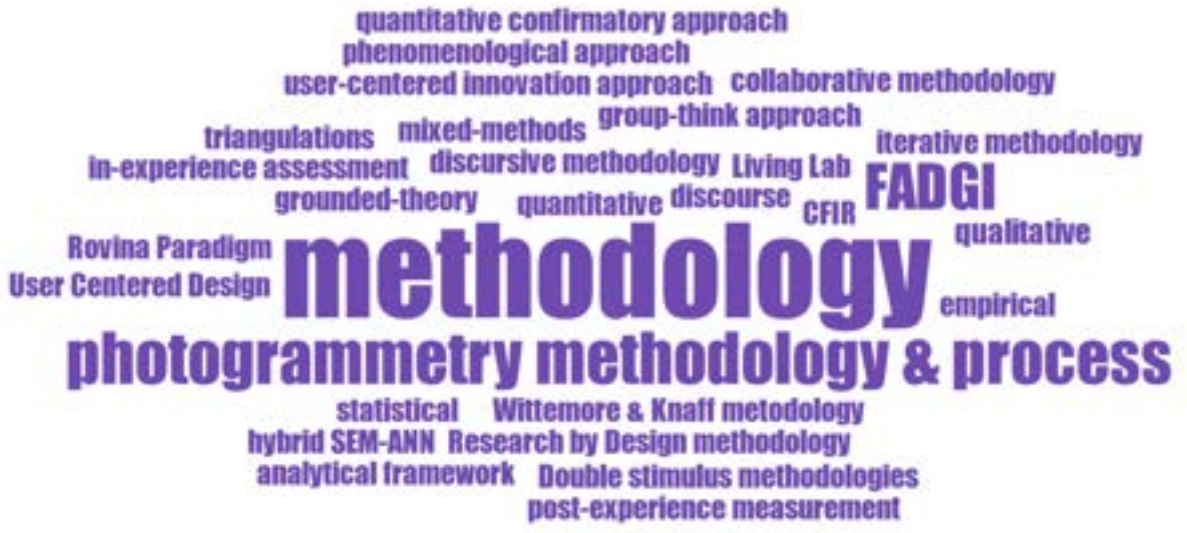
Fig. 4. The overall code map.

Source: Self-authored, 2024

Primary code: Methodology

The research methodology encompasses the strategic approach, toolkit, and structured plan of inquiry which, when implemented, aids in addressing the research problem by collating heterogeneous data, employing a spectrum of methods and techniques, interpreting the amassed data, conducting qualitative and quantitative analyses, and deriving conclusions from the research findings. It serves as a theoretical, conceptual, and empirical framework for conducting rigorous research. Consequently, the encoding of the most frequently emerging methodologies in the scrutinized publications was conducted. Among the most commonly used methodologies in the literature reviewed were, for example, quantitative confirmatory approach, triangulations, phenomenological approach, double stimulus methodologies, as well as FADGI (a collaborative effort started in 2007 by federal agencies to articulate common sustainable practices and guidelines for digitized and born digital; standardisation methodology) and photogrammetry methodology & process (a cheap, flexible and accurate solution to obtain 3D point clouds and textured models. The results of the coding were presented on Figure 5. The main advantage of this photogrammetric methodology is that a cloud of points and a precise mesh object with texture can be obtained at the same time (Besoain et al., 2021)

Fig. 5. Tag code of commonly used methodologies in VR experience research.



Source: Self-authored, 2024

The appearance of FADGI procedures and photogrammetry methodology and process earlier in the tag cloud indicates their relevance for standardisation and digitalisation, making them pivotal for prototyping and accomplishing the objectives of the IMPULSE project. However, they may not necessarily align with investigating user needs. Consequently, they were omitted from the subsequent visualization, enabling the identification of new, more frequently employed methodologies. These encompass,

among others, user-centred design, collaborative methodologies, research by design methodology, discursive methodology, and others, as illustrated in Figure 6.

Fig. 6. The tag cloud pertaining to methodologies excluding procedures used in digitalisation and standardisation.

Source: Self-authored, 2024

Primary code: Area/Domain

Among the most frequently occurring codes related to area or domain, codes associated with cultural heritage emerged, which may also be attributed to the intention of acquiring specific resources related to user VR experience. Additionally, the studies focused on museums, which could result from a bias towards this type of literature and the application of VR in this area, as well as its placement by project partners in the Zotero library. Subsequent analyses may reveal additional or entirely different domains where VR is applied and research on VR experience is conducted. Furthermore, education, digital heritage, medicine, design, and archaeology were among the most frequent codes assigned. Visualization presented on Figure 7 depicts the most commonly occurring codes related to area/domain.

Fig. 7. The code cloud pertaining to the dimensions in which the studies were conducted.

Source: Self-authored, 2024

Primary code: Research objective – generalised

Table 1 exclusively presents the selected research objectives identified and coded during the thematic analysis conducted. Studies conducted in the fields of art, including museums, cultural heritage, education, and design, were chosen for visualization. Each of the scrutinised studies featured intricate research objectives and referenced additional studies, case studies, projects, and analyses of diverse instances of VR technologies and VR experiences from varied users, necessitating in-depth analysis.

Table 1. *Selected research objectives in relation to research areas, users and research methods*

No.	study	research objective	area	users	methods
1	(África et al., 2023)	"The aim of the study is to ascertain the emotions triggered by a VR stimulus through the expressions on the e-WOM online reviews, the present research focuses more closely on the categorical theory of emotions such as that by Plutchik (1980), and consequently the following research question is formulated: RQ2: What are the emotions triggered by the VR headset stimulus regarding the Van Gogh VR experience?"	Art, Museums	Audience, General users	Observation, Text-mining, Sentiment analysis
2	(Chung et al., 2024)	"This study investigated the characteristics of visitor experience in relation to the spatial environment of VR exhibitions, particularly focusing on the representational fidelity of the real-physical world. We experimented with comparing the user experience in reality-based (realistically representing the physical world, high representational fidelity level) and virtuality-based (surreal, low representational fidelity level) VR exhibition settings	Art, Museums > VR exhibitions	General users	Observation, Interviews, VR experiment, Questionnaires > IPQ, Simulator Sickness Questionnaire, PPM

		to explore design implementation."			
3	(Evans, 2019)	"The focus of this paper is to assess what those barriers are, and whether they can be overcome in a manner that will allow for the potential of immersive educational experiences through VR to be realised in the near future. Understanding the barriers to VR as a concept could be investigated in several ways through empirical research. "	Education	Experts, Creative industry > performanc e creators, films/movie creators	Semi structured interviews, Field study, Clickstream / analytics
4	(Kari & Kosa, 2023)	"The present study therefore aimed to explain the factors that drive the use and acceptance of VR games. We extended the hedonic-motivation system acceptance model with utilitarian and inconvenience factors to capture the pertinent features of VR systems more holistically."	Education	gamers	Questionnaire, covariance-based structural equation modelling, Clickstream / Analytics, Modelling methods, Longitudinal studies
5	(Lam, 2023)	"This research examines factors that influence the artists' decisions to use specific techniques in their processes. The findings of the research will discuss the potential of virtual reality in art creation and the creative process for such artists, with reference to their work."	art	Artist > painters	Case study
6	(Li et al., 2023)	"This study aims to comprehensively understand the existing literature on immersive technology in museum exhibitions, focusing on virtual reality (VR), augmented reality (AR), and the visitor experience."	Art, Cultural heritage > digital heritage, tourism, Museums	-	Bibliometric analysis, Critical literature review, Clickstream / Analytics

7	(Mcveigh-Schultz et al., 2018)	"We aimed to go beyond pain points and surface level desires and instead sought out opportunities to reimagine the broader problem space by exploring alternative interaction rituals for collaboration and creativity in VR."	Design > furniture design	Creative industry > design professionals, Scientists, Engineers, Project managers	Case study, Field study, Design methods, Experience prototyping, Interviews, Observation
8	(Verhulst et al., 2021)	"To summarize, this study aims to help fill three gaps in the existing literature. The first, the lack of comparative work, is addressed by directly comparing the user experience of three different versions (one VR, two AR). The second, the lack of real-world studies, is addressed by using regular visitors to the National Gallery in London, UK, as participants. And the third, the lack of analysis of the drawbacks of immersive technologies, is addressed by including negative side effects (for example, nausea and feeling uncomfortable) in the outcome measures. The research question is: Do VR and AR versions of an immersive cultural experience engender different user perceptions of presence, engagement, enjoyment, and do they have negative side-effects?"	Art, museums	General users	VR experiment, storytelling, Questionnaire (survey) > IPQ, presence questionnaire
9	(Wu & Kim, 2022)	"In conclusion, the objective of this study was to explore users' perceptions of technological features in VR and AR and analyse the advantages and disadvantages of technologies in fashion retailing."	Design > fashion	Students, non-users > potential users	Focus groups

10	(Young et al., 2023)	"This study aimed to explore an audience's experiences viewing a volumetric music video presented in VR with and without vibrotactile feedback. This process involved observing and evaluating music video audiences individually to gather data on their experiences when engaging with such materials."	art	audience	observation

Source: Self-authored, 2024

Primary code: Technology

The aim of the conducted critical analysis and scoping review, along with thematic analysis and coding, was to identify the technologies (see Figure 8) utilized in VR experience research, including applications, programs, tools, and specific names of immersive virtual environments appearing in publications. As a result, a specific quantity of codes within the coding tree was obtained, with attention directed towards those most frequently mentioned, analysed, and explored. Additionally, it was observed that VR, metaverse, AR, and XR are often combined. Furthermore, there exists imprecision in terminology and definition not only of the technologies themselves but also of specific virtual environments, necessitating further clarification in subsequent research conducted within the IMPULSE project, as well as the concretization of the metaverse concept and the definition of a specific metaverse platform emerging within the project.

Fig. 8. The tag cloud assigned to the most frequently appearing in publications and studies on technologies.

Source: Self-authored, 2024

Primary code: Users

The process of assigning codes to various user groups, identified during thematic analysis and literature review, was based on both deductive coding, aligned with the predefined user and non-user groups outlined by the project's objectives, and inductive coding, which captured actual, investigated user types. For instance, these included teachers, children, gamers, the creative industry, and experts (interpreted broadly as individuals professionally engaged in VR and immersive environment creation, domain specialists, individuals possessing extensive qualifications, skills, and knowledge about user VR experience, immersive environments, etc.). The cloud of codes depicted in Figure 9 comprises the most frequently occurring codes pertaining to distinct categories of examined users, exported from publications and in accordance with the conducted critical analysis of literature and scoping review. Particular attention is warranted towards codes concerning students, artists, the creative industry, non-users, and potential users, as well as research related to VR experience among general users.

Fig. 9. Tag cloud indicating most frequently occurring codes for the users' category.

Source: Self-authored, 2024

Primary code: Methods

Within the methods employed in the scrutinised publications, a variety of research methods and techniques were applied, encompassing not only users themselves but also virtual environments (see Figure 10). Thus, within the second-order codes, various types of methods and techniques were identified deductively, in accordance with the adopted methodology. However, during the coding process, numerous other methods associated with broadly understood user research, interdisciplinary approaches, or borrowed from other fields were recognized, necessitating consideration in the development of a bespoke methodology for the IMPULSE project. Consequently, the hierarchical coding tree included, for example, methods based on experiments further divided into between-subjects experiments, creative experiments, VR experiments (with a subordinate four-level code of VR laboratory experiment), and within-subject

experiments. The expansion of codes through their systematic classification also extended to statistical methods, as well as questionnaires (surveys), and typical user research methods (e.g., remote moderating testing, unmoderated testing, usability testing, user testing, user/customer feedback). Similar branching pertained to codes subordinated to the primary code of physiological methods, through which bioelectrical brain activity, electrodermal activity, and even optical techniques used to detect volumetric changes in peripheral circulation were investigated, including ECG, EDA, EEG, EOG, eye-tracking, fMRI, GSR, health-related measurements, PPG, real-time kinematic/kinetic data, and SKT.

Fig. 10. The code cloud with the most frequently used methods for VR UX research based on thematic analysis.

Source: Self-authored, 2024

The analysis will furnish with a diverse array of methods and tools; however, we must consider constraints such as the project team size, equipment availability, software, and all other pertinent issues (barriers). Below, the visualization (see Figure 11) separately presents a code cloud pertaining to the remaining methods, which does not include codes related to various types and scales of questionnaires. This demonstrates the diversity in the application of methods investigating users and their VR experience. Among them, notable categories include case studies, experiments, psychological methods, ZMET (Zaltman Metaphor Elicitation Technique, studying the unconscious thoughts, feelings, needs, and desires of users), as well as physiological methods, and statistical analysis, VR experiments, observations, interviews, clickstream/analytics, and design methods.

Fig. 11. The code cloud with the most frequently used methods for VR UX research, excluding survey-related codes.

Source: Self-authored, 2024

Furthermore, to distinguish and concentrate exclusively on a single type of method, which stands out as the most popular within the overall array, serving as an ancillary rather than principal approach to studying users among the recognized methodologies, the code cloud was utilized to visualize on Figure 12, the most commonly appearing codes across different types and scales of questionnaires.

Fig. 12. The code cloud with the most frequently used types and scales of questionnaires (surveys).

Source: Self-authored, 2024

Various types of questionnaires necessitate validation and customisation to particular dimensions, user demographics, research goals, and themes. Questionnaires serve as supplementary research instruments, invariably complementing other methodologies. As a subsequent phase within the activities of Work Package 1, the selection of optimal research methodologies and techniques for each phase of user experience (UX) research and each user category, in accordance with the classification adopted in the project, will assume critical importance during the execution of Task 1.2.

Primary code: VR experience

Furthermore, the coding developed themes for specific and differentiated dimensions, areas and research relating to user experience in virtual environments, which are collectively referred to as the VR experience (see Figure 13). Codes were placed on perception in virtual environments, presence, interactions undertaken in immersive environments, including specific information behaviour, immersion issues, various barriers, technology adoption, first- and third-person perspective and others.

Fig. 13. Tag cloud with codes dedicated to VR experience and the most frequently occurring codes.

Source: Self-authored, 2024

It should be noted that this is not intended to be a comprehensive list of factors that can be considered under the term VR experience. Rather, it is intended to provide an initial direction for further detailed analysis, which will be conducted in collaboration with interested partners from other WPs during the subsequent stages of WP1's work.

Next steps

The next steps in developing a methodology for researching VR users and non-users include additional searching for publications targeting the specific issues identified by each WPs, incorporating the comments to this report, organizing and structuring research methods and the order in which they shall be applied (e.g., which procedures are best suited for eliciting user requirements and needs, which for rapid prototype testing, which for evaluation of the finished product, etc.), developing specific procedures and research tools for the first studies, and conducting a preliminary study.

In parallel to the conceptual work on the research methodology used in IMPULSE, we plan to conduct further work and analysis using MAXQDA, including converting codes into variables, categorizing codes in the MAXDIctio dictionary, and performing auto-coding.

We are primarily focusing now on qualitative research, including concurrent small-team efforts (e.g., qualitative interviews with experts on VR technology), eventually co-opting new researchers to assist our process.

The results of the scoping review will contribute to the selection and development of the best possible research procedures for use at various stages of the IMPULSE project. Currently, we are focusing primarily on the preliminary study and researching the needs of VR users and non-users.

The selection of any specific methodologies, methods and research tools used during the preliminary studies and research conducted in the initial stages of the IMPULSE project will be determined by, among other things:

- the research objectives of the various stages (e.g., understanding the needs of VR users, obtaining requirements for WP2);
- the technical capabilities and work schedule of the IMPULSE project (e.g., access to a VR studio, having a prototype - we do not have such capabilities at the initial stage of research);
- access to users and non-users in IMPULSE's priority groups - thanks to our cooperation with the CAPHE project, we have the opportunity to participate in the 2024 year in conferences, VR festivals and rehearsals for operas using VR; we also have access to artists working in VR and AR (e.g., musicians, actors and sculptors from Italy and Portugal; in addition, we have contacts with local cultural institutions, e.g., the Academy of Music), as well as experts in VR, MR, AR, MUVEs;
- the skills of the researchers and the time allocated to the tasks.

After having considered the above factors, we are thinking of using the following procedures during the preliminary studies: field studies or contextual inquiry (due to access to artists while working on projects in VR during rehearsals for a VR opera, among others), interviews, focus groups, ZMET, observations. The following detailed work on the methodology will be conducted during the internal UJ methodology meeting (7.05.2024) and WP1 meeting (10.05.2024).

Limitations

This stage of WP1's work (scoping review) is the first step in developing a procedure for researching VR users and non-users as part of the IMPULSE project - it is an important step, but just an initial one. Using MAXQDA provides us with the flexibility to perform follow-up analyses, although the program has some limitations, so we plan to utilize more tools for data analysis and visualization (e.g., Python). Access to full texts of publications is limited - we have made efforts to obtain full texts that could not be downloaded via Zotero (e.g., we contacted authors of publications via Research Gate), nevertheless not all full texts could be obtained, so we also relied on abstracts. The Zotero library should have started to be created earlier, preferably from the initial work on the project.

A review of the literature revealed terminological inconsistencies and instances where the methodology employed was not adequately described. In order to address these shortcomings, we conducted a search for information on selected procedures that were relevant to our research. This process will continue.

Moreover, concerns include questionnaire purchase costs, participant recruitment (ethical and legal constraints) and the application of tools for physiological reaction research (issues of study supervision, uniform equipment, and software) - we lack the means to utilize methods such as FMRI, EEG, ECG, despite their application in VR UX research.

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Appendix to Scoping review report: List of Codes

Codebook	Memo	Counts
		our codes: 6798 (all codes, with imports from Zotero: 11226)
aim of research		316
area	discipline, subject, object - e.g. medicine	5
archeology		6
archeological sites		6
architecture		4
urban design		2
art		46
immersive theatre		2
cultural heritage		155
digital heritage		46
historical accuracy	accuracy is about 'getting the historical facts correct' (mochocki2021, P. 3)	3
historical authenticity	authenticity is 'about getting the experience and expectations of the past "right"' (mochocki2021, P. 3)	22
tourism		10
design		1
fashion		24
furniture design		1
interior design		1
education		52
digital education		10
learning theories		0
constructivist learning		1
enquiry-based learning		1
games-based learning		1
situated learning		1
geography/cartography		5
Industry 4.0		4
media culture		1
medicine		25
museums		124

VR exhibitions			8
psychology			4
sport			5
citation		content referred to in the state of research or discussion of the results	27
co-citation			12
combined citation			1
self-citation			1
dimension		cognitive, social, affective, technology etc. - if applicable	15
behavioural			31
simulator/motion sickness		VR sickness	273
cognitive			41
affordance			4
Affordance theory			94
cognitive load theory			1
expertise reversal level		it refers to the reversal of the effectiveness of instructional techniques on learners with differing levels of prior knowledge. The primary recommendation that stems from the expertise reversal effect is that instructional design methods need to be adjusted as learners acquire more knowledge in a specific domain. Expertise is described as "the ability to perform fluently in a specific class of tasks".	1
mental models			1
mental workload		mental ergonomics	3
Yerkes-Dodson law		The law dictates that performance increases with physiological or mental arousal, but only up to a point. When levels of arousal become too high, performance decreases. The process is often illustrated graphically as a bell-shaped curve which increases and then decreases with higher levels of arousal.	1
cultural		eg. western and eastern cultures; the way that people view the world around them based on their cultural background, experiences, and beliefs	6
educational			23
digital literacy			6

			Experiential learning theory			based on several fundamental models of experiential learning, including Lewin, Dewey, and Piaget, which basically refer to learning from experience or learning by doing. Learners immerse in a particular experience and reflect their experiences to develop new skills, attitudes, or ways of thinking (Lewis & Williams, 1994). Experiential learning is defined as “the process whereby knowledge is created through the transformation of experience. Knowledge results from combination of grasping and transforming experi-ence” (Kolb, 1984, p. 41). (fromm2021, P. 2)	2
		exploratory					7
		multidisciplinary perspective					6
		narrative					18
			storyworld			‘a storyworld can be fictional or non-fictional or have components of both’ (Schrier, Torner & Hammer 2018, p. 352). Its ‘mental representation’ is based on ‘three conditions . . . being logically consistent, large enough to stimulate the imagination, and experienced as complete’ (Ryan, 2019, p. 82). (mochocki2021, P. 13)	2
			worldness			the potential to generate a mental image of a believable storyworld	4
		philosophical					3
		psychological					34
			affective				35
				affective state			6
					Emotion Matching (EM)	Feeling as another person feels (kembe2022, P. 7)	5
					Empathic Concern (EC)	Feeling for another person who is in need (kembe2022, P. 7)	6
				emotions			14
				empathy			24
			ARCS Model of Motivation			The ARCS model (Keller 1983) is a motivational design process that includes a synthesis of motivational concepts and theories that are clustered into four categories: attention (A), relevance (R), confidence (C), and satisfaction (S).	1
			comfort factor			the extent in which VR offers a safe and protected space for learning	1

			Imagine-other Perspective (IOP)	Imagining how another person thinks or feels given his or her situation (kembe2022, P. 7)	6
			Imagine-self Perspective (ISP)	Imagining how one would think and feel in another's situation or "shoes" (kembe2022, P. 7)	6
			SDT	self-determination theory	3
			Theory of perceived risk		1
		social			36
		technology adoption/acceptance			0
			HMSAM	the hedonic-motivation system acceptance model (HMSAM) (Lowry et al. 2013), which we extend by (1) adding utilitarian factors and (2) inconvenience factors pertinent to VR systems	3
			Multi-user acceptance model		3
			TAM	Technology Acceptance Model	40
			technology anxiety		1
			UTUAT2	Unified theory of adoption and use of technology 2	1
	embodiment				36
		Human Enhancement		Human Enhancement is a broad term covering several disciplines in fields such as electrical, mechanical, and genetic engineering[31]. Moore [24] defines it as "any attempt to temporarily or permanently overcome the current limitations of the human body through natural or artificial means. It is the use of technological means to select or alter human characteristics and capacities, whether or not the alteration results in characteristics and capacities that lie beyond the existing human range" (sadeghian2021, P. 2)	2
	methodology			qualitative, quantitative	62
		analytical framework			5
		CFIR		Consolidated Framework for Implementation Research (CFIR) framework	3
		collaborative methodology			3
		discursive methodology		A discursive approach enables you to explore the construction of meanings in human interaction.	2
			discourse		2

		Double stimulus methodologies		2
		empirical		5
		FADGI	a collaborative effort started in 2007 by federal agencies to articulate common sustainable practices and guidelines for digitized and born digital; standardisation methodology	178
		grounded-theory		3
		group-think approach		3
		hybrid SEM-ANN	a hybrid analysis of Structural Equation Modeling (SEM) and Artificial Neural Network (ANN), through SmartPLS and SPSS software	2
		in-experience assessment		2
		iterative methodology		1
		Living Lab		5
		mixed-methods		7
		phenomenological approach		1
		photogrammetry methodology & process	a cheap, flexible and accurate solution to obtain 3D point clouds and textured models. The main advantage of this photogrammetric methodology is that a cloud of points and a precise mesh object with texture can be obtained at the same time (Besoain et al. - 2021 - Developing a Virtual Museum Experience from the D.pdf, P. 8)	226
		post-experience measurement		1
		qualitative		14
		quantitative		6
		quantitative confirmatory approach		1
		Research by Design methodology	Research by Design (RbD) is a transdisciplinary and methodologically distinct method of knowledge production, which involves “knowing through making”. (...) “research by design” also differs radically from a commercially motivated “design practice” because it not only deals with the product but more importantly with the process of its creation as a part of the investigation, which is transferrable	2

			and creates useful knowledge and insights. (kocaturk2023, P. 4)	
		Rovina Paradigm	a Rovina Paradigm to improve: the state of the art in measuring, documentation and classification (and thus indirectly supporting diagnosis activities) through a novel approach to surveying, data management and fruition based on three main components: • DigiRo, an automated robot for collecting data with high-precision sensors, including laser scanners and cameras; • ARIS, the cloud-based Archaeological Information System, to manage, share and elaborate data in the form of photo-realistic and metrically precise 3D models of the explored sites; • Web and VR Visualizers, that allow to virtually navigate the 3D models through a very intuitive interface which also allows for an immersive experience	1
		statistical		2
		triangulations		1
		User Centered Design		7
		user-centered innovation approach		2
		Wittemore & Knaff metodology	five steps: step 1 – identify a framework (i.e., a blueprint for the analysis), step 2 –search the data base for sources, step 3 – filter the sources according to the inclusion cri-teria, step 4 –code the relevant sources according to the framework identified in step 1, and step 5 – aggregate the findings in a detailed QoE model	1
	methods		transparent, qualitative, quantitative, forms of recording	74
		"in the wild"	the phrase "in-the-wild" describes in situ HCI research approaches that report user experience phenomena in everyday living (Rogers & Marshall, 2017). Previous studies have demonstrated that these materials impact the observer in suppressing explicit expressions of bias in controlled laboratory settings. (Young et al. - 2022 - Exploring virtual reality for quality immersive em.pdf, P. 6)	2
		3D graphics interactions		4
		A/B testing		2

		adaptive virtual reality-based training	"the training in which the problem, the stimulus, or task is varied as a function of how well the trainee performs." (Kelley 1969). In order for a training system to be adaptive, it should have three fundamental components: (1) trainee's performance measurement; (2) adaptive variable; and (3) adaptive logic. Performance measures can be collected prior to training (e.g., user's pro-fle information, learning style) or using formative (e.g., monitoring trainee's movement during training and in real time) or summative (e.g., accuracy after each training session) evaluation methods. (Zahabi - 2020, P. 726)	6
		archival research		1
		behavioral methods		2
		bibliometric analysis		8
		body mapping	post-experience evaluation tool	4
		card sorting/tree testing		0
		case study		96
		clickstream/analytics		56
		cognitive methods		2
		cognitive walkthroughs		14
		common method bias	variance infation factors (VIF)	4
		comparative study		10
		comparison		3
		constant comparison	method consists of: (1) data reduction, (2) data display, (3) data comparison, and (4) conclusion drawing and verification	1
		concept maps		7
		concept testing		2
		content analysis		11
		co-word analysis	a content analysis technique, identifies the frequency and co-occurrence of keywords in a literary corpus	1
		context mapping		2
		contextual inquiry	Contextual inquiry is a type of ethnographic field study that involves in-depth observation and interviews of a small sample of users to gain a robust understanding of work practices and behaviours. https://www.nngroup.com/articles/contextual-inquiry/	1

		covariance-based structural equation modelling		1
		critical incident analysis technique		1
		critical literature review	Critical literature review, scientific papers review, publications review, open media analysis	20
		intensive review		1
		MERSQI	Medical education research quality	1
		data analysis		27
		Delphi technique		19
		design methods		34
		design research approach		1
		design thinking		15
		interaction design		6
		desirability studies		0
		desk research		17
		diary method		8
		dULS	Data Use Limitations	1
		elicitation	technique or method or study	21
		ethnographic observational studies		1
		evaluation		10
		heuristic assessment		6
		in-depth evaluation		2
		experience prototyping	Experience prototyping is a group of research methods that focuses on the designers going through prototypes firsthand and taking an active role in understanding or simulating the users' needs to evaluate their design. Most versions ask the designers to roleplay as characters in a scene, using their newfound point of view to experience pain points and gain valuable insight that might have been otherwise missed. https://medium.com/research-methods-group-4/experience-prototyping-d59d69ec943d	1
		experiments		0
		between-subjects experiment	Between-subjects (or between-groups) study design: different people test each condition, so that each person is only exposed to a single user interface	18

				https://www.nngroup.com/articles/between-within-subjects/	
			creative experiment		9
			VR experiment		50
			VR laboratory experiment		4
			within-subjects		11
		expert review		Expert review, also known as expert evaluation or usability inspection, is a method used in UX (user experience) design to assess the usability and overall quality of a product or system. It involves having an experienced evaluator, typically a UX professional, review and analyze the interface based on their expertise and knowledge of usability principles. The goal of an expert review is to identify usability issues and provide actionable recommendations for improving the user experience. It is often conducted during the early stages of the design process to catch potential problems before conducting user testing or making significant design changes. https://medium.com/uxness/what-is-expert-review-in-ux-design-2e3512d767f	9
		exploratory design			1
		field studies		a field study is a type of context research that takes place in the user's natural environment (sometimes referred to as in situ, Latin for "in place") as opposed to a lab or an orchestrated setting. https://www.nngroup.com/articles/field-studies/	41
		focus groups			28
		guerrilla usability testing			1
			guerrilla user testing model		1
		immersive netnography		Immersive netnography is a specific set of data collection, analysis, ethical, and representational research practices that apply to a wide range of digital media phenomena, including immersive technology experiences such as virtual reality, augmented reality, and the Metaverse. (kozinets2022, P. 10)	10

		in-experience UX measurements		11
		interviews		33
		group interview		4
		semistructured interviews		7
		in-depth interviews		2
		laboratory	VR research conducted in laboratory settings	9
		literature and practice review		1
		literature review	critical literature review, scientific papers review, publications review, open media analysis	3
		longitudinal studies		9
		manual modeling		3
		market analysis		10
		Mental Rotation Test		2
		meta-analysis		2
		modelling methods		2
		netnography	"a set of general instructions relating to a specific way to conduct qualitative social media research using a combination of different research practices grouped into three distinct categories of data collection, data analysis, and data interpretation and their six overlapping stages or 'movements'" (Kozinets, 2020, p. 7) emphasizes data and the method's procedural elements and considers the earlier links to ethnography and anthropology inessential.	11
		objectivist deductive method		1
		observation		45
		live observation _ VR goggles		0
		participatory research		8
		participatory design		2
		perspective-taking task	task of writing a diary for the person shown in the image (kembe2022, P. 7)	14
		photo-modelling		18
		physical load	physical ergonomics	1
		physiological methods		10
		ECG	Electrocardiography	2
		EDA	Electrodemal activity	1
		EEG	Electroencephalography	1
		EOG	Electrooculogram	1

				eyetracking		42
				fMRI	functional magnetic resonance imaging	1
				GSR	Galvanic skin response	2
				health-related measurements	VR specific	1
				PPG	Photoplethysmography	2
				real-time kinematic/kinetic data		1
				SKT	Skin temperature	1
			project analysis			2
			public place or event		research conducted in public place or during event	3
			questionnaire (survey)			93
				questionnaires and scales		20
					Absolute Category Rating with Hidden References (ACR-HR)	1
					ATT	Attitude toward technology	2
					AVE	Average variance extracted	11
					BaE	Beliefs about Empathy (BaE) scales relating to empathic concern and perspective-taking on a fully labeled 6-point Likert scale (1 = strongly disagree; 6 = strongly agree)	4
					BI	Behavioural intention	1
					Connectedness to Nature Scale		1
					CR	Composite reliability	3
					dG		1
					discomfort scale	Discomfort is influenced by biomehanical design aspects (pressure point) and is more relevant to the ergonomic designing. It was designed to assess seat comfort.	0
					Engagement with Beauty		1
					FMS	Fast Motion Sickness Scale	3
					FSS	Flow State Scale; is a measure of flow in sport and physical activity settings. The nine FSS scales of the 36-item instrument represent the dimensions of flow, and each scale is measured by four items	2
					HTMT	Heterotrait-Monotrait ratio	3
					IOS	"Inclusion of Other in Self" (IOS) scale - to measure "oneness" as to how close or connected the participants felt	1

					to the protagonist or focus group during the session	
				IQR	median and interquartile range	1
				Likert scale		33
				Nature Relatedness Scale		1
				PANAS	Positive and Negative Affect Schedule	4
				PU	Perceived usefulness	14
				SEA	Scale assessing experienced strain	1
				SRMR	Standarized root mean residual	4
				subscales		1
				hedonic subscales	visual aesthetics, commitment, and status), emotions - positive, negative	0
				System Usability Scale		15
				TA	Technology anxiety	1
				TP	Technology perception	1
				TR	Technology readiness	1
				TSG	Technology for social good	1
			questionnaires and types			11
				ATDPS	Attitude Toward Disabled Persons Survey (ATDPS)	3
				AttrakDiff	a standardized test questionnaire to measure attractiveness of an interactive system divided in three dimensions: Pragmatic Quality (PQ), Hedonic Quality-divided in Stimulus (QH-E) and Identity (QH-I), and Overall attractiveness (ATT). The questionary is composed of 28 items presented as contrasting word pairs [29]. (Dupont et al. - 2023 - Innovative User eXperience approach for the design.pdf, P. 5)	62
				BFI	Big Five Inventory	1
				CCPIG	Competitive and Cooperative Presence in Gaming Questionnaire; cooperative social presence analysis	1
				CSQ	CyberSick-ness Questionnaire	1
				demographics questionnaire		1
				Framework Competence		1
				GEQ	Game Experience Questionnaire	7
				ICT-SOPI	ICT-Sense of Presence Inventory questionnaire	2

				Immersive Tendency Questionnaire		4
				Interaction Preference		1
				Interpersonal Reactivity Index Questionnaire (IRI)	Interpersonal Reactivity Index Questionnaire (IRI)	3
				Lightning Preference		1
				MCQs	Multiple choice questionnaires (MCQs)	1
				meCUE	modular evaluation of key Components of User Experience	40
				MMSQ		1
				Motion Sickness Questionnaire		3
				MSSQ	Motion Sickness Susceptibility Questionnaire	2
				Simulator Sickness Questionnaire		18
				VR motion sickness questionnaire		5
				VRSQ	Ames et al. : Virtual Reality Sickness Questionnaire (VRSQ), specifically intended for use with head mounted displays	8
				NASA - TLX	NASA Task Load Index (NASA-TLX)	19
				PMM	Personal meaning map (Chung et al. - 2024 - Comparison of visitor experiences of virtual reali.pdf, p. 2)	1
				PPM	Positive Personality Measurement; measures the diverse aspects of individuals' conceptualization over time	1
				presence questionnaire		22
				IPQ	Igroup Presence Questionnaire	12
				UCL Presence Questionnaire		1
				Quantic Foundry Gamer Motivation Profile		1
				RIMMS	Reduced Instructional Materials Motivation Survey	5
				SIM - TLX	Simulation Task Load Index	0
				SMEQ	Subjective Mental Effort Questionnaire	1
				Tool Competence Questionnaire		1

				UEQ	User Experience Questionnaire (UEQ)	64
				UTAUT	Unified Theory of Acceptance and Use of Technology Questionnaire	2
				VR UX	Virtual Reality User Experience questionnaire = 8 scales: presence, engagement, immersion, flow, emotion, experience consequences, judgment, technology adoption	3
		recommendations			Recommended methods, mentioned in the publication or mentioned as necessary for application; mentioned in the methodology proposal, but not applied	22
		RITE			Rapid Iterative Testing and Evaluation - RITE is a method that involves updating the prototype after a usability issue surfaces by participants — rather than waiting until the study is complete. https://medium.com/research-methods-2021/rapid-iterative-testing-and-evaluation-rite-d6fecdd9e509	1
		satisfaction test				1
		scenarios				4
		ScientoPy scientometric tool				2
		sensor-based methods				1
			outdoor&indoor			1
		sentiment analysis				17
		Serial Reaction Time (SRT) task			Serial reaction time (SRT) is a commonly used parameter in the measurement of unconscious learning processes. [1] This parameter is operationalised through a SRT task, in which participants are asked to repeatedly respond to a fixed set of stimuli in which each cue signals that a particular response (i.e., button press) needs to be made. https://en.wikipedia.org/wiki/Serial_reaction_time	1
		simulation				2
		snowball method				3
		software development				1
		statistical analysis				47
			hypothesis testing			0
				ANOVA	Analysis of variance	1
				Kruskal-Wallis tests		1
				non-parametric tests		1

					Wilcoxon signed rank test		1
				pwrSEM		is a Shiny web app developed by Y. Andre Wang for power analysis for parameter estimation in structural equation modelling.	1
			model testing				0
				Bartlett's test			1
				Cronbach alpha			2
				MAP		Minimum Average Partial	1
				power analysis		the calculation used to estimate the smallest sample size needed for an experiment, given a required significance level, statistical power, and effect size	1
				Principal Component Analysis			2
		storyboards					2
		storytelling					10
			digital storytelling				6
		systematic review					11
			PRISMA			Preferred Reporting Items for Systematic Reviews and Meta-Analyses	4
		talk-aloud protocol				a related to think-aloud protocol but slightly different data-gathering method. Talk-aloud protocl involves participants only describing their actions but not other thoughts. This method is thought to be more objective in that participants merely report how they go about completing a task rather than interpreting or justifying their actions	13
		target location				moving the study to the target location (i.e., con-ducting a field study) such as a school, or a living space, researchers can avoid the negative impact of artificial laboratory setting on the external validity of the study, therefore achieving a higher level of experimental realism	3
		textCNN				convolutional neural networks for sentence classification (textCNN)	4
		thematic analysis					20
			coding				11
			deductive and inductive				1
		think-aloud-protocol					17
			co-discovery				0
			retrospective				0

			simultaneous (concurrent)		0
		usability benchmarking			0
		user study			6
			remote moderating testing		0
			unmoderated testing		0
			usability testing		10
			user testing		19
			user/customer feedback		2
		visual analysis			3
		Wizard of Oz Method		the Wizard of Oz method is a moderated research method in which a user interacts with an interface that appears to be autonomous but is (fully or partially) controlled by a human. https://www.nngroup.com/articles/wizard-of-oz/	5
		workload analysis			4
			SWAT	the Subjective Workload Assessment Technique (SWAT) is a subjective rating technique using three dimensions (time load, mental effort load, and psychological stress load) and three levels (low, medium, and high) for each dimension to assess workload	1
		workshop		"a workshop is characterized by a group of individuals who have come together with more or less a common goal i.e. to acquire new knowledge, problem solve, brainstorm or innovate. Depending on the size of the group, a workshop is facilitated by a single or multiple facilitators. A workshop removes participants for their everyday contexts and places them in a context that provokes reflection and innovation" https://think.design/user-design-research/workshop/	12

		ZMET	Zaltman metaphor elicitation technique (ZMET) is a market research tool. ZMET is a technique that elicits both conscious and especially unconscious thoughts by exploring people's non-literal or metaphoric expressions. It was developed by Gerald Zaltman at the Harvard Business School in the early 1990s. As Zaltman described it, "A lot goes on in our minds that we're not aware of. Most of what influences what we say and do occurs below the level of awareness. That's why we need new techniques: to get at hidden knowledge-to get at what people don't know they know." The technique has been used by academic researchers and for marketing purposes to study a variety of topics related to both marketing and the social sciences. Zaltman metaphor elicitation technique - Wikipedia	48
	needs			63
	organisation of research			91
		data collection		8
			SMA	Social media analytics	1
		experience phase		3
		limitations		164
		online meeting		1
		post-experience phase		0
		preparation phase		9
			digital objects use		3
		procedure		61
			spiral model	introduced by Boehm [1986]. The spiral model is based on cycles where a prototype is constantly improved and redesigned based on the insights provided by reviews and testing. The roots of such iterative—these days often called “agile”—development go back as far as the 1950s [Larman and Basili 2003]. (Reunanen 2015, P. 5)	1

						waterfall model	defined by Winston W. Royce [1970] in his article “Managing the Development of Large Software Systems.” The stages originally defined by Royce are system requirements, software requirements, analysis, program design, coding, testing, and deployment. Later on, modified versions have been introduced, with a smaller number of stages or different labelling, but the main concept of sequentially proceeding development has remained the same. As noted already by Royce, the waterfall model is rigid by nature and mistakes made at the beginning will propagate to the later stages, possibly requiring costly and time-consuming backtracking. (Reunanen 2015, P. 4)	1
			recruitment				recruitment of users for the study	14
			searching				database searching, screening, theoretical background preparation	3
						keywords	keywords used in the procedure of research, scanning databases, literature & bibliometric analysis	5
			task description					8
			taxonomy design					2
	technology						VR, XR, MUVE etc.	48
			3D models					6
			3D scans					3
			algorithms					5
						eXtreme gradient boosting (XGBoost)	XGBoost, which stands for Extreme Gradient Boosting, is a scalable, distributed gradient-boosted decision tree (GBDT) machine learning library.	2
						Procedural Generation Algorithm Selection		1
						stereo parallax estimation	algorithm using deep learning to construct a mechanism to simulate human eye vision in a virtual reality (VR) environment	4
			AR				augmented reality	44
				AR applications				31
				AR interactions				6
				AR systems				1
			BIM				building information modelling	4
			blockchain					27

		chatbots						2
		CVEs						Collaborative Virtual Environments	3
		drones						0
		games						0
			computer games					44
				exergames				4
				game design				4
				game engines				2
				games engines				1
				persuasive games				a pervasive game is one where the gaming experience is extended out into the real world,[1] or where the fictional world in which the game takes place blends with the physical world. (...) Pervasive games have been associated with ubiquitous games, augmented and mixed reality games, mobile games, alternate reality games, (enhanced) live action role playing, affective gaming, virtual reality games, smart toys, location-based or location-aware games, cross-media games and augmented tabletop games. https://en.wikipedia.org/wiki/Pervasive_game	5
				serious games				a serious game or applied game is a game designed for a primary purpose other than pure entertainment.[1] The "serious" adjective is generally prepended to refer to video games used by industries like defence, education, scientific exploration, health care, emergency management, city planning, engineering, politics and art.[2] Serious games are a subgenre of serious storytelling, where storytelling is applied "outside the context of entertainment, where the narration progresses as a sequence of patterns impressive in quality ... and is part of a thoughtful progress".[3] The idea shares aspects with simulation generally, including flight simulation and medical simulation, but explicitly emphasizes the added pedagogical value of fun and competition. https://en.wikipedia.org/wiki/Serious_game	15
				location-based AR/MR games				1
				VR games				19
		haptic technology						5

		heterotopias	are unique, multilayered epistemic contexts that connect other systems through the exchange of information; Heterotopias is both a digital zine and website, hosting studies and visual essays that dissect spaces of play, exploration, violence and ideology	7
		Immersive technology	technologies that simulate visual, auditory, haptic and motion realities along a Reality-Virtuality continuum	38
		Metaverse	"a massively scaled and interoperable network of realtime rendered 3D virtual worlds that can be experienced synchronously and persistently by an effectively unlimited number of users with an individual sense of presence, and with continuity of data, such as identity, history, entitlements, objects, communications, and payments" (Ball, 2020) - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	364
			Decentraland		2
			Meta Horizon		0
			Mozilla Hubs		0
			Open Simulator		0
			Roblox		4
			Sandbox		0
			Spatial		0
		MMORPGs	Massively multi-player online role-playing games	0
		MR	mixed reality	28
		MUVE		1
			Active Worlds	example from the first generation of virtual environments for multiple users - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	1
			AltSpace VR	example from the second generation of virtual environments for multiple users - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	1
			High Fidelity	example from the second generation of virtual environments for multiple users - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	0
			Rec Room	example from the second generation of virtual environments for multiple users - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	0

			Sansar	example from the second generation of virtual environments for multiple users - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	0
			Second Life	example from the first generation of virtual environments for multiple users - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	56
			SurrealVR	example from the second generation of virtual environments for multiple users - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	0
			Teen Second Life	example from the first generation of virtual environments for multiple users - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	0
			The Sims Online	example from the first generation of virtual environments for multiple users - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	0
			There	example from the first generation of virtual environments for multiple users - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	0
			VRChat	example from the second generation of virtual environments for multiple users - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	83
		software			8
		software development			4
		SVEs		Social Virtual Environments	0
		TDT		Taxonomy of Digital Technology	1
		tools			12
			drones		1
			Google glass		9
			Gravity Sketch	Gravity Sketch is a 3D design and collaboration tool that enables you to create cars, sneakers, furniture, characters and more. If you are a designer or an artist, this is a great tool to easily express your ideas and solve complex design challenges working directly in 3D at any scale. https://store.steampowered.com/app/551370/Gravity_Sketch/	2
			MasterpieceVR	MasterpieceVR is a 3D sculpting and painting tool that is an extension of traditional artistic workflows and opens up new ways for rapid ideation, creation and collaboration in virtual space. Creative professionals and artists can quickly learn to create high-quality 3D content and collaborate with others	3

				from all over the world. https://www.meta.com/pl-pl/experiences/pcvr/361221470668584/	
			Quill	Quill by Smoothstep ("Quill") is a VR illustration and animation tool empowering creators to tell immersive stories. https://quill.art/	1
			RiftArt	a VR tool for supporting the teaching a nd studying of Art History	1
			Tilt Brush	painting app from Google VR	30
			Tvori	create story prototypes such as animatics & previs, prototype XR apps, and make complete animated films https://store.steampowered.com/app/517170/Tvori/	1
			VR headsets		34
		Virtual worlds			1
			Horizon Worlds	a social VR world	1
		volumetric video		Volumetric video (VV) is a media format representing 3D content captured and re-constructed from the real world by cameras and other sensors similarly commonly used in computer graphics (Smolic et al. 2022). (Young et al. - 2023 - Feel the Music!— Audience Experiences of Audio–Tact.pdf, P. 5); "Volumetric capture or volumetric video is a technique that captures a three-dimensional space, such as a location or performance. [1] This type of volumography acquires data that can be viewed on flat screens as well as using 3D displays and VR goggles." https://en.wikipedia.org/wiki/Volumetric_capture	6
		VR			169
			CVEs	Collaborative Virtual Environments	7
				Social Virtual Environments		4
				Virtual Worlds	"VR spaces where thousands of people can interact simultaneously within the same three-dimensional synthetic graphical	9

	context" - IMPULSE Plenary Meeting (1.03.2024), Charitos D.	
Immersive virtual environments (IVEs)		30
virtual heritage	one of the computer-based interactive technologies in virtual reality where it creates a visual representation of monuments, artifacts, buildings and culture to deliver openly to global audiences	18
VR applications		39
VR installation		4
VR systems		6
XR		21
Terminology	more precise definitions of terms in the field of VR, AR, XR; comparison of terms and attempts to organize them	9
tips for using VR/AR/XR	for example, hints on how to apply VR/AR/XR in the creation of museum exhibitions and what to look out for	66
users		48
artists		16
dancers		0
musicians		4
painters		2
sculptors		1
audience	for example, the audience at a music concert	9
children		8
clinicians		1
creative industry		4
design professionals		3
films/movie creators		2
game creators		1
performance creators		3
VR or MUVE creators		0
designers		2
engineers		1
enthusiast		2
experts	persons with extensive, in-depth knowledge and experience in a specific field or area	25
gamers		11
general users		20
metafluencers	current name of influencers in the metaverse	1
non-users		8

			potential users	6
		project managers		1
		scientists		10
		students		33
		teachers		10
	VR experience			316
		abuse&harrasment		1
		barriers		31
		experience economy	the experience economy is the selling of memorable experiences to customers. Coauthors and economists B. Joseph Pine II and James H. Gilmore coined the term "experience economy" in a 1998 article about how the next generation of consumers—millennials—would prefer compelling experiences over products. Pine and Gilmore's article led to their 1998 book, The Experience Economy, followed by the publication of other business books discussing how business models were changing to prioritize exciting in-person and digital experiences. https://www.masterclass.com/articles/experience-economy	3
		flow experience	flow can be defined as the positive experience of complete absorption in an activity, which is both spontaneous and effortless; flow experience can be described following six components: (1) Merging of action and awareness, (2) Centring of attention on a limited stimulus field, (3) Loss of self-consciousness, (4) The feeling of control of one's action and the feeling of control over the demands of the environment, (5) Coherent, non-contradictory demands for ction and clear, unambiguous feedback, and (6) Autotelic nature (no need for external goals or rewards).	6
		immersion		22
		multiple virtual experiences		2
		performance		3
		presence	the feeling of being inside the virtual world; Presence is a theoretical concept describing the extent to which media represent the world (in both physical and social environments).	33

			IPCMCP	Interoceptive Predictive Coding Model of Conscious Presence	5
			self-presence		0
			social presence		8
		technology adoption			3
		UX user experience			15
			CUE	Component model of User Experience	1
			perceived usefulness	defines the extent to which individuals believe that using a particular technology will improve their performance and productivity; it measures how far an individual believes that the use of a particular technology will improve their performance	5
			usability		10
		VR experience design			14
		VR interactions		ways in which educators and learners interact with and consume educational content, DEC (Digital Education Content)	46
			interaction interfaces		10
			VR user behaviours	e.g. information behaviours	5
		VR intervention			1
		VR materiality			2
		VR motivations			7
		VR navigation			9
			locomotion/teleportation		8
		VR perception			33
			FPS	First Person Shooter style	13
			haptic musical experience		7
			haptic senses		0
			telepresence	immersion in virtual reality for different purposes	5
			third-person perspective		12
	VR therapy			therapeutic role of interactions in VR, psychological dimension	12
		VRET		virtual reality exposure therapy	3

5.2 Questionnaires

5.2.1 General Questionnaire for users (Group 1 and Group 2)

Questionnaire for group 1 - students and academics, general, exploratory, educational/didactic dimension included. Anonymous, without prototype, possibly leaving an e-mail address there is the possibility of an invitation to a research experiment (with prototype).
Disseminated in universities - includes group 1 and possibly group 2, as an exploratory survey, in addition to the questionnaire used in the target groups (convenient sample = non-random sampling method).

Introduction to project aims/invitation .....[space to enter text]
Possible consents - processing of information in the project/ consent to the processing of information/data will be required .....[space to enter text]

User Experience with VR – general questionnaire		
Number/section	**Question**	**Cafeteria questions/statements of choice**
0.1. Experience with VR – general questions		
0.1.1	How often do you use VR technology?	[ ] Never - If selected, proceed to the non-user questionnaire. [ ] Rarely (once a year or less) [ ] Occasionally (a few times a year) [ ] Frequently (a few times a month) [ ] Very frequently (weekly or more)
0.1. 2	How would you rate your proficiency with VR technology?	[ ] Beginner (use VR rarely) [ ] Intermediate [ ] Advanced [ ] Expert
0.1. 3	What VR devices have you used before? (Check all that apply)	[ ] Oculus Rift/S [ ] Oculus Quest/Quest 2 [ ] HTC Vive [ ] Valve Index [ ] PlayStation VR [ ] Other (please specify): _____

0.1. 4	What VR platforms do you use most often?	[ ] Spatial [ ] VR Chart [ ] Meta Horizon [ ] Decentraland [ ] Open Simulator [ ] Roblox [ ] Sandbox [ ] not a platform but Unity products [ ] not a platform but WebGL products [ ] Other (please specify): _____
0.1.5	Have you ever encountered any difficulties or barriers while using VR?	[ ] physical symptoms, e.g., headache, dizziness, feeling nauseous [ ] feeling nervous [ ] feeling of embarrassment [ ] weight of VR goggles [ ] technical barriers - lack of a sufficiently powerful computer, lack of an adequate Internet network [ ] economic barriers - lack of finances [ ] lack of knowledge (e.g., how to select VR equipment, how to combine different software and hardware, how to use the equipment) [ ] the requirement to additionally log in to services or platforms and disclose your data [ ] Other (please specify): _____
	VR Tools Preferences	
0.2.1	What type of VR tools do you use in your work? (Check all that apply)	[ ] Physical media (e.g., paint, pencil, clay) [ ] Digital media (e.g., Photoshop, Illustrator) [ ] 3D modeling software (e.g., Blender, Maya) [ ] Mixed media [ ] Other (please specify): _____
0.2.2	How frequently do you collaborate with others in VR environment?	[ ] never [ ] rarely [ ] occasionally [ ] frequently [ ] very frequently
0.2.3	What is the aspect of VR that captivates you the most?	Open -

0.2.4	If you are creatively using VR then have you noticed any issues with importing 2D / 3D content onto VR platforms and/or VR development software / tools?	[ ] any problems [ ] low mesh quality [ ] scanning problems [ ] too large file size [ ] incompatible data formats [ ] data loss during import of 2D/3D objects [ ] incorrect saving of changes on VR side [ ] Other (please specify):_____
0.2.5	What is the average size (area) of the virtual environments you usually enter?	[ ] room-sized [ ] building sized [ ] more expansive [ ] Other (please specify):_____
	Educational dimension	
0.3.1	How do you see VR potential and challenges in your field of study/discipline?	Open question
0.3.2	In your opinion, is VR important or helpful for your studies, task completion, learning, or application among teaching methods?	[ ] Insignificant and not helpful [ ] rather insignificant [ ] Slightly important and helpful [ ] Don't know [ ] Rather important and helpful [ ] Definitely important and helpful
0.3.3	Considering your current methods of study or teaching, how do you think VR could impact collaboration or learning environments?	Open
2. Interface (SUS + meCUE)		
2.1	**Consequences of use (meCUE)**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
2.1.1	If I could, I would use VR environment daily.	-
2.1.2	I would not swap VR environment for any other.	-
2.1.3	I can hardly wait to use VR again.	-
2.1.4	In comparison to VR environment, no others come close.	-

2.1.5	I would get exactly VR environment for myself again at any time.	-
2.1.6	When using VR environment, I lose track of time.	-
3. Space and immersion (CCPIG + iPQ + AttrakDiff-2)		
3.1	**Team Identification (CCPIG [Cooperative Social Presence])**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
3.1.1	I am aware of any members in the virtual environment (VR)	-
3.1.2	I act with other members in mind while navigating virtual space.	-
3.1.3	I consider other members' possible plans and thoughts during interactions.	-
3.1.4	I feel like I was part of a group within the virtual environment.	-
3.1.5	I felt a social connection to other members (camaraderie) in the virtual space.	-
3.2	**Presence in VR space (IPQ)**	
3.2.1	Do you think there are other real people in the virtual environment besides you?	*Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:*
3.2.2	Do you think that there are artificial characters (e.g. computer game opponents) within the virtual environment?	*Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:*
3.2.3	To what extent are you aware of your surroundings in the physical/real world when navigating in the virtual world? (e.g. sounds, room temperature, other people, etc.).	[ ] unaware [ ] rather unaware [ ] don't know [ ] rather aware [ ] definitely aware
3.2.4	How real did the virtual world seem to you?	[ ] unreal [ ] rather unreal [ ] don't know [ ] rather real [ ] definitely real
3.2.5	I usually have a sense of operating in a virtual space rather than operating something from the outside.	*Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:*

3.2.6	Are your experiences in the virtual environment consistent with your experiences in the physical/real world?	[ ] strongly disagree [ ] rather disagree [ ] don't know [ ] rather agree [ ] strongly agree
3.3	**Immersion (Cooperative Social Presence (CCPIG))**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
3.3.1	I do not feel present in virtual space.	-
3.3.2	I am not aware of my physical/real environment.	-
3.3.3	In the computer-generated world, I have a sense of "being there."	-
3.3.4	Somehow, I feel that the virtual world surrounded me.	-
3.3.5	I feel present in virtual space.	-
3.3.6	I still pay attention to the physical/real environment.	-
3.3.7	The virtual worlds seem more realistic than the real world.	-
3.3.8	I feel like I was just perceiving pictures.	-
3.3.9	I am completely captivated by the virtual world.	-
3.3.10	I can freely express my emotions via my avatar.	-
3.3.11	In VR, I can recognize the emotions and intentions of other users at the same level as in the physical world.	-
3.4	**Hedonic Quality - Identification (HQ-I): AttrakDiff-2**	*For each statement, please choose how you usually/often feel about the virtual environment on a scale of 1 to 7*
3.4.1	Isolating - Connective	The VR feels isolating (1) / connective (7)
3.4.2	Unprofessional - Professional	The VR surroundings feel unprofessional (1) / professional (7).
3.4.3	Inventive - Conventional	The VR graphics look inventive (1) / conventional (7).
3.4.4	Tacky - Stylish	The avatars appear usually tacky (1) / stylish (7).
3.4.5	Dull - Captivating	The virtual space seems dull (1) / captivating (7).
3.4.6	Alienating - Integrating	The virtual environment feels alienating (1) / integrating (7).
3.4.7	Unimpressive - Impressive	The virtual environment is unimpressive (1) / impressive (7).

3.4.8	Conventional - Innovative	The virtual environment is conventional (1) / innovative (7).
4. Actors (CCPIG)		
4.1	**Awareness (CCPIG)**	*The Prism of Awareness represents a relevant and reliable test of the coherence of a measurement scale.*
4.1.1	I act in VR with others in mind	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
4.1.2	I react to other users' actions	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
4.1.3	I know what other users are trying to achieve	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
4.1.4	I am aware that other users might work out my goals	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
4.1.5	The actions of other users affect the way I play	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
4.1.6	I feel I am affecting other users' actions/ I feel I have an influence on the actions of other users	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
5. Social Action (CCPIG) in VR environments		
5.1	I feel other VR users are looking out for me	[ ] never [ ] rarely [ ] don't know

		[ ] often [ ] always
5.2	I feel I am contributing to others	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
5.3	I feel others are helping me	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
5.4	I feel my actions make a difference to others	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
5.5	The actions of others affect my thoughts and actions	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
5.6	Other VR users play a significant role in my experience of the game	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
5.7	Other VR users communicate well	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
5.8	Other VR users have a mutual understanding	[ ] never [ ] rarely [ ] don't know [ ] often [ ] always
6.Objects (meCUE + AttrakDiff-2)		

6.1	**User emotions (meCUE)**	*Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:*
6.1.1	Interacting in VR with objects exhilarates me.	-
6.1.2	Interacting in VR with objects makes me tired.	-
6.1.3	Interacting in VR with objects annoys me.	-
6.1.4	Interacting in VR with objects relaxes me.	-
6.1.5	When interacting in VR with objects I feel exhausted.	-
6.1.6	The objects in VR make me feel happy.	-
6.1.7	The objects in VR frustrate me.	-
6.1.8	The objects in VR make me feel euphoric.	-
6.1.9	The objects in VR make me feel passive.	-
6.1.10	The objects in VR calm me.	-
6.1.11	When interacting in VR with objects I feel cheerful.	-
6.1.12	VR objects anger me.	-
6.1.13	What features are most important to you in a creative VR space? (e.g., ease of use, collaboration tools, realistic rendering)	Open
6.1.14	Have you interacted with digitalized cultural heritage objects before? If yes, please describe your experience.	Open
7. Demography/Metrics Questionnaire		
7.1	Age:	[ ] 18-24 [ ] 25-34 [ ] 35-44 [ ] 45-54 [ ] 55-64 [ ] 65 and over [ ] Prefer not to say
7.2	Gender:	[ ] Male [ ] Female [ ] Non-binary/Third gender [ ] Prefer not to say

7.3	Education Level:	[ ] High School [ ] Some College [ ] Associate Degree [ ] Bachelor's Degree [ ] Master's Degree [ ] Doctorate [ ] Prefer not to say
7.4	Field of studies/discipline	Please indicate:_____
7.5 additional, allows the selection of participants for the research stage with a prototype	Enter your email address if you agree to be invited to the rest of the study and to participate in the experiment with the VR environment prototype and data processing.	Please indicate: _____

5.2.2 Questionnaire for non-users

NON-USERS' Questionnaire for group 1 - students and academics as well as group 2 – artists, artistic schools' students. Anonymous, without prototype, possibly leaving an e-mail address there is the possibility of an invitation to a research experiment (with prototype).

Questionnaire to be filled in if a negative answer is given to the question on the use of VR.
It is possible to ask questions without a specific task & scenario.

Disseminated in universities - includes group 1 and art schools/art environment for group 2, as an exploratory survey, in addition to the questionnaire used in the target groups (convenient sample = non-random sampling method).

Introduction to project aims/invitation .....[space to enter text]
Possible consents - processing of information in the project/ consent to the processing of information/data will be required .....[space to enter text]

	Non-Users Questionnaire (General)	
Number/section	**Question**	**Cafeteria questions/statements of choice**
0.1	**Experience with VR**	
0.1.1	How often do you use VR technology?	[ ] Never – if never, questions will be raised like whether they play online games, whether they study together with friends, whether they chat online; what form of online communication do they prefer (apart from social media)
0.1.2	Your role in academic community	[ ] Student [ ] Faculty member
0.1.2a (student)	Apart from social media, how often do you cooperate with other students through online games?	[ ] Never – Non-Virtual Acculturation [ ] Rarely (once a year or less) [ ] Occasionally (a few times a year) [ ] Frequently (a few times a month) [ ] Very frequently (weekly or more)
0.1.2b (scholar)	Apart from social media, how often do you teach in online games virtual environment?	[ ] Never – Non-Virtual Acculturation [ ] Rarely (once a year or less) [ ] Occasionally (a few times a year)

		[ ] Frequently (a few times a month) [ ] Very frequently (weekly or more)
0.1.3a (student)	Have you ever attended online classes that were organized in an online game environment?	*(yes = 1) / (no = -1)*
0.1.3b (student)	If yes:	Please specify: _____
0.1.4	How would you rate your proficiency with online gaming?	[ ] Beginner [ ] Intermediate [ ] Advanced [ ] Expert
0.1.5	What online game have you used in collaborative learning/teaching?	Open (short) Please specify: _____
0.2	**Tools Preferences**	
0.2.1	What type of communication do you use while collaborating with other people? Item 1 – Individual chat (text) Item 2 – Team chat (text) Item 3 – Voice (individual) Item 4 – Voice (team) Item 5 – external channel (e.g. Discord)	[ ] Never [ ] Rarely [ ] Occasionally [ ] Frequently [ ] Very frequently
0.2.2	What are your expectations regarding this game environment for group work?	Open
0.2.3	Do you have any concerns about using an online game environment for personal communication? If so, please specify.	Open
	Section 1. Interface (SUS + meCUE) VR environments/MUVEs	
1	**Task 1.** Imagine that you use online game again for learning/taking classes/teaching…	***Scenario**: During online communication, while looking on the screen, having people around you, how can you relate to the quality of such group activity.*

1.2	**Consequences of use (meCUE)**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
1.2.1	If I could, I would use the product daily.	If I could, I would use this online game environment daily.
1.2.2	I would not swap this product for any other.	I would not swap this online game environment for any other.
1.2.3	I can hardly wait to use the product again.	I can hardly wait to use this online game environment again.
1.2.4	In comparison to this product, no others come close.	In comparison to my favorite online game environment, no others come close.
1.2.5	When using the product, I lose track of time.	When using this online game environment, I lose track of time.
	Section 2. Space and immersion (CCPIG + iPQ + AttrakDiff-2)	
2	**Task 2.** Let's say you need to communicate with the group.	***Scenario****: Using your preferable channel of communication, being gathered in one place, making pauses for game action*
2.1	**Team Identification (CCPIG [Cooperative Social Presence])**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements.***
2.1.1	I was aware of my team	I was aware of my group members near me in the virtual environment.
2.1.2	I acted with my team-mates in mind	I acted with my group members in mind while being separated around the map.
2.1.3	I considered my team-mates' possible plans/thoughts	I considered my group members' possible ideas and thoughts during our interactions.
2.1.4	I felt like I was part of a team	I felt like I was part of a group within the virtual environment.
2.1.5	I felt a social connection to my team-mates (camaraderie)	I felt a social connection to my group members (camaraderie) in the virtual space.
2.4	**Hedonic Quality - Identification (HQ-I): AttrakDiff-2**	***For each statement, please choose how you feel about the online game environment on a scale of -1 to 1, where: 1 = Good property/ 0 = Don't know / -1 = Bad property***
2.4.1	Isolating - Connective	The virtual room feels isolating (-1) / connective (1).
2.4.2	Unprofessional - Professional	The surroundings feel unprofessional (-1) / professional (1).
2.4.3	Cheap - Premium	The graphics look cheap (-1) / premium (1).
2.4.4	Tacky - Stylish	The avatars appear tacky (-1) / stylish (1).
2.4.5	Dull - Captivating	The virtual space seems dull (-1) / captivating (1).
2.4.6	Alienating - Integrating	The virtual environment feels alienating (-1) / integrating (1).

2.4.7	Unimpressive-Impressive	The virtual environment is unimpressive (-1) / impressive (1).
2.4.8	Conventional - Innovative	The virtual environment is conventional (-1) / innovative (1).
	Section 3. Actors (CCPIG)	
3	**Task 3.** Considering the online game environment as virtual learning/teaching space	***Scenario**: When seeking help or asking questions in group…*
3.1	**Social Action (CCPIG)**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
3.1.1	I felt my team-mates were looking out for me	I felt my group members were looking out for me.
3.1.2	I felt I contributed to the team	I felt I contributed to the group.
3.2.3	I felt the team helped me	I felt the group helped me.
3.1.4	I felt my actions made a difference to my team-mates	I felt my actions made a difference to my group members.
3.1.5	The actions of my team-mates affected my thoughts and actions	The actions of my group members affected my thoughts and actions.
3.1.6	My team-mates played a significant role in my experience of the game	My group members played a significant role in my experience of the virtual environment.
3.1.7	My team communicated well	My group communicated well.
3.1.8	The team had a mutual understanding	The group had a mutual understanding.
	Section 4. Avatar embodiment (optional)	
4	**Task 4.** Try to remember your avatar from games or groups meetings	***Scenario**: Steering avatar in group meeting on screen gives you any feeling about connection or sense of presence in a group?*
4.1	**External appearance and response to external stimuli**	
4.1.1	4.1.1 - If the virtual body is not collocated with the participants' body:	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
4.1.2	I felt as if my (real) mind were drifting toward the virtual avatar or as if the virtual avatar were drifting toward my (real) mind.	-
5.	What features are most important to you	Open

	in a virtual online game space? (e.g., ease of use, communication tools, realistic rendering)	
6.	Have you enjoyed taking a break and playing with teammates? If yes, please describe your experience.	Open
	Metrics questions	
7	Section 7. Demographic Information	
7.1	Age:	[ ] 18-24 [ ] 25-34 [ ] 35-44 [ ] 45-54 [ ] 55-64 [ ] 65 and over [ ] Prefer not to say
7.2	Gender:	[ ] Male [ ] Female [ ] Non-binary/Third gender [ ] Prefer not to say
7.3	Education Level:	[ ] High School [ ] Some College [ ] Associate Degree [ ] Bachelor's Degree [ ] Master's Degree [ ] Doctorate [ ] Prefer not to say
7.4	field of study/discipline	Open

5.2.3 Questionnaire with experiment and prototype usage

Questionnaire for group 2 - of art students and academics in art schools, artists (G2) and selected active users from the group of students and academic teachers (G1), as well as a group of experts willing to participate in this phase of the research (group would be selected from G1&G2). This questionnaire can be used within G3 users if they accept the invitation and are interested in participating in the experiment using the prototype. The questionnaire includes the selected and expected VR UX dimensions. Anonymous, with prototype, based on a research experiment (with prototype).

The general questionnaire for G1&G2 will be distributed in art schools, among artists (G2) and also at selected universities, departments and institutes (G1). The initial stage questionnaire will be employed for the purpose of identifying active users and experts to be invited to participate in the subsequent phase of research. This will be conducted on the basis of email contact information provided by respondents to the survey and invitations sent out. The second survey will be conducted in conjunction with the prototype and the experiment, comprising three stages or phases. These are: before the experiment, during the experiment (based on tasks and scenarios) and after the experiment. It can be used in addition to case studies/prolegomena for retrospective think-aloud protocols., in addition to the questionnaire used in the target groups (convenient sample = non-random sampling method).

Introduction to project aims/invitation .....[space to enter text]
Possible consents - processing of information in the project/ consent to the processing of information/data will be required .....[space to enter text]

	Pre-Experiment Questionnaire	
Number/section	**Question**	**Cafeteria questions/statements of choice**
0.1	**Experience with VR**	
0.1.1	How often do you use VR technology?	[ ] Never [ ] Rarely (once a year or less) [ ] Occasionally (a few times a year) [ ] Frequently (a few times a month) [ ] Very frequently (weekly or more)
0.1.2	How would you rate your proficiency with VR technology?	[ ] Beginner [ ] Intermediate [ ] Advanced [ ] Expert

0.1.3	What VR devices have you used before? (Check all that apply)	[ ] Oculus Rift/S [ ] Oculus Quest/Quest 2 [ ] HTC Vive [ ] Valve Index [ ] PlayStation VR [ ] Other (please specify): _____
0.2	**Artistic Tools Preferences**	
0.2.1	What type of artistic tools do you use in your work? (Check all that apply)	[ ] Traditional media (e.g., paint, pencil, clay) [ ] Digital media (e.g., Photoshop, Illustrator) [ ] 3D modeling software (e.g., Blender, Maya) [ ] Mixed media [ ] Other (please specify): _____
0.2.2	How frequently do you collaborate with other artists?	[ ] Never [ ] Rarely [ ] Occasionally [ ] Frequently [ ] Very frequently
0.2.3	What are your expectations from this VR environment experiment?	
0.2.4	Do you have any concerns about using VR technology? If so, please specify.	
0.2.5	What are your main motivations for choosing XR (VR, AR or immersive experiences) over analogue media for your artworks?	[ ] Creating immersive experiences that are not possible with traditional media [ ] Engaging audiences through interactive art [ ] Experimenting with new forms of expression [ ] Collaboration with other artists in a shared virtual space [ ] Other (please specify):_____
0.2.6	How does the use of XR (VR, AR, or immersive experiences) influence your perception of space and dimensions in your artwork?	[ ] Significantly enhances [ ] Slightly enhances [ ] No influence [ ] Slightly diminishes

		[ ] Significantly diminishes
	Experiment Questionnaire (with prototype)	
Sequence	*Original wording*	*Adjusted wording*
Step	**Section 1. Interface (SUS + meCUE)**	
1	**Task 1.** Before we start…	***Scenario**: You are in a virtual environment where you can interact with various digital cultural heritage objects. Your task is to change the tool you are using. For instance, switch from a paintbrush to a sculpting tool, make some adjustments to the environment, and then turn a specific feature on and off.*
1.1	**System Usability evaluation (Cecotti et al., 2020)**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
1.1.1	I think that I would like to use this feature frequently.	I think that I would like to use the main menu frequently.
1.1.2	I found the feature unnecessarily complex.	I found navigating the main menu unnecessarily complex.
1.1.3	I think that I would need the support of a technical person to be able to use this feature.	I think that I would need the support of a technical person to change the environment settings.
1.1.4	I thought the various functions in this feature were well integrated.	I thought the various functions for tool selection were well integrated.
1.1.5	I thought there was too much inconsistency in this feature.	I thought there was too much inconsistency in the tool selection feature.
1.1.6	I would imagine that most people would learn to use this feature very quickly.	I would imagine that most people would learn to use the environment settings very quickly.
1.1.7	I found the feature very cumbersome to use.	I found changing the control settings very cumbersome to use.
1.1.8	I felt very confident using the feature.	I felt very confident using the control settings feature.
1.1.9	I needed to learn a lot of things before I could get going with this feature.	I needed to learn a lot of things before I could get going with the interface.
	Section 2. Space and immersion (CCPIG + iPQ + AttrakDiff-2)	

2	**Task 2.** Before we start…	***Scenario**: You are in a multi-user virtual environment (MUVE) designed to resemble a museum or an exhibition space. As you navigate through different sections, you interact with various digital cultural heritage objects and other virtual participants. You will explore different rooms, each with unique themes and environmental settings. Your tasks include observing the environment, interacting with both real and artificial characters, and using various tools and features within space. Throughout the process, pay attention to your sense of presence and immersion in the virtual environment.*
2.1	**Team Identification (CCPIG [Cooperative Social Presence])**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
2.1.1	I was aware of my team	I was aware of my group members in the virtual environment.
2.1.2	I acted with my team-mates in mind	I acted with my group members in mind while navigating the virtual space.
2.1.3	I considered my team-mates' possible plans/thoughts	I considered my group members' possible plans and thoughts during our interactions.
2.1.4	I felt like I was part of a team	I felt like I was part of a group within the virtual environment.
2.1.5	I felt a social connection to my team-mates (camaraderie)	I felt a social connection to my group members (camaraderie) in the virtual space.
2.3	**Immersion (Cooperative Social Presence (CCPIG))**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
2.3.1	I did not feel present in the virtual space.	I did not feel present in the virtual space.
2.3.2	I was not aware of my real environment.	I was not aware of my real environment.
2.3.3	In the computer-generated world, I had a sense of "being there."	In the computer-generated world, I had a sense of "being there."
2.3.4	Somehow, I felt that the virtual world surrounded me.	Somehow, I felt that the virtual world surrounded me.
2.3.5	I felt present in the virtual space.	I felt present in the virtual space.
2.3.6	I still paid attention to the real environment.	I still paid attention to the real environment.
2.3.7	The virtual world seemed more realistic than the real world.	The virtual world seemed more realistic than the real world.

2.3.8	I felt like I was just perceiving pictures.	I felt like I was just perceiving pictures.
2.3.9	I was completely captivated by the virtual world.	I was completely captivated by the virtual world.
2.4	**Hedonic Quality - Identification (HQ-I): AttrakDiff-2**	***For each statement, please choose how you feel about the virtual environment on a scale of 1 to 7, where: 1 = left impression = 7 = right impression, e.g. 1 = Isolating = 7 = Connective***
2.4.1	Isolating - Connective	The virtual room feels isolating (1) / connective (7).
2.4.2	Unprofessional - Professional	The surroundings feel unprofessional (1) / professional (7).
2.4.3	Cheap - Premium	The graphics look cheap (1) / premium (7).
2.4.4	Tacky - Stylish	The avatars appear tacky (1) / stylish (7).
2.4.5	Dull - Captivating	The virtual space seems dull (1) / captivating (7).
2.4.6	Alienating - Integrating	The virtual environment feels alienating (1) / integrating (7).
2.4.7	Unimpressive - Impressive	The virtual environment is unimpressive (1) / impressive (7).
2.4.8	Conventional - Innovative	The virtual environment is conventional (1) / innovative (7).
	Section 3. Actors (CCPIG)	
3	**Task 3.** Before we start…	***Scenario**: with mirror….*
3.1	**Awareness (CCPIG)**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
3.1.1	I acted with my opponents in mind	I acted with my fellow artists in mind.
3.1.2	I reacted to my opponents' actions	I reacted to the actions of other artists.
3.1.3	I knew what my opponents were trying to achieve	I knew what the other artists were trying to achieve.
3.1.4	I was aware that my opponents might work out my goals	I was aware that other artists might understand my goals.
3.1.5	The actions of my opponents affected the way I played	The actions of other artists affected the way I worked.
3.1.6	I felt I affected my opponents' actions	I felt I influenced the actions of other artists.
	Section 4. Objects (meCUE + AttrakDiff-2)	
4	**Task 4.** Before we start…	***Scenario:**..*

4.1	**User emotions (meCUE)**	*Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:*
4.1.1	The product exhilarates me.	Interacting with objects exhilarates me.
4.1.2	The product makes me tired.	Interacting with objects makes me tired.
4.1.3	The product annoys me.	Interacting with objects annoys me.
4.1.4	The product relaxes me.	Interacting with objects relaxes me.
4.1.5	When using this product, I feel exhausted.	When interacting with these objects, I feel exhausted.
4.1.6	The product makes me feel happy.	The objects make me feel happy.
4.1.7	The product frustrates me.	The objects frustrate me.
4.1.8	The product makes me feel euphoric.	The objects make me feel euphoric.
4.1.9	The product makes me feel passive.	The objects make me feel passive.
4.1.10	The product calms me.	The objects calm me.
4.1.11	When using this product, I feel cheerful.	When interacting with these objects, I feel cheerful.
4.1.12	The product angers me.	The objects anger me.
	Section 5. Actions (NASA-TLX + AttrakDiff-2 + FSS)	
5	**Task 5.** Before we start…	***Scenario**: ….*
5.2	**Flow Short Scale (FSS)**	*Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:*
5.2.1	I feel just the right amount of challenge (ABA)	I feel just the right amount of challenge.
5.2.2	My thoughts/activities run fluidly and smoothly (FP)	My thoughts/activities run fluidly and smoothly.
5.2.3	I do not notice time passing (ABA)	I do not notice time passing.
5.2.4	I have no difficulty concentrating (FP)	I have no difficulty concentrating.
5.2.5	My mind is completely clear (FP)	My mind is completely clear.
5.2.6	I am totally absorbed in what I am doing (ABA)	I am totally absorbed in what I am doing.
5.2.7	The right thoughts/movements occur of their own accord (FP)	The right thoughts/movements occur of their own accord.
5.2.8	I know what I have to do each step of the way (FP)	I know what I have to do each step of the way.
5.2.9	I feel that I have everything under control (FP)	I feel that I have everything under control.
5.2.10	I am completely lost in thought (ABA)	I am completely lost in thought.
	Post-experiment Questionnaire	

Section 6. Interface (SUS + meCUE)		
6.1	**Consequences of use (meCUE)**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
6.1.1	If I could, I would use the product daily.	If I could, I would use this VR environment daily.
6.1.2	I would not swap this product for any other.	I would not swap this VR environment for any other.
6.1.3	I can hardly wait to use the product again.	I can hardly wait to use this VR environment again.
6.1.4	In comparison to this product, no others come close.	In comparison to this VR environment, no others come close.
6.1.5	I would get exactly this product for myself (again) at any time.	I would get exactly this VR environment for myself again at any time.
6.1.6	When using the product, I lose track of time.	When using this VR environment, I lose track of time.
	Section 7. Space and immersion (CCPIG + iPQ + AttrakDiff-2)	
7.2	**Presence in VR space (IPQ)**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
7.2.1	Were there other real people within the virtual environment besides yourself?	Were there other artists within the virtual environment besides yourself?
7.2.2	Were there artificial characters (e.g. computer game opponents) within the virtual environment?	Were there artificial characters (e.g., extras, virtual assistants or NPCs) within the virtual environment?
7.2.3	How aware were you of the real world surrounding while navigating in the virtual world? (i.e. sounds, room temperature, other people, etc.)	How aware were you of the real-world surroundings while navigating in the virtual world? (e.g., sounds, room temperature, other people)
7.2.4	How real did the virtual world seem to you?	How real did the virtual art studio seem to you?
7.2.5	I had a sense of acting in virtual space, rather than operating something from outside.	I had a sense of creating art within virtual space, rather than operating tools from the outside.
7.2.6	How much did your experience in the virtual environment seem consistent with your real-world experience?	How much did your experience in the virtual art studio seem consistent with your real-world experience in an art studio?
7.2.7	How real did the virtual world seem to you?	How real did the virtual environment feel to you?
	Section 8. Actors (CCPIG)	

8.1	**Social Action (CCPIG)**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
8.1.1	I felt my team-mates were looking out for me	I felt my group members were looking out for me.
8.1.2	I felt I contributed to the team	I felt I contributed to the group.
8.1.3	I felt the team helped me	I felt the group helped me.
8.1.4	I felt my actions made a difference to my team-mates	I felt my actions made a difference to my group members.
8.1.5	The actions of my team-mates affected my thoughts and actions	The actions of my group members affected my thoughts and actions.
8.1.6	My team-mates played a significant role in my experience of the game	My group members played a significant role in my experience of the virtual environment.
8.1.7	My team communicated well	My group communicated well.
8.1.8	The team had a mutual understanding	The group had a mutual understanding.
	Section 9. Objects (meCUE + AttrakDiff-2)	
9.1	**4.2 Interaction with the object AttrakDiff-2 [Hedonic Quality - Stimulation (HQ-S)]**	***For each statement, please choose how you feel about the virtual environment on a scale of 1 to 7, where 1 = left impression = 7 = right impression, e.g. 1 = Conservative 7 = Creative***
9.1.1	Conservative - Creative	The objects feel conservative (1) / creative (7).
9.1.2	Conventional - Inventive	The objects feel conventional (1) / inventive (7).
9.1.3	Unimaginative - Creative	The objects feel unimaginative (1) / creative (7).
9.1.4	Cautious - Bold	The objects feel cautious (1) / bold (7).
9.1.5	Ordinary - Innovative	The objects feel ordinary (1) / innovative (7).
	Section 10. Actions (NASA-TLX + AttrakDiff-2 + FSS)	
10.1	**Psychophysical demand x [Pragmatic Quality (PQ)**	***For each statement, please choose how you feel about the virtual environment on a scale of 1 to 7, where: 1 = left impression = 7 = right impression, e.g. 1 = Confusing = 7 = Clearly structured***

10.1.1	How mentally demanding was the task? [Confusing - Clearly structured]	The task was confusing (1) / clearly structured (7).
10.1.2	How physically demanding was the task? [Complicated - Simple]	The task was complicated (1) / simple (7).
10.1.3	How hurried or rushed was the pace of the task? [Unruly - Manageable]	The task was unruly (1) / manageable (7).
10.1.4	How successful were you in accomplishing what you were asked to do? [Cumbersome - Efficient]	The task was cumbersome (1) / efficient (7).
10.1.5	How hard did you have to work to accomplish your level of performance? [Confusing - Clearly structured]	The task was difficult (1) / easy (7).
10.1.6	How insecure, discouraged, irritated, stressed, and annoyed were you? [Unpredictable - Predictable]	The task was stressful (1) / relaxing (7).
	Section 11. Avatar embodiment (optional)	
11.1	**Body ownership.**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
11.1.1	I felt as if the virtual body I saw when I looked down was my body	-
11.1.2	It felt as if the virtual arm I saw was someone else	-
11.1.3	It seemed as if I might have more than one body	-
11.1.4	I felt as if the avatar I saw when looking in the mirror was my own body.	-
11.1.5	I felt as if the virtual me I saw when looking at myself in the mirror was another person	-
11.2	**Agency and motor control.**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
11.2.1	It felt like I could control the virtual tool as if it was in my own hand	-
11.2.2	The movements of the virtual pointer were caused by my movements	-
11.2.3	I felt as if the movements of the virtual legs were influencing my own movements	-

11.2.4	I felt as if the avatar was moving by itself	-
11.3	**External appearance.**	***Do you agree (yes = 1) / disagree (no = -1) / don't know (0) with the following statements:***
11.3.1	It felt as if my (real) head were turning into an 'avatar' head	-
11.3.2	At some point it felt as if my real body was starting to take on the posture or shape of the virtual body that I saw	-
11.3.3	At some point it felt that the virtual face resembled my own (real) face in terms of shape, skin tone or other visual features.	-
11.3.4	I felt like I was wearing different clothes from when I came to the laboratory	-
11.3.5	6.4 Response to external stimuli.	-
11.3.6	I felt that my own hearing could be affected by virtual environment' sounds	-
11.3.7	I felt a comforting sensation in my body when I heard [sound]	-
11.3.8	When opera/immersion started, I felt the instinct to look for sound source	-
11.3.9	I felt as if my ____had ____"	-
11.3.10	I had the feeling that I might be harmed by the falling objects surrounding me	-
11.4.11	If the virtual body is not collocated with the participants' body:	-
11.4.12	I felt as if my (real) ____were drifting toward the virtual ____or as if the virtual ____were drifting toward my (real) ____	-
11.5	What features are most important to you in a creative VR space? (e.g., ease of use, collaboration tools, realistic rendering)	Open
11.6	Have you interacted with digitalized cultural heritage objects before? If yes, please describe your experience.	Open

	Section 12. Demographic Information	
12.1	Age:	[ ] 18-24 [ ] 25-34 [ ] 35-44 [ ] 45-54 [ ] 55-64 [ ] 65 and over [ ] Prefer not to say
12.2	Gender:	[ ] Male [ ] Female [ ] Non-binary/Third gender [ ] Prefer not to say
12.3	Education Level:	[ ] High School [ ] Some College [ ] Associate Degree [ ] Bachelor's Degree [ ] Master's Degree [ ] Doctorate [ ] Prefer not to say
12.4	Artistic specialization	Please specify: _____

5.3 Scheme of Interviews

5.3.1 Scheme of interview for IMPULSE users (experts selected from G1 & G2 as well as G3)

1. What kind of VR platforms (e.g. Spatial) and tools (e.g. VR goggles) are you using in your work?
1.1. What type of VR are you mostly using? [e.g. Immersive with HMD, projection-based, desktop?]
1.2. Which (specific) hardware are you using? e.g. specific HMD, or phone (if accessing VR content through mobile phone)?
1.3. Have you used / are you currently using multi-user games (e.g.. MMORPGs) or multi-user social virtual worlds (e.g. Second Life or similar platforms)?
1.4. What mode of interaction (in VR) do you find most convenient or inconvenient (e.g. handheld controllers, hand tracking and gaze-based systems)?

2. From your perspective: what are the advantages and disadvantages of those VR platforms and tools that you mentioned in terms of your artistic needs?
2.1. In what ways is VR useful in your field? For which types of tasks do you find VR well- and/or ill-suited? In what ways is it preferable to work with more conventional interfaces?
2.2. Do you experience adverse effects when using VR? How often? How severe?
2.3. What is the aspect of VR that captivates you the most?

3. Do you use VR mainly to inspect cultural heritage content (or other types of content) or do you also interact with / transform / manipulate the content? If you interact with the content, what type of interaction do you usually engage in?

4. Do you notice any issues related to importing 2D / 3D content onto VR platforms and/or VR development software / tools?

5. What is the average size (area) of the virtual environments you usually enter? (e.g. room-sized, building-sized, more expansive)?

*[IF NOT USING VR] Why have you not been interested in using VR up till now? [not applicable if the audience are VR experts]

Specific questions based on previous observations (will vary depending on who the user is):
1. <space to fill>
2. <space to fill>
3. <space to fill>

5.3.2 Scheme of Interviews with academics, artists and non-users

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)

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: _____

(General non-users, G1&G2) 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? [**artists**] How do you incorporate VR/XR technologies into your artistic practice?	**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? - 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?	**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:**

	[artists] How do VR and XR offer unique opportunities for artistic experimentation that other media do not?	- 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	**Goal**: Elicit thoughts on the transformative potential of VR in educational settings.

	VR could impact collaboration or learning environments? How do you see its potential and challenges?	**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?	

5.4 Scheme of Observations

<specify date in format DDMMYYYY>, observation point: <space to fill>, observation code: <space to fill>,
start time: <space to fill>, end time: <space to fill>

1. **EVENTS:**
1.1. Type of VR event, e.g. VR opera, VR performance, VR museum exhibition
1.2. rehearsal for type of event
1.3. lecture
1.4. conference paper
1.5. workshop on <space to fill>

2. **SPACE**
2.1. VR SPACE
2.1.1. general level: Spatial / single VR / multi-user VR / <space to fill>
2.1.2. details of virtual setting (e.g. classroom / concert hall on the beach / amphitheatre) / <space to fill>

2.2. "reality" SPACE
2.2.1. indoors? - where: <space to fill>
2.2.2. outdoors? - where: <space to fill>

3. **ACTORS**
3.1. musicians - how many: <space to fill>
3.2. singers - how many: <space to fill>
3.3. dancers - how many: <space to fill>
3.4. conductor - how many: <space to fill>
3.5. audience - how many: <space to fill>
3.6. <space to fill> - how many: <space to fill>
3.7. <space to fill> - how many: <space to fill>

observers without VR goggles: <space to fill>

4. **OBJECTS**
4.1. in VR
4.1.1. sculptures?
4.1.2. paintings?
4.1.3. musical instruments?
4.1.4. paints?

4.1.5. brushes?
4.1.6. landmarks?
4.1.7. others?
4.1.8. other elements of the world that can be interacted with, e.g. benches, chairs, stairs, doors?

4.2. in "reality
4.2.1. VR goggles?
4.2.2. controllers?
4.2.3. pads?
4.2.4. haptic gloves?
4.2.5. treadmills?
4.2.6. steering wheels?
4.2.7. moving seats?
4.2.8. regular chairs/seats?
4.2.9. <space to fill>

5. **ACTIVITIES**
5.1. Communication between VR users - does it occur? If so, how do VR users communicate?

5.2. Use of information and virtual tools by VR users - does it occur? If so, in what ways, with what tools, with what information and when? Is the use of tools and information easy/intuitive, does it require focus and time, does it cause users problems to the extent that users repeat the action or abandon the idea of the activity?

5.3. interactions with objects, e.g. lifting a vase, pouring paint on a sculpture, zooming in or rotating an object in space, touching piano keys, waving a baton, stopping at an object, no interaction with objects other than viewing them according to a script (as in the Van Gogh exhibition)

5.4. VR user's mode of movement
5.4.1. in VR space: 1. walking, 2, flying, 3. teleportation, 4. 'rollercoaster', 5. <space to fill>;
5.4.2. in physical space: 1. moving (walking, bending, jumping, etc.) in a designated space, without the use of additional equipment; 2. moving on a treadmill or with the help of other equipment; 3. no movement other than, for example, moving the head and turning on a chair
5.5. <space to fill>

6. **TIME** - to link with activities / acts and actors + objects
(1), (2) - consecutive events
(1-), (1-) - simultaneous events

(1) <ACTORS> - <ACTIVITIES> - <ACTORS><OBJECTS> - (2) <ACTORS> - <ACTIVITIES> - <ACTORS><OBJECTS>

*. CUTTING OFF, IMMERSION, EMBODIMENT
*.1. how does it occur?
*.2. which of the user's senses are cut off from the outside world and redirected to VR?
*.3. what are the reactions of the VR user? (this is more for an interview, if possible)

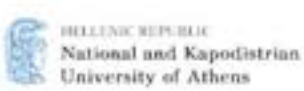
GOALS and FEELINGS to be marked at ACTIVITIES and TIME dimensions + to be checked during a possible interview

7. **GOALS** (what actors/users are attempting to accomplish)
7.1. <space to fill>
7.2. <space to fill>
7.3. <space to fill>

8. **FEELINGS** (emotions in particular contexts)
8.1. <space to fill>
8.2. <space to fill>
8.3. <space to fill>

IMPULSE

IMmersive digitisation: uPcycling cULtural heritage towards new reviving StratEgies



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