



Mixed Reality Experiences for Social Impact

A Design & Development Framework

Mariza Dima, Brunel University of London
Damon Daylamani-Zad, Brunel University of London
Vangelis Lypmouridis, Enosis VR

Mixed Reality Experiences for Social Impact: A Design and Development Framework

This design and development framework is proposed as a comprehensive method for creating immersive experiences for social impact. It focuses on the involvement of additional stakeholders such as cultural, arts and government organisations, and communities in the design and development process of socially impactful digitally mediated immersive experiences under the approach of **“the world as a stage”**. The framework consists of 4 phases meant to be done in the suggested order: **Preparation, Design, Production, and Monitoring the Performance.**

“The world as a stage” metaphor views experience design and performance as a process and practice that blurs the lines between life and digitally mediated experience. Borrowing concepts, roles, and methods from theatre and performing arts strengthens the use of storytelling, emphasises the audience's participatory and (inter)active role, and highlights the importance of physical space in developing these new experiences.





The framework consists of 4 project development phases meant to be done in the suggested order. The Preparation Phase involves team building and decision making on the collaborative processes and is a fundamental step to ensure a seamless collaborative design. The Design Phase offers a guide on how to bring the vision shaped in the Preparation Stage to action, adding important decision-makers to the group, and polishing details of the final experience. Then, the technical side and systems architecture needs to be carefully set up before development takes place. The development of these digitally mediated physical experiences concerns an emerging hybrid living environment, where Internet of Things (IoT) devices, smart sensors, and peripherals, distributed computer systems, humans, robots, and AI, need to coexist, coordinate, and collaborate towards matching the user's or the system's intent within a specific context of use. The Production Phase includes directions to dealing with this complexity, and in-situ design decisions. Finally, Monitoring the Performance Phase offers support for capturing challenges and opportunities and reflecting on how the design can be improved.

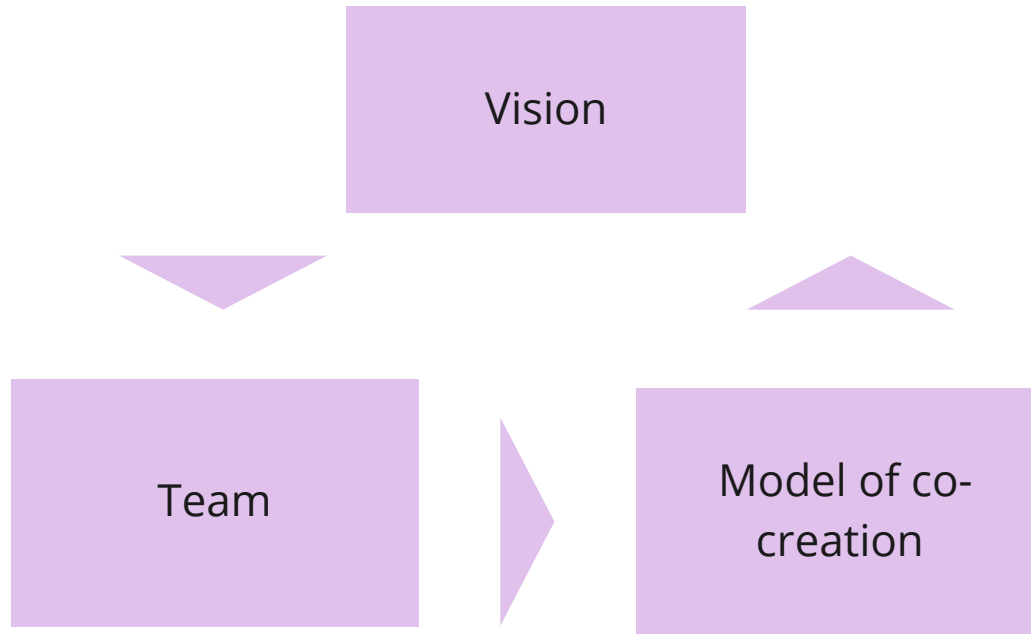
The design of Mixed Reality Reality experiences (MR) is a complex process that involves several disciplines, required to combine methods and expertise from different domains to produce a well-rounded, meaningful experience. The relevant research field has produced a handful of design methodologies, approaches, and toolkits to guide the design process. This framework is an addition to the existing, growing discussion around design and development processes and guidelines.

The framework was put together as a result of the design and development process of two world-first MR live theatre performances in the UK and US as part of an international collaborative research project funded by the AHRC in the UK and the National Endowment for Humanities in the US in collaboration with UK and US Heritage organisations under the scheme of New Directions for Digital Scholarship in Cultural Institutions. ‘Jin’s Dream’ and ‘Sancho’s Journey’ are two MR experiences that fuse smart AR glasses and live theatre and take place in a heritage site for small groups of visitors. We named these MR Heritage Performances (MRHP). The research project under which these MRHPs were designed and developed explored the frontiers of using MR technology and live theatre as a novel way to engage audiences in a theatrical story-driven participatory experience under specific concepts, in this instance, ones that challenge colonial narratives. The research and the developed cutting-edge live performances for social impact brought to light complex stories of the 18th-century transatlantic slave trade in two distinct historic sites on both sides of the Atlantic, London, and New England. The project further investigated the impact of these performances on audience engagement and learning, as well as the challenges and opportunities that immersive technology-supported experiences bring to heritage sites. The perplexed collaborative process between different disciplines, stakeholders, communities, and institutions required the development of a new, appropriate co-creation model, a unique system for production and development, and a novel framework for the interaction design of similar experiences. We have distilled our process into several outputs, one of which is the one you are reading now which focuses on immersive experience design and development.

Mariza Dima, Damon Daylamani-Zad, Vangelis Lympouridis

Contents

	1 Preparation	4
	1.1 Shape vision, impact and outcomes	5
	1.2 Build team and working methodology	8
	1.3 Shape a shared model of co-creation	11
	2 Design	14
	2.1 Bring Vision to Action	15
	2.2 Assemble Experts, Stakeholders & Focus Groups	18
	2.3 Design the experience	21
	3 Production	24
	3.1 Design technical infrastructure	25
	3.2 Set the Stage	28
	3.3 Conduct Technical Rehearsals	31
	4 Performance	34
	4.1 Monitor the experience	35
	Authors	38



1 PREPARATION

Preparation

Shape vision, impact and outcomes

Concept, Context and Content (the three Cs) are important tools in setting a solid foundation for your project. This diagram can be used as a starting point for project ideation. The sentence that is formed helps define the scope, goal(s) and outcome and becomes the compass across the development of the project. Create many of these based on multiple perspectives and select the best fit.

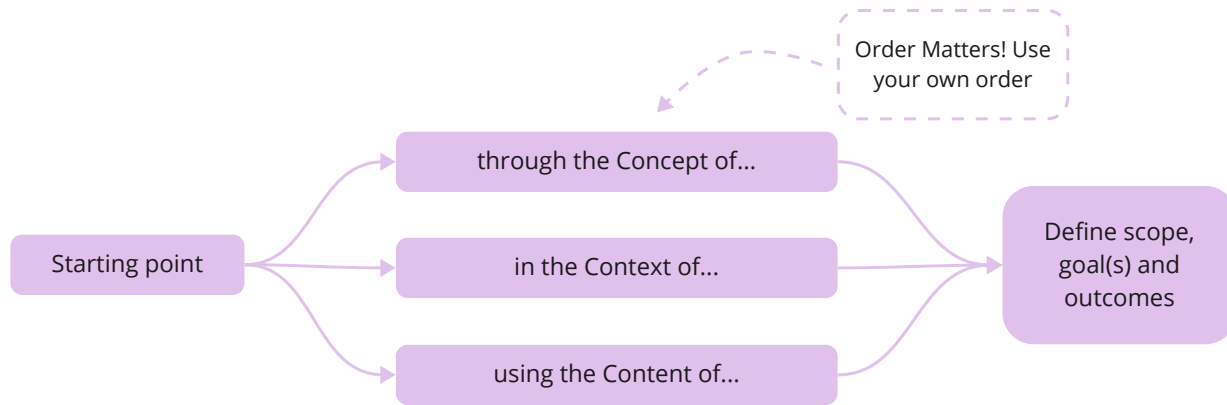


Figure 1. Starting point prompts

EXAMPLES

- Using the **Concept** of decolonization in the **Context** of the Marble Hill House we aim to produce Mixed Reality Heritage Performance **Content**
- In the **Context** of decolonization through the **Concept** of mixed reality heritage performance we aim to develop a historic heritage performance using Historic Deerfield archival **Content**
- We aim to produce decolonization **Content** in the **Context** of mixed reality heritage performance under the **Concept** of co-creation

Project Vision Statement

A vision statement includes the items that form the backbone idea of the project, items that will not change down the line of design and production.

It is a compass that will guide the team to the completion of the project without changing its fundamental building blocks, and will guide new people who may join the team at different stages.

You can shape the vision statement using the guide in Figure 1. Extra elements can be added if they are important to the project, guide the vision and should remain unchanged throughout.

Preparation

Build team and working methodology

Building the right team and choosing the cross-disciplinary working methodology to secure outcomes is a foundational step to a smooth and fruitful collaboration. There are three suggested working methodologies with different outcomes and levels of difficulty and requirements in terms of skills, and time. There is literature online to delve deeper into their differences and what it means for the collaboration.

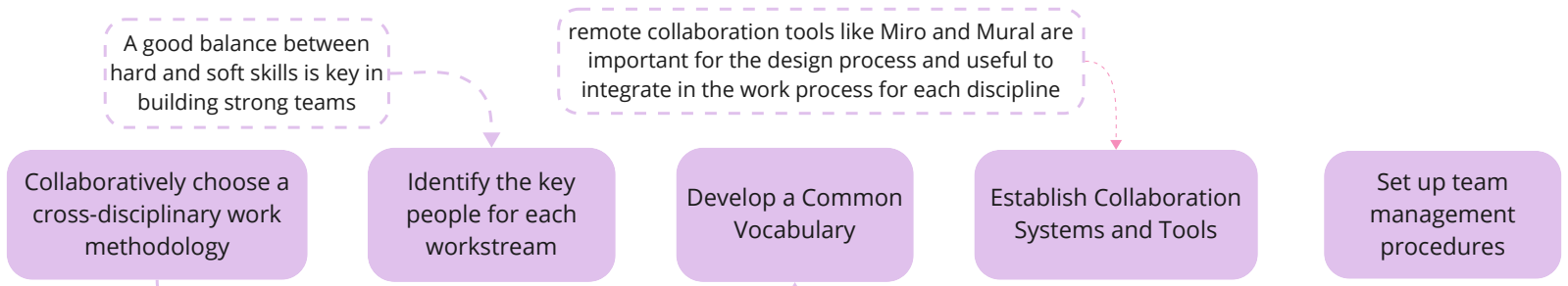


Figure 2. Team building and working protocol

Difficulty, Skill & Time	Methodology	Process	Outcome
	Transdisciplinary	fuses disciplinary-specific knowledge, approaches and methods to produce new methodologies towards a common issue	development of a new theoretical framework built on the shared collective knowledge
	Interdisciplinary	analyzes discipline-specific methods and synthesizes new methods towards a coherent approach to a common issue	production of new knowledge in each discipline related to the researched area
	Multidisciplinary	draws on knowledge from different disciplines to address a common issue	immediate solutions to a problem without a major contribution to knowledge or methods

Most difficult when doing transdisciplinary work. It is useful to hear how different disciplines understand words necessary to the work, e.g. interpretation, interaction, mixed reality, immersive performance, script. **Discuss** these and **agree on a common definition. Share** information of different work methods, tools and processes.

Figure 3. Multi- Inter- and Trans- disciplinary working methodologies

Core Team Setup

At the end of this process a core cross-disciplinary team should be in place and a working methodology should have been decided.

The core team can include sub-teams based on the number of different disciplines and workstreams. For example, for heritage organizations a core team can include digital engagement specialists, interpretation director, historians, and visitor experience specialists.

The design and production core teams can include interaction/digital design professionals, software-hardware and media development professionals, engineers, creatives, producers, dramaturgs, script writers.

Preparation

Shape a shared model of co-creation

Preparation - Shape a shared model of co-creation - **Process**

As you approach the last stage of Preparation, shaping a model of co-creation will help the team approach problem solving from the holistic perspective. Participation of communities of interest (e.g. activists, local communities, stakeholders) would add knowledge, experience and perspectives in the design and development of the project. Combined with the inputs from the expert communities, which can act as a focusing filter, this process populates the problem space and sets the grounds for meaningful co-creation. These inputs fused with the domain knowledge of the core team, under a solutioning mindset approach, leads to optimal solutions in translation from generic to specific. The three items in the inner diagram below are the product of deep engagement with domains of knowledge outside one's own discipline, while embracing indeterminacy and complexity when facing a problem.

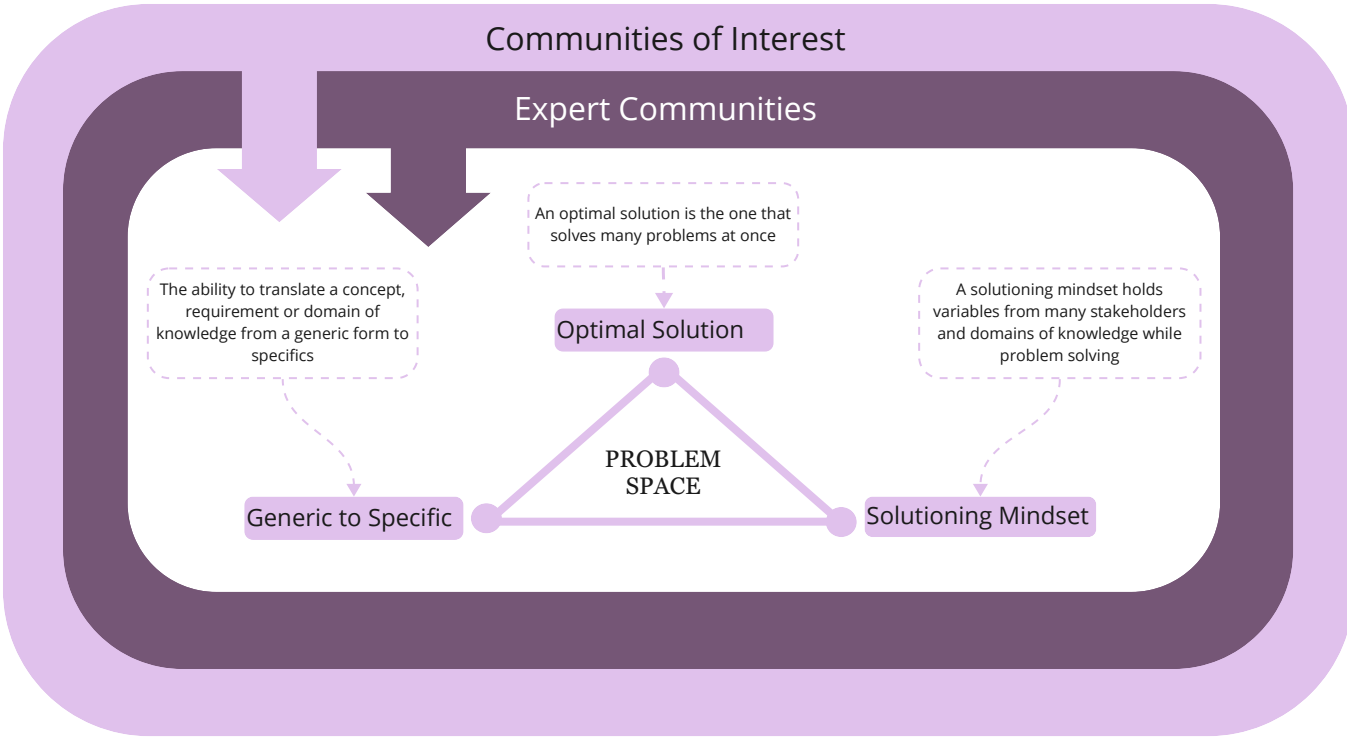


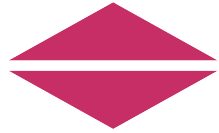
Figure 4. Co-creation Model

Model Capture for the current and future projects

At the end of this process it is useful to describe and illustrate the model of co-creation and development, preferably digitally, and make it accessible by the whole team.

You can consult it anytime during the project development, add notes as the project and collaboration develops, and keep it for future projects.

Bring Vision to Action



Assemble Experts,
Stakeholders & Focus
Groups



Design the experience

2 DESIGN

Design

Bring Vision to Action

As you begin the design process one of the first decisions is whether the output performance/experience will be more factual or whether some artistic license will be permitted (Figure 5). A more factual approach means that the performance will adhere to sociohistorical facts whereas a more artistic approach means that although it will be based on sociohistorical facts these do not have to be represented in an accurate way. For example, there could be a meeting between two historic characters for whom there is no evidence that they ever met.



Figure 5. Style of Interpretation



Figure 6. Funnel model for content development

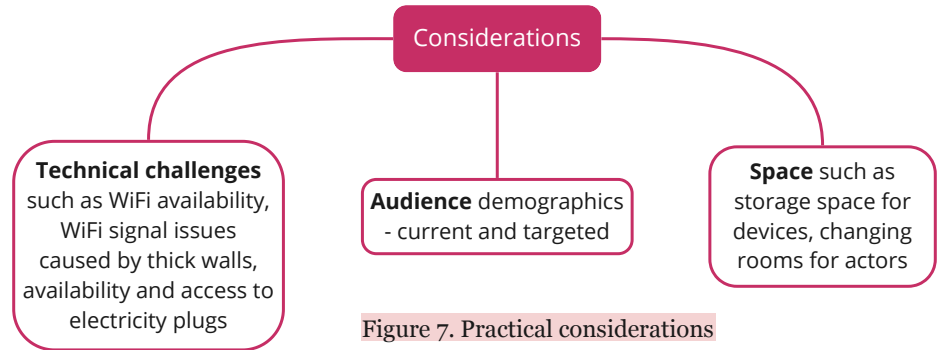


Figure 7. Practical considerations

Content development

Developing the story will take at least a few full days of workshops. Starting from the sociohistorical evidence available and with the vision in mind, the items to be decided at this stage is the time the performance will take place in, the location or rooms, the characters (and secondary characters that you may want to be mentioned in the play), specific events that will set the stage and drive the story, and objects of importance to the story and overall performance.

Exploring these items, will start a parallel process of revealing specific themes that together with the vision (3Cs) can focus the story. Example themes can be social dynamics, economy, religion, etc. The themes and the vision are the lenses for the overall narrative (Figure 6). During content development, technical, space and audience requirements are important to be considered (Figure 7).

Executive summary of the project

An executive summary will detail briefly the story, and contain information about the style of interpretation, targeted audience, and explored themes.

High-level description of production

The high level description of production includes items such as the selected rooms for the performance, spaces for storing equipment and possibly actors changing rooms, space-related health and safety requirements for the performance, and a list of any technical challenges that need to be resolved.

List of characters, events, places and objects

A list of all the characters, events, places and objects that will be included in the performance. Adding these in an online collaboration spaces eases the process of visual research on the content that will help the interaction design and development process.

Design

Assemble Experts, Stakeholders &
Focus Groups

Assembly of these groups and collaboration can be shaped as needed

Experts

It is important to work with the expert communities as a 'critical friends' group who can guide the process at every step and ensure the vision is meaningfully carried out. As the narrative and production is shaped at a high level, subject specific expertise is injected into the design. For example, historians can consult on items such as historical events and characters, narrative designers can be brought in that help with narrative development, while experts in relevant social justice areas (e.g. decolonisation, repairing or sustainability) can consult on the script and story. External expertise can also be sought for purposes outside the experience design, for example the core team may organise a decolonisation workshop with an expert for their own education on how to approach the design process with a decolonising lens.

Focus Groups

Focus groups accesses expertise from the end-user base. It should be formed from a diverse group of individuals and include representatives of the communities of interest. An example is a heritage site's on-site volunteers who know about the history of the place, and engage with visitors on a daily basis. Testing of an early mock-up prototype with focus groups (e.g. selected volunteers, communities of interest and members of the organisation) is also useful.

Stakeholders

It is important to bring to the discussion all stakeholders of the project. These include key people involved in decision making for the space(s) where the performance will take place (e.g. the heritage institution's personnel that facilitates the realisation of the design - such as property managers, marketing officers, senior management), communities of interest, and special interest groups.

List of people to consult

At the end of the process you should have a compiled list of people to consult and a draft schedule of activities with them running in parallel to the design of the experience.

Design

Design the experience

Having the deliverables from Stage 1 ready, the next step is to write the script and design the interactions in the hybrid cyber-physical environment with a dramaturgical approach. The development of these two aspects is complimented with iterative rapid prototyping in the space. All elements of this Stage contribute to the creation of the dramaturgy of the performance.

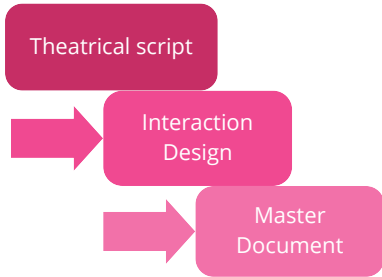


Figure 8. Example of the waterfall method starting from the theatre script

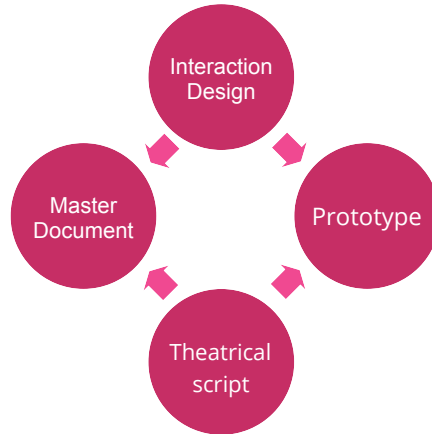


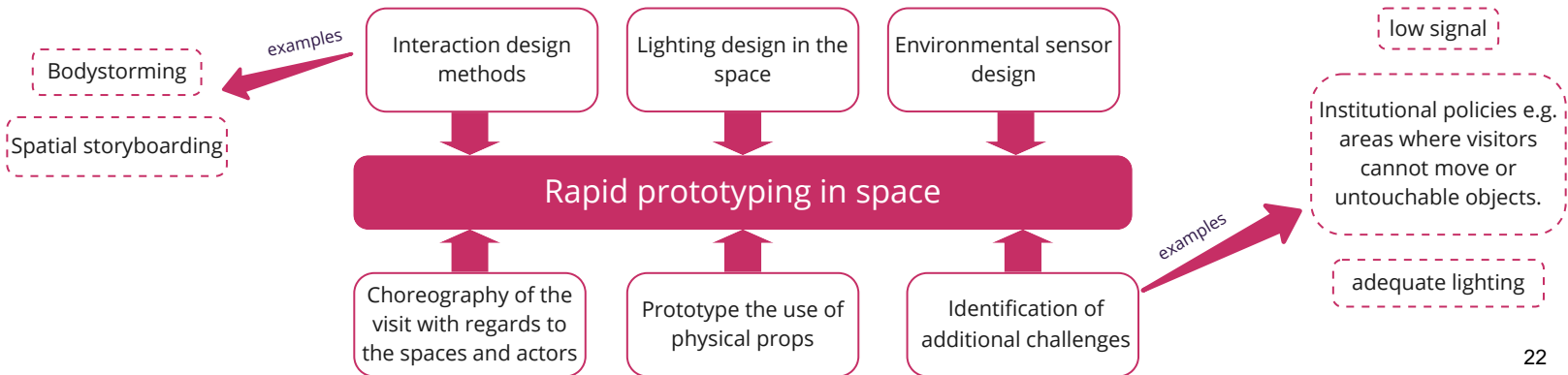
Figure 9. Iterative method

Design Method

The script and interactions can be developed either linearly (**Waterfall method**, Figure 8) or iteratively in parallel (**Iterative method**, Figure 9).

If you follow the waterfall model you start from one, finish it, and continue with the other. Irrespectively with which one you start first, it will affect to some degree the other, so some iterative development/minor changes will be needed towards the end to tie things together seamlessly and meaningfully. With the iterative method you can start with either interaction design or theatrical script but start early and iterate.

Whichever method you choose, one discipline, and consequently team or person, should take the lead.



Master Production Document

The Master production document includes the script that contains both the theatrical dialogues and the immersive reality interactions (use of colour coding is useful), notes related to technical challenges, and any notes that are useful for the production. It is also useful to include 3D scans of the spaces with annotations for visual references. These can be obtained with free 3D scanning apps on devices that support 3D scanning technology such as Lidar.



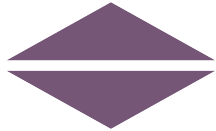
If academic and/or institutional research is a component of the experience then evaluation methods should be sought out and a solid evaluation plan prepared at this stage.

Examples:

User-centred evaluation. Assess the usability, accessibility, engagement, and immersion of the audience. There are many scales in literature that can be used to measure these. Heuristic evaluation is an appropriate method (see next stage process).

Institutional-centered evaluation. Assesses impact of elements set from the institution perspective, for example, learning, understanding of history, educational value, behavioural change.

Design technical
infrastructure



Set the Stage



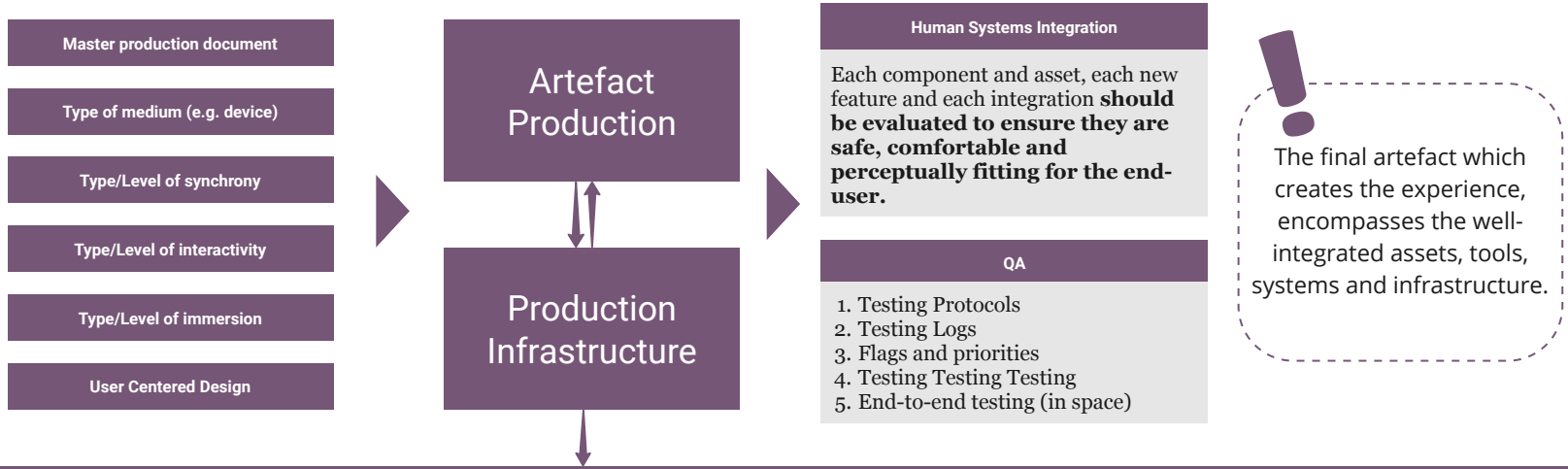
Conduct Technical
Rehearsals

3 PRODUCTION

Production

Design technical infrastructure

The Master document information along the items on the left side list below will guide the design of the technical infrastructure to support the artefact production. Other important decision points are the types/level of synchrony between physical and digital agents and media, of interactivity, and of immersion. Users should be at the core of production design throughout.



Real Time 3D (RT3D) Pipeline

1. Infrastructure for 3D asset management
2. Framework for real-time interactions between assets
3. Rendering Engine and development platform
4. Real-time communication protocol

Spatial Interaction Pipelines

1. Spatial integration and spatial occlusions (physical - virtual)
2. Anchoring systems global or other persistent anchoring
3. Physical space fitting of digital assets
4. Dynamic Interaction areas and orchestration

Content Production and Integration Pipelines

1. Content management system
2. Content standards and formats
3. Content import and export pipelines
4. Content creation process and pipeline

Networking and Synchronization Systems

1. Network infrastructure (reliability & robustness)
2. Networking Protocols and messaging framework
3. Synchronisation between servers, clients & devices
4. Content synchronisation layer (Linear & Dynamic)

Real Time Performance Control System (Wizard of Oz)

1. Systems and tools to monitor the performance
2. Timelines, tools and interfaces to control the RT3D performance
3. Rehearsals tools and rapid adjustments framework
4. Crisis management tools and frameworks

Systems Diagram

A system diagram is used to document the systems and tools used as they are developed during production. It can be used to ensure all aspects are considered and to develop future artefacts in a similar domain.

Artefact

A well designed artefact should include the assets, tools, systems and infrastructure, well integrated and ready for performance. These can also be potentially reused and repurposed for future performances and other endeavours.

Technical Manual

The document should include the full details of how the different technical aspects are developed and how to use them. It includes the most common potential bugs and breaking points and how to recover from them. References to the common language developed for the team is ideal.

Operation Manual

This document entails the details of how to operate the developed tools and systems for a successful performance. As much as possible it should avoid technical jargon and focus on practicality. Ideally, this should be written so that most members of the team could use it to operate the experience. It should be written so that it aligns with the script.

Production

Set the Stage

Digital Layer

Examples:

1. **Digital Assets.** Feel and look of digital avatars, costumes, environments within the Mixed Reality stage.
2. **Spatial Integration.** Integration of the digital assets in conjunction with the physical layer.
3. **Auditory Integration.** Integration of immersive sound effects and music within the physical layer.
4. **Interactivity.** All methods used to enable detection of events and drive action.
5. **Feedback.** Methods used to inform participants (e.g. physical actors) and systems of various events.

Physical Layer

Examples:

1. **Props.** The physical elements, environmental sensors, wearable devices, active (sensors, olfactory devices) and passive props to serve the interactions.
2. **Light Design.** Creating appropriate atmosphere. Make use of existing light sources in space e.g. fireplace and windows, being mindful of natural light changes during the experience. Lights can also contribute to interactions.
3. **Costumes.** If procuring real costumes, check that body sensors can securely be placed on the body, e.g. under a relatively tight sleeve, or that the costume have places to hold the sensors, for example, pockets.

Integration Layer

Examples:

1. **Technical Integration Evaluation.** Evaluating using mixed methods in areas such performance flow, IoT performance, latency, integration etc.
2. **Institution-centred evaluation.** Assesses impact of elements set from the institution perspective, for example, health and safety, safeguarding etc.
3. **Context-centred evaluation.** Assess the impact of the elements of the set from the perspective of the communities of interest.

Stage Design

The stage design plan for the Mixed Reality performance including items such as props, light design, costumes, list of actors, environmental and/or on-body sensors.

Performance Flow

The plan for the Mixed Reality performance flow including timelines, event triggers, physical movements, integration of physical and digital layers.

Integration Guidelines

A set of guidelines based on the specifics of the performance context and content including guidelines set by the communities of interest, the institution safeguarding policies for site and exhibits, health and safety considerations, risk assessment and mitigation plans.

Production

Conduct Technical Rehearsals

In-situ Rehearsals

1. **Heuristic evaluation:**

Identify a list of heuristics based on the project setup to assess the stage design, performance flow and integration.

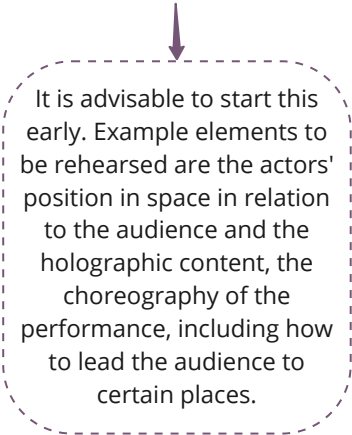
2. **Stage ergonomics:**

Positioning: Position, and possibly anchor, the holographic material in the space, and adjust accordingly to the viewing position of audience, lights and other stage elements as needed.

Occlusion: Ensure that holographic material is occluded by the physical space to the best possible extent, and that physical items or physical actors are not being occluded by the volumetric material on the device.

Calibration: Calibrate the device at the start.

3. **Actors training (if applicable):** the physical actors work with the director to practise with wearing and using the on-body and/or on-costume sensors.



It is advisable to start this early. Example elements to be rehearsed are the actors' position in space in relation to the audience and the holographic content, the choreography of the performance, including how to lead the audience to certain places.

4. **Participant feedback:** Record, analyse and act on the feedback by audience, stakeholders, actors (if applicable).

Fitting & Adjusting

1. **Fitting** the technology with the physical aspects of time and space.
2. **Adjusting** colour palettes, check blending, check physical lighting with respect to how it affects the display of the volumetric material and how it affects any physical actors' presence.
3. **Check and fine tune** position, feel and look, orientation, brightness, contrast, time and pace, sound volume.
4. **Update** the Master Production document including snapshots from the device.

Performance Flow

1. **On boarding.** Plan how to induct the audience to the device. Part of the learning can be weaved into the performance narrative. For example, actors or digital content can drive actions like simple head movements to help audiences familiarise with the device.
2. **Off boarding.** Plan for a smooth end of the performance and support the audience in taking the device off.
3. **Moving through space.** Plan how certain digital elements are turned on and off during the performance, e.g. walls.
4. **Gaze attention.** Record where the gaze falls during the performance.
5. **Network Reliability.** Check for potential network blockers such as thick walls.
6. **Accessibility.** Ensure that spaces and designed interactions are accessible.
7. **Risk Identification.** Identify potential risks during the performance run and mitigate them.

On / Off boarding

A plan for how to greet participants, set expectations, carry out their induction to the experience, and how to smoothly end the performance.

Final Performance

The final artefact. All stakeholders, performers and other staff are informed of the processes and all specifics of running the performance.

Risk Assessment

A thorough list of potential safety and performance-related risks with a severity score and mitigations.

Immersive script

The immersive script is the Master Production document updated with the final decisions with regards to the performance.

Monitor the experience

4 PERFORMANCE

Performance

Monitor the experience

1

Check for unpredictables

Even the best planning and rehearsals do not safe proof the final performance from unpredictable things happening, be it audience behaviour, technical glitches or otherwise. Check for anything unforeseen during the first few runs.

2

Audience movement

Observe how audience moves through space in case there is a pattern that was not predicted which will result in some adjustments on where and how the audience is guided to stand or sit.

3

Risk Management

Manage any identified and unforeseen risks such as technical failures, emergencies - medical or otherwise.

4

Fix technical issues

Fix any issues that come up during the performances. The first few runs will be crucial in highlighting technical issues so it is important that developers are in situ or stand by for quick response. Resist enhancing the interactions at this point.

5

Logistics

Have a robust plan for charging the devices. As a rule of thumb you need to have available twice the number of devices that will be used in each performance. Plan regular team and actor breaks.

6

Reflect

Reflect on all aspects of the experience, refine or fine-tune what is possible without making huge changes and re-evaluate.

Insights

A list of insights related to 1-6. Some things will be resolved on the spot while others will inform the next iterations, if any, or added to the report and/or publications to support further research.

Report on findings

It is good practice to keep a written report of the insights. These can be added on the online production tool, published in academic papers, and shared in different ways with the wider research community and stakeholders.



If academic and/or institutional research is a component of the experience then, the evaluation insights are a deliverable.

Authors



Dr Mariza Dima is a Reader (Associate Professor) in Games Design with a focus on Creative Technology for Games at Brunel University of London. She has an interdisciplinary background in applied mathematics, Human-Computer Interaction, and media and games studies. Her work explores, by design, how to create meaningful, engaging, seamless experiences with Immersive Reality technologies in different contexts such as performance, cultural heritage and health with social justice as a drive.



Dr Damon Daylamani-Zad is a Senior Lecturer (Associate Professor) in Creative Computing (Games and AI) at Brunel University of London. His work is focused on the use of Immersive technologies (AR/VR/MR) and applications of AI to address real-world problems and challenges including cultural heritage, serious games, decision making and collaborative environments.



Dr Vangelis Lypouridis is the founder of Enosis, a specialized R&D and innovation company in Los Angeles. As faculty at USC the Viterbi School of Engineering and the School of Cinematic Arts he taught AR/VR and Mixed Reality to 450+ students and pioneered XR research and productions exhibited worldwide in prestigious venues such as the World Economic Forum in Davos, the V&A in London, and the Tribeca and Sundance film festivals and conferences such as IEEEVR, SIGCHI and SIGGRAPH.

This design and development framework is one of the outputs of the UKRI/NEH funded research project **Designing Mixed Reality Heritage Performances to Support Decolonisation of Heritage Sites.**

Project team:

Dr Mariza Dima (UK Principal Investigator, Brunel University of London)

Dr Mary Caulfield (US Principal Investigator, State University of New York at Farmingdale State College)

Dr Dominique Bouchard (UK Co-Investigator, English Heritage)

Dr Damon Daylamani-Zad (UK Co-Investigator, Brunel University of London)

Dr Holly Maples (UK Co-Investigator, University of Essex)

Project Collaborators:

Dr Vangelis Lympouridis (CEO, Enosis VR LLC)

Anne Lanning (Senior Vice President, Historic Deerfield)

Dr Barbara A. Mathews (Public Historian)

This work was funded by



NATIONAL
ENDOWMENT
FOR THE
HUMANITIES



Arts and
Humanities
Research Council

For more information: www.mxr4impact.com

ISBN: 9781908549662

© 2024. This work is openly licensed via [CC-BY-ND](https://creativecommons.org/licenses/by-nd/4.0/)

