

Earthquakes, communities and heritage: telling stories of resilience through co-designed immersive media

1. Introduction and contextual research

Natural catastrophic events can result in people experiencing displacement from environments of trust. This can cause feelings of being uprooted and a loss of control over one's physical space, making individuals and communities very vulnerable and threatening their resilience. Following catastrophic events, people may live in displacement for many years before they can move back to newly reconstructed urban contexts. Such environments do not always reflect the identity of the community, leaving inhabitants scattered and disconnected. When people recall their experiences of natural catastrophes, the strong entanglement of the physical environment and the identity of a community is revealed.

3D immersive and interactive storytelling (i.e. Virtual Reality) can be an effective way to reveal this entanglement and show the effects that such tragic events can have on a community's identity and sense of place. Virtual Reality (VR) provides a multi-sensory experience within a digitally reconstructed environment, which simulates real-life experience (Greuter et al. 2018; Champion 2017; Galeazzi and Di Giuseppantonio Di Franco 2017).

In a VR system, stories integrating multimodal datasets (360-panoramas, audio-video interviews, sound, music, archival images/newspapers, poems) can populate 3D-reconstructed environments and help communities both to reflect on and reconnect to the lost place through narratives about the values and significance they attach to specific features of that place. Such systems can only be realised through meaningful collaboration between the communities affected and all stakeholders involved in the design and development of the system. This co-design process must be reflexive, multi-vocal, and based on mutual trust, empathy, and respect for vulnerability; i.e. a strong ethical framework.

Co-creation approaches involving communities are not new in digital heritage and film studies (Parameswaran and Gaedtke 2021; Di Giuseppantonio Di Franco et al. 2019; Cizek 2015). However, a solid ethical framework that involves communities in the various iterations of the creation cycle is still missing. The main objective of this paper is to address this by exploring the value of the experimental application of an iterative design-thinking method in the creation of VR experiences of places that have been lost after natural catastrophic events. We take as our case study *Italia Terremotata*, an immersive VR documentary that tells the story of the community of Senerchia, hit and partially destroyed by the 1980 Irpinia earthquake in Italy. Senerchia was one of over 40 towns almost completely destroyed by this earthquake, which left 2483 people

dead, 7700 injured, and 250,000 homeless. After the event, most of the inhabitants lived in prefabricated houses for up to 20 years before they were able to move to the new town, built next to the ruins of the abandoned old town. Senerchia and other affected communities are still recovering from this life-changing event.

The town was recreated virtually through a combination of 3D laser-scanning and 360-videos, which were used as a *container* for community stories revealing the values and significance that the inhabitants attach to the place. Our place-centred and community-based VR experience was developed borrowing approaches from design studies (Dorst 2016; Kimbell 2011), with particular attention to the emerging field of Digital Cultural Heritage Design (Mason and Vavoula 2021; Mason 2018; Mitroff Silvers et al. 2013). This multidisciplinary approach involved the community in the design of a tool to facilitate the identification of the values they assign to a place; how these values contribute to their identity formation; and what happens to this identity when the place is lost. Values-led participatory design (Dolcetti et al. 2021; Iversen et al. 2012) and value-sensitive design (Friedman and Hendry 2019) provide a framework for a reflexive 3D immersive storytelling system that is community-based and participatory.

Our creative practice-based approach integrated a linear form of documentary storytelling (2D film) and ethnographic research in an iterative design process aimed at

developing socially meaningful non-linear immersive narratives. By allowing free navigation and selection of people's stories in the 3D-reproduced environment, this VR experience aims to make visible the link between social rebuilding and material reconstruction in the context of catastrophic natural events.

We used an iterative design process that moves from generating insights (stories of resilience and adaptation to natural catastrophic events) from the community (human-centred approach – Kimbell 2011: 287), to idea generation and testing (creation of a value-led immersive experience), to the final development of the immersive application. This approach is characterised by trial-and-error learning that tests a range of possible solutions with community members and other project stakeholders (Beverland et al. 2015: 593).

We based our approach around the creation of a series of prototypes as a way of experimenting and developing our concepts, learning about the strengths and weaknesses of our storyboard and ideas. This approach meant we were able to identify new directions that subsequent prototypes might take. Prototyping is regarded as a way to experiment and develop concepts rather than finalising them.

Within this iterative design-thinking framework, a cross-disciplinary (heritage studies; storytelling and narrative design; film; sound design; 3D-imaging; interactive application design) team of creative thinkers developed progressive sets of

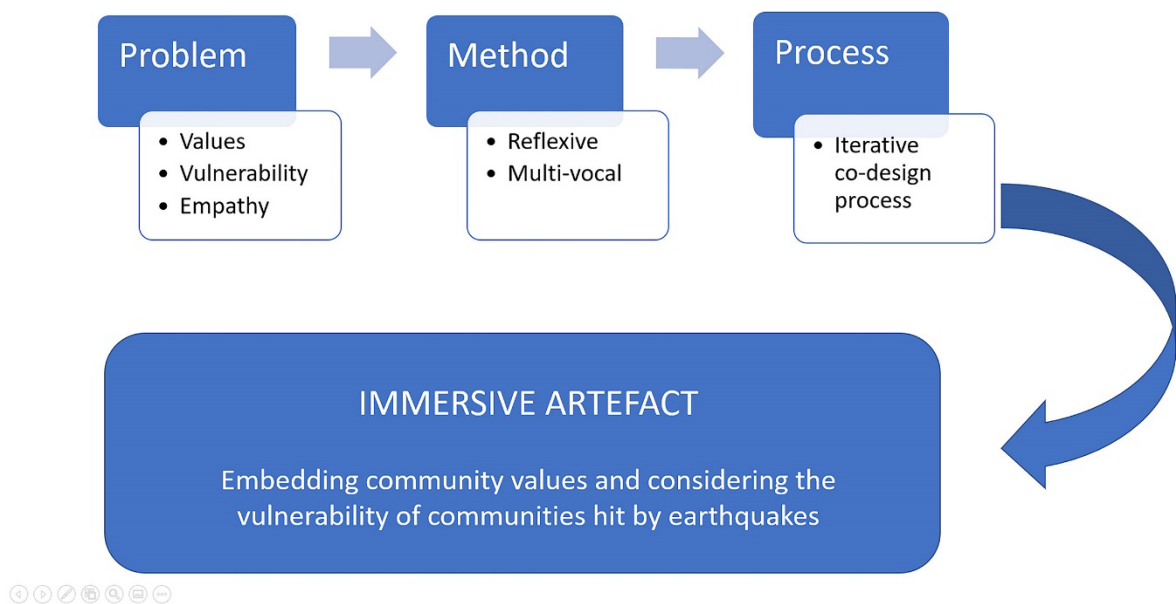
interventions that allowed volunteer community members to explore, reflect on, and emphasise the connections between the digitally reproduced environment and their sense of place.

Our digital artefact (the VR system) is the result of an iterative sequence of actions based on intuitive strategies (i.e. immediately perceived without resorting to the act of reasoning through supportive evidence). According to Almendra and Christiaans (2013: 99), while these processes 'allow people to deal with cognitive load', the risk is that they can produce bias in judgement. We believe that this bias can be moderated by modelling creative design as a co-evolution practice, as per Dorst and Cross (2001). The co-evolution practice starts with the formulation of a problem on one side (problem space) and of ideas for a solution on the other side (solution space). Both problem and solution spaces are tested through a series of iterations that combine analysis, synthesis, and evaluation:

creative design involves a period of exploration in which problem and solution spaces are evolving and are unstable until (temporally) fixed by an emergent bridge which identifies a problem-solution pairing. A creative event occurs as the moment of insight at which a problem-solution pair is framed: what Schön (1983) called 'problem framing'.

(Dorst and Cross 2001: 437)

In our specific case the problem formulation consisted of the creation of a place-centred VR immersive artefact that reproduced lost heritage by considering place-value (sense of place) as conceptualised by the affected community. This value-led approach must consider the vulnerability of communities affected by environmental trauma and possible impact that visualisation could have on those who visually revisit their trauma (Jones 2017; Laing 2020). Our proposed solution was the creation of an ethical framework that considered ‘vulnerability’ and ‘empathy’ as the central design values of our iterative framework (Fig. 1).



<insert Figure 1>

Our iterative process was based on a constant reflexive and multi-vocal dialogue with volunteer members of the community of Senerchia and all stakeholders involved in the production of the VR immersive artefact (film makers, sound designers, 3D designers, heritage and digital humanities experts). This dialogue allowed us to build mutual trust and understanding and functioned as our bridge between problem space and solution space.

Such collaborative work allows for a more holistic and reflexive approach to the design problem that does not depend solely upon the designer's own perceptions and interpretations of the problem. While designer-centred approaches often impose constraints that limit the defining of sharable community goals, holistic and collaborative approaches provide a social and participatory conceptual framework for the design process. Scholars have recognised the holistic and multidisciplinary nature of the design process (Micheli et al. 2018; Almendra and Christiaans 2013; Dorst and Cross 2001) and question whether design is an hermeneutical process. Some have argued that design activities proceed by way of an hermeneutical circle (Snodgrass and Coyne 1997) – one that is described as a circular relationship of the whole and its parts in the interpretation process. In other words, we cannot understand the meaning of the whole if we don't grasp the meaning of the parts (Almendra and Christiaans 2013). This holistic approach requires the removal of the pre-given perspectives that each

individual attaches to a certain context; that is the process of projection defined by Heidegger (1962) as 'fore-structures of understanding':

The process that Heidegger describes is that every revision of the fore-projection is capable of projecting before itself a new projection of meaning; rival projects can emerge side by side until it becomes clearer what the unity of meaning is; interpretation begins with fore-conceptions that are replaced by more suitable ones. This constant process of new projection constitutes the movement of understanding and interpretation.

(Gadamer 1989: 269)

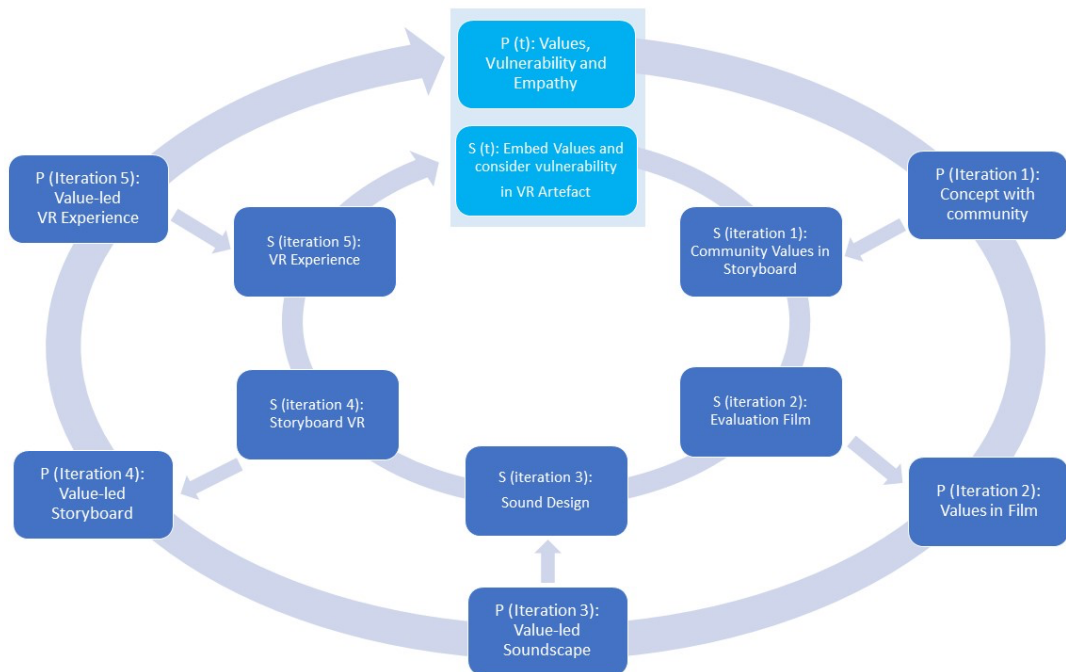
Our holistic approach allowed participants to engage with design-thinking in an ongoing process that started from interaction with the 2D audio-visual medium. This continued with the creation of the storyboard for the VR experience and ended with ongoing experimentation and testing. There is good evidence of how visualisation techniques and storytelling can 'clarify the characteristics of the idea and make it more amenable to critical consideration and feedback' (Glen et al. 2014: 658; Carlgren et al. 2016; Liedtka 2015). For this reason, a 2D documentary replicating and representing the contents of the VR application in a linear and non-immersive way was used to co-design the storyboard for the VR application and start the prototyping phase.

This holistic and multidisciplinary framework offers important insights into:

- the role of creative practice-based research in enabling meaningful and socially relevant innovation that helps communities to reflect on and reconnect to the lost/abandoned place;
- how a creative and multidisciplinary iterative design process including linear storytelling practices and creative technologies can support the development of immersive technologies that provide a more critical and emotional understanding of the heritage of natural catastrophic events.

The remainder of this paper presents our creative practice-based framework, which includes five iterations, beginning with observation and experience and four prototypes:

- definition of the concept with the community; setting community values for storyboard;
- 2D film (Prototype 1) to visualise contents of VR application in linear way;
- creation of sound design (Prototype 2);
- community feedback on 2D film and 3D VR application (Prototype 3);
- improvement of the 3D VR experience (Prototype 4) (Fig. 2).



<insert Figure 2>

2. Iteration 1 – Definition of the concept with the community: setting community values for the storyboard

Our project attempted to co-design creative interventions that could help members of the community reflect on the loss of their tangible heritage and consider how this affected their sense of identity and of belonging to the place.

The first iteration of our design-thinking concept was based on video ethnography (Smith and Dunkley 2021; Redmond 2019). Our aim was to find an empathetic way to engage these affected communities in reflecting about their town today and their

relationship with the old town, particularly the identity of their community. Our main objective was to develop a framework that could integrate ethnographic research with multimodal storytelling (i.e. storytelling that integrates different modes of media). We intended to put the 'place' at the centre of the design process through the co-creation of people's stories and their active involvement in the selection of information and archival records.

Community-based co-creation in this context implies the consideration of different aspects around decision-making and relationships including who decides the terms of engagement, contents, and nature of the digital artefact, as well as why and who benefits from this type of co-creation and creative interventions. It is crucial, therefore, to involve the community from the beginning of the process in order to engage with their expectations and needs in relation to heritage recovery and regeneration, as well as preservation and management.

During the conceptual and preliminary phase of this research we spent time in Irpinia to build trust and relationships with local communities. Our first interactions were facilitated by one of our co-authors, who has family connections with the town of Calabritto, very close to Senerchia, which was also badly affected by the 1980 earthquake. These two rural towns share many stories (e.g. family members living in

the two towns; inter-marriage), as well as a rural and pastoral history based on subsistence agriculture and exploitation of natural resources.

The first part of our iterative framework was characterised by several visits to Calabritto and Senerchia:

Fieldwork 1: Exploratory fieldwork in Irpinia

During the first visit we interviewed people in Calabritto to develop a better understanding of the problems and needs of this unique but also vulnerable area. The relationships and trust built in Calabritto created the pre-conditions necessary for the subsequent collaboration with the municipality and community of Senerchia.

After a preliminary inspection of the town and a workshop with members of the municipality the direct connection of the citizens of Senerchia with the ruins of the old town was immediately clear. This phase dates to the 17th century and was built uphill on the line of a medieval phase of castellation, the ruins of which are still visible (Fig. 3).



<insert Figure 3>

By the early 19th century the inhabitants of the old town had started to move downhill and we learned that this later development was almost completely destroyed by a landslide caused by the earthquake. The most socially vibrant area of the 19th-century development was the square outside the cathedral, with four bars/cafes. Many of the young people who died in Senerchia were trapped in these bars while watching a football match. Following the earthquake, the remains of this development were literally reduced to dust to make concrete for the new town. During our conversations many people claimed that the bell-tower of the cathedral was still in place after the disaster and could have been restored but instead this iconic remnant was replaced by a new iron tower, standing on a cement base and complemented by a clock stopped at the time of the earthquake (Fig. 4).



<insert Figure 4>

These informal conversations helped us to get a sense of how people conceived the earthquake as a clear spatial and temporal divide (a before and an after, an old and a new). We also learnt that to move on after this devastating tragedy, people simply had to 'roll up their sleeves' and get on with life. This caused a lack of community reflection on the social effects caused by the losses (of lives and place) and on the effects of the reconstruction on their sense of self, of community, and of belonging to the place.

This first visit made it clear that we needed to design a digital immersive experience that would allow the inhabitants of Senerchia to reflect on place, sense of place, and community building, as well as revealing how the materiality of a place affects the identity of a community. Therefore, we organised a second campaign to collect data

from video interviews and visual rendering (3D digital replica) of the actual landscape of Senerchia through laser scanning and 360-filming.

Fieldwork 2: 3D and 360 data collection and interviews with the community

After a preliminary planning phase, we visited Senerchia for the second fieldwork campaign. The main aim was the digital reproduction of the place (old and new Senerchia) and the recording of interviews with members of the community that had experienced the 1980 earthquake.

- a) Place (3D laser scanner): the data collection was conducted using integrated technologies and media. A 3D digital replica of the town was created using a Faro 3D laser scanner, which allows creation of a very accurate digital replica of the surfaces and colours of the environment. This technology was used to reproduce the external fabric of the buildings. Several acquisitions (scans) were collected along the main street of the old town that had survived the earthquake and the area of the new town rebuilt on the rubble of the 19th-century town destroyed by the disaster (Fig. 5). These areas were selected for their strong entanglement with the stories of the community. The 3D-reproduced environment was then used as a container for these stories (in audio-visual format) as well as 360 interactive videos of house interiors that give a clear picture of the earthquake damage.

b) Sense of Place (video interviews with community members): after direct engagement with the place and observations of how people interact with the town (i.e. informal discussions with people during data collection on their relationship with the place), we began video interviews with surviving members of the community. One of the most interesting aspects of this ethnographic work was that some of the people interviewed explained how they were talking for the first time since 1980 about the earthquake, their personal experience, and their feelings: 'You cannot talk about these things in the family, because it is painful!' (Resident of Senerchia). One woman, who moved to England after the earthquake said:

It definitely stays with you, and anybody that opens up to talk to you guys...

I mean, that's very brave... I've never been able to share that [my memories] with anybody... I think it's important to bring out what one has gone through, because you might help other people [in the future].

Participants discussed their interaction with specific places in the built and natural environment before, during and after the earthquake. Using this information, it was possible to select places and stories for the documentary and start co-designing the narrative with the community. This phase was complemented by an interview with poet Franco Arminio, who experienced the earthquake in 1980 and

has written several narratives and poems about the event including *Viaggio nel Cratere* (Arminio 2003).

- c) Visual hotspots in the 3D-reproduced environment (360 videos): the narratives collected allowed us to reflect on iconic features in the town that we decided to reproduce through 360 interactive videos to provide a context for the stories. A GoPro Max 360 camera was used for data collection. These were then integrated with the interviews to create audio-visual stories accessible virtually in the 3D-reproduced environment.



<insert Figure 5>

Fieldwork 3: Feedback from community members, second data collection and sound recording

After preliminary processing of all data collected during the second fieldwork campaign, we returned to Senerchia to show the data collected to participants and receive their feedback during a co-design workshop. This meeting was critical to evaluate the effectiveness of the stories and identify missing audio-visual material. This workshop with the community emphasised the importance of both natural (e.g. water/wind/birds), and human-produced sounds (e.g. music/people's voices in square) for the creation of a more emotional and 'authentic' experience with the place. At this stage, an expert sound designer joined our team to provide guidance on how best to record audio on-site and then design and integrate it in the experience.

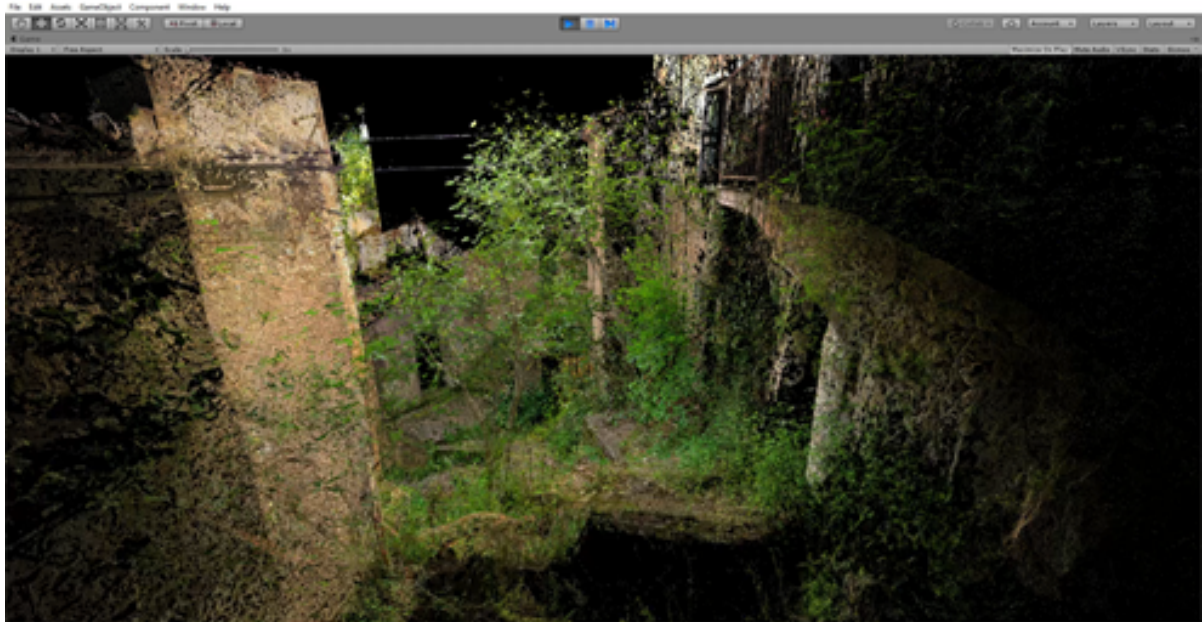
3. Iteration 2/Prototype 1: 2D film to visualise contents of VR application in linear way

During Iteration 1, we assessed people's familiarity with 3D technologies and realised that many community members were not familiar with them, so we decided an alternative medium was required to facilitate their interaction with the audio-visual contents during the co-design phase of the VR experience. This important feedback prompted us to explore the use of a 2D linear and non-interactive version of the VR

experience, integrating the stories and digital contents selected with members of the community (Iteration 1), as an effective and easier tool to visualise the contents, brainstorm, and co-design the 3D immersive application. Three specific formats were used for the 2D film:

- video renderings of the 3D-replica of the town;
- wrapped 360 videos (perceived as 180-degree shots);
- video interviews with members of the community.

We decided that rather than attempting a realistic rendering of the actual landscape, we should aim to render the community's conceptualisation of sense of place artistically. While all the stories of the earthquake marked a clear divide between before and after, our visual representation of the old town aimed to reproduce a suspended time that could reveal the loss, pain, hope, wait in displacement, return, reconstruction, and sense of incompleteness produced by relocation to the new town. Our artistic choice was to use the 3D point-cloud without reproducing the surface of the 3D model (i.e. without realistic rendering). The point-cloud was integrated in the Unity gaming platform to create an ethereal representation of the town that could visually reproduce a suspended time (Video 1).



<insert Video 1>

To represent the temporal separation between the stories of the town before, during and after the earthquake we decided to create a visual contrast between the point-cloud and a more realistic representation of specific locations in Senerchia, made using 360 videos. These videos were wrapped and integrated in the 2D film (Fig. 6). They accompany the video interviews describing the abandoned places.

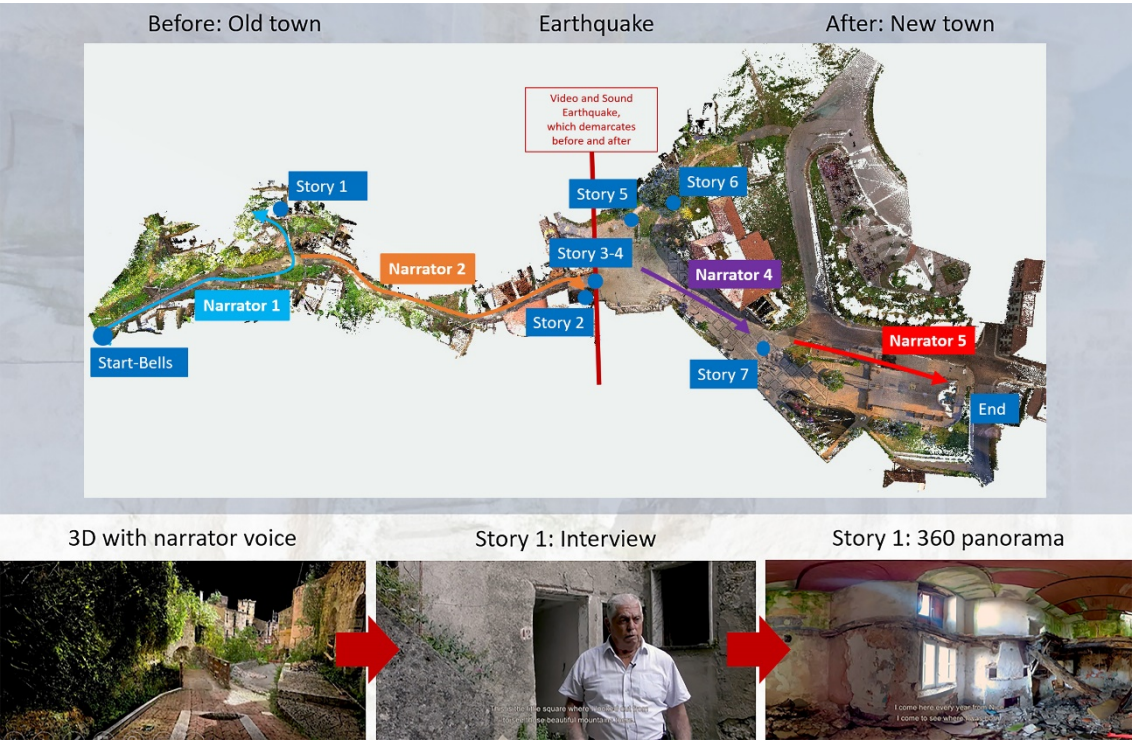


<insert Figure 6>

A linear documentary guides the viewer through a dramatic arc of experience via a set of events that could happen chronologically. Other ways to represent the 'story' include creating a hyper-real world (Patel 2020; Patel et al. 2017) which engages the audience through experience and several creative tools. The recitation of poetry at the beginning of our film explores the poetic mode – one that evokes memories and emotion – while the narrator takes on the role of the lyrical, at times questioning, guide through the journey. Other tools of production included the use of sound design, placing these very real 'interviews' within that hyper-real mnemonic landscape. Allowing the viewer to plot their own way through the townscape was also crucial –

guiding the unveiling of hotspots according to how the narrative unfolds until the earthquake with its life-changing consequences for the participants. Much of this resulted from the co-creative approach to understanding the nuanced and universal aspects of the shared experience of the earthquake.

We divided the stories into three main groups: before, during and after the earthquake. We then located them in areas of the 3D-reproduced space that were physically linked to the stories: Before ('old town'); Earthquake; After ('new town') (Fig. 7).



<insert Figure 7>

We decided to represent the rupture constituted by the earthquake through the use of a hyper-real, saturated visualisation (i.e. inconsistent black and white) of the stories.

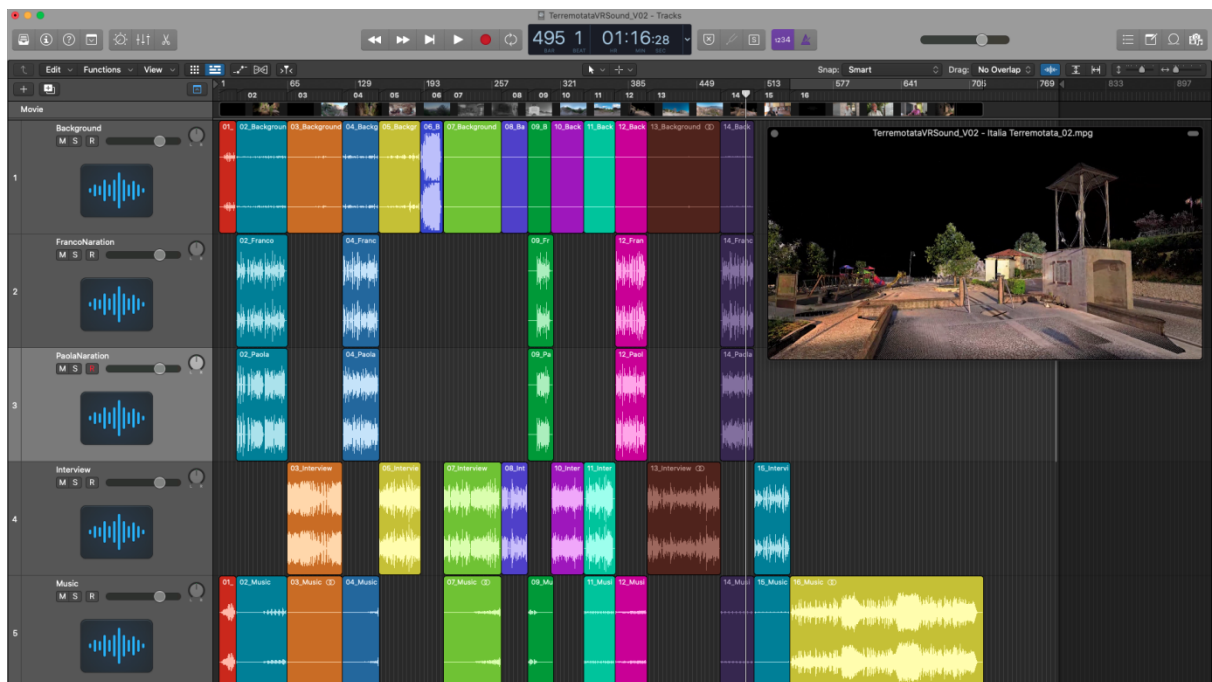
We realised that visualisation alone was not enough to convey the tension of the earthquake stories [problem setting] and that a sound-design component might help us achieve this tension [solution] (Fig. 8), so we organised a series of meetings with the sound designer to commence iteration 3.



<insert Figure 8>

4. Iteration 3/Prototype 2: Creation of sound design

The visual representation of place and sense of place guided the process of developing a sound-design experience for the 2D film. Audio assets from the 2D film were then extracted into sound ‘objects’ which can be triggered, and looped (where necessary), from within an asynchronous and immersive application. Figure 9 shows the final sound objects organised in the 2D fixed-length film, using an object-oriented approach which makes them immediately available for reuse in an interactive and asynchronous immersive piece.

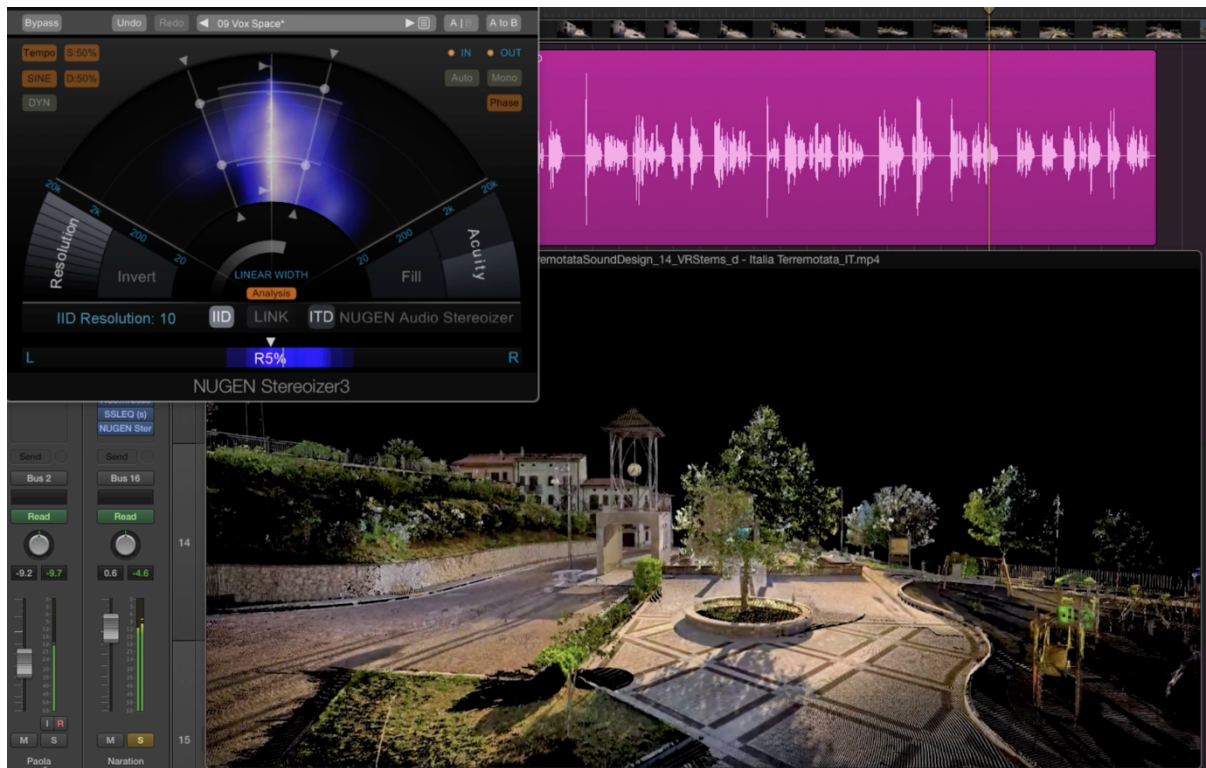


<insert Figure 9>

The sound-design methodology for the 2D film borrowed several creative methods and approaches from the film *The Crossing* (Patel et al. 2019). In particular, similar approaches to abstract sound design, foley (i.e. simulations of every-day sounds), narration and the use of hyper-real sounds to provoke emotion and immersion in the viewer were used. However, the sound design for *Italia Terremotata* deviated from that in *The Crossing* in two distinct ways: firstly, it followed a more conventional approach owing to the fact that the 2D-film edit was in progress when sound design commenced, whereas with *The Crossing*, sound design contributed significantly in developing the storyboard and timeline of the film. Secondly, *Italia Terremotata* makes considerable use of music to generate emotion and provide background sound beds, whereas *The Crossing* had no conventional music incorporated, despite using many musical concepts and processing tools in its creation. Comparing these two methods provides a valuable case-study of how different sonic methods can be used to achieve comparable emotive and immersive experiences for the viewer in non-linear or interactive films.

Italia Terremotata's sound revolves around the dialogue between interviewees and narrator, with all other sounds used to enhance and link the stories in each scene. For example, where an interviewee is discussing a particular scenario, the background sound bed is generated with recorded and sample sounds representing their

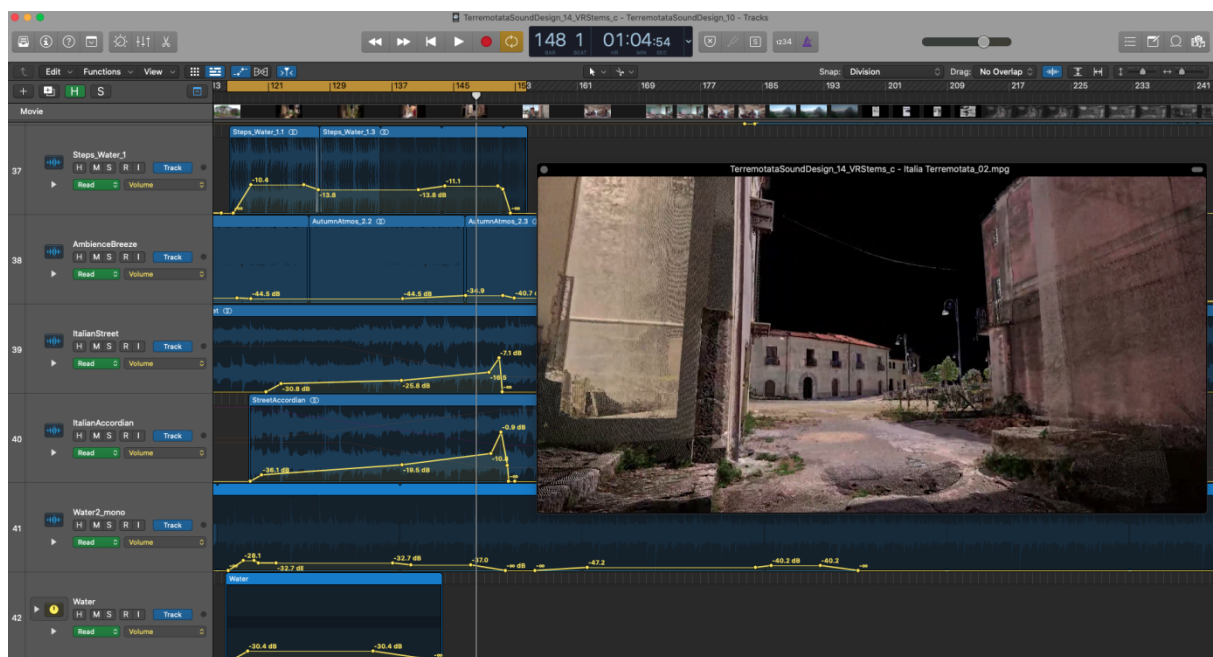
immediate environment and music sympathetic to the story. For authenticity and to capture the emotive stories and responses, interviewees were recorded on location in Senerchia, although as a result, the recordings were somewhat compromised from a technical perspective and had to be post-processed to remove background noise and bring clarity and presence to each passage of dialogue. The narration dialogue was recorded in both English and Italian and was processed similarly to the interview dialogue, the only exception being the use of the Nugen Stereoizer plugin (stereo-widening processor) to give the narration a subtle sense of width and thus allow the listener to feel closer to (and more immersed with) the narrator; this is particularly noticeable when listening on stereo headphones.



<insert Figure 10>

Diegetic (i.e. original sounds from the videos) and foley sounds were used as background sound beds, providing a sense of location and environment to the listener. For example, when the narration combines with a visual journey through the 3D virtual reconstruction of Senerchia, a realistic recreation of the streets being followed was achieved using foley recordings and library sounds. Considerable attention was paid to the dynamic nature of these sounds that become quieter or louder depending on the virtual journey and to balance with the narration. Foley sounds used include general ambience, running water, footsteps, wind, birds, road noise, church bells and crowd

noises, blended to give an authentic representation of the town as it would have sounded before the earthquake. Figure 11 shows an example of the dynamic volume automation applied to different background sounds as the narrator moves through narrow streets, across a stream of water and up to the main square of Senerchia. In this example, the background sound bed incorporates a thriving busy crowd and an Italian accordion performance. The volume of street noise rises as the film approaches the derelict town square to present a sonic ‘ghost’ of the sounds that would have been present prior to the earthquake.



<insert Figure 11>

The most abstract and hyper-real sounds used in *Italia Terremotata* are those introduced to signify the horror and panic of the earthquake event itself. This sound passage borrows concepts from classic horror films (i.e. Hitchcock's *Psycho*, *Chernobyl*¹) and sound design approaches employed in *The Crossing*.

Several songs and musical sounds were used in *Italia Terremotata*, predominantly to connect scenes and to provoke reflective, emotive responses in the audience. The music adds an additional emotive layer to the stories that are told in dialogue, translating some of the emotions through another form of human communication. The musical palate is chosen to be connected loosely with classical and folk genres, using classical piano, a church choir, opera vocals, folk-inspired acoustic guitar and the final piece which accompanies the end credits: *La Lumaca* by Vinicio Capossela. Emotive piano and the opera vocal of *Ave Maria* by Marisa Di Muro are used to heighten both the stories of loss and the eventual sense of peace and acceptance in the earthquake survivors. The guitar progression written specifically for the film by sound designer Rob Toulson and used alongside the narrative of the villagers re-emerging and finding new ambitions in their futures is delicate and tentative, but also positive and hopeful.

¹ Mini-series created by Craig Mazin

The folk-classical music palate chosen gives a subtle congruence to the music used throughout the film, but is also gentle, emotive, and retrospective, linking back to the scene of the earthquake over 40 years before.

5. Iteration 4/Prototype 3: Community feedback on 2D film and 3D VR application

The data collected during fieldwork and the 2D film allowed the development of a creative approach which used ethnographic research and film formats to increase participants' understanding of the audio-visual contents and to foster their active participation in the co-design of the VR experience. For this iteration, we invited the people of Senerchia who had participated in the interviews and content creation to watch the 2D documentary and provide us with essential feedback for the development of the VR application:

- they acknowledged the validity of the film in providing a different engagement with the event for people who experienced the earthquake. They thought the film was powerful and delicate at the same time. They found the atmospheric digital presentation of the old town quite poetic and thought this 3D 'hyper-real' visualisation functioned as a gentle way to gather their stories and reveal their community values and attachment to the place. At the same time, they felt that the film could foster empathy and understanding of the impact that

the disaster had, and is still having, on the community. This comment was particularly rewarding and recognised the effectiveness of our value-led design-thinking approach which sees empathy as one of 'the core values of human-centeredness' (Carlgren et al. 2016: 51) in the process of creating more meaningful and impactful experiences.

- While participants found the 2D documentary very engaging, they were not always aware of the location of the stories in the reproduced space, since the narrative fragments follow the video of the 3D content in a linear sequence without reference to exact locations. They suggested that the VR experience should indicate the position of the stories as they felt a clear understanding of the spatial location of these narratives in the 3D-reproduced environment would help people to grasp their strong emotional connection with the lost/abandoned place. We achieved this by creating a 2D interactive map of the town that shows the location of the stories (i.e. hotspots on the map) to help orientate the user and reveal the spatial relationship between stories in the 3D immersive environment (Iteration 5).

- Participants also recognised the integrated use of the 3D-reproduced environment and wrapped 360 videos (perceived as 180-degree shots) as an effective approach to Senerchia and its heritage. However, they also mentioned how all these elements detached them from a real representation of the town:
Participant 01 – “The use of 3D is very appropriate; we perceive the space better. I think that visualising the physical aspects of the town is important in this documentary as this is the town's story... The foreground vanishing as we move along bothered me a little because it was making it harder for me to think of it as a real space”;
Participant 02 – “I thought the overlap of 180-degree footage sometimes over some interview sequences was interesting... The 3D was really good, though the black of the sky was off-putting to me”.

We discussed this ‘Real’ vs ‘Hyper-real’ representation of the town with participants, explaining that the reason behind this decision was the need to provide a hyper-real experience and engagement to reproduce the in-between nature of the place (i.e. the ruins of the old town representing a landscape frozen in the past, but still iconic and important for the community today; Iteration 2). Participants appreciated this choice

but suggested making this detachment from reality visually clearer in the 3D immersive environment.

The 2D linear film was also live-streamed on the Facebook page of the project on the 40th anniversary of the 1980 Irpinia earthquake

(<https://www.facebook.com/ItaliaTerremotata>). The film was presented during an event co-organised with the municipality of Senerchia and some of the participants in the co-design/co-creation process. This online conversation provided an opportunity to engage with members of the community affected by the 1980 earthquake who had not been directly involved in the design activity. Almost 300 people participated in the event, with more than 4000 visualisations of the recorded video.

While some of the participants from the workshop are still living in Senerchia, others had migrated to cities both in Italy and across the world (e.g. UK/France/Spain/North America/ Argentina/Venezuela), before or after the earthquake. This event was a great opportunity to reconnect with people and plan for future activities and events to revitalise the town of Senerchia and the surrounding area. Everyone greatly appreciated the film and after the event we received some private messages from people who wanted to share their feelings after having seen the documentary. One message was especially important, as it validated the visual representation of our

ethnographic work. This was sent by a citizen of L'Aquila who experienced the 2009 earthquake, which badly damaged that city killing 303 people. They wrote:

Very interesting and emotionally engaging work. While watching it we have re-experienced emotions that are still very fresh. It is so true, the time for us is split between before and after the earthquake and... indeed we are not the same people as before. Here [in L'Aquila] we have been luckier though; the more timely interventions and a more considerate reconstruction plan show that something has changed in Italy [in relation to the reconstruction stage]...

The feedback received following our interviews and Facebook event allowed us to start designing the VR version of the documentary. The first iteration of this VR design/creation process consisted of splitting the linear story created for the film into multiple narratives. Each was then exported into a separate file to facilitate their positioning in the different areas of the 3D-reproduced town, as well as easier management of the dataset in Unity. The original idea was to reproduce the linear experience of the 2D film (Iteration 2) which alternates the narrator voice accompanying exploration of the 3D-reproduced point-cloud with people stories; a combination of video-interviews and 360 videos of emotional landmarks in the town that trigger memories (Fig. 7).

In the first prototype of the VR application, the stories and narrator's voice were accessed by user proximity – the user activates the content (i.e. narration starts) when they move in the area of interest. At the end of each story the user can activate the next item in a linear path created for the system. This linear/virtual path reproduces the linear narration of the film (Iteration 2). At this stage of development, this seemed the best solution to allow easy interaction with the stories and other content, but our approach changed after the first testing phase of the VR experience (Iteration 5).

6. Iteration 5/Prototype 4: Improvement of the 3D VR experience

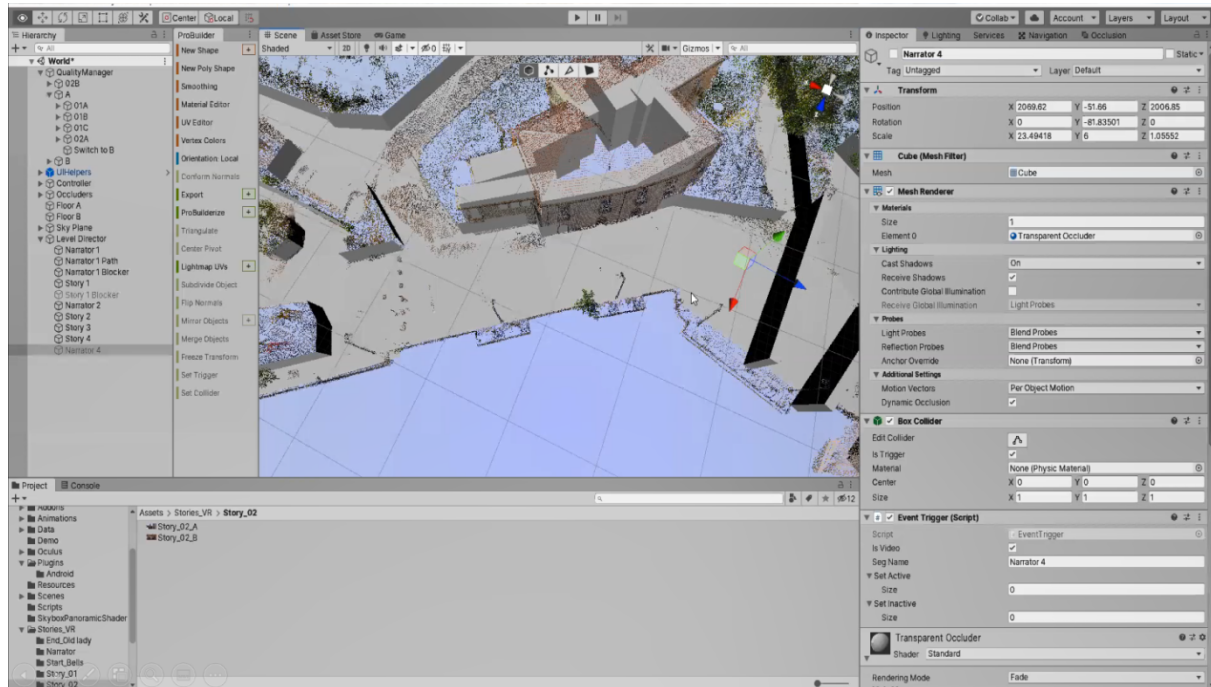
The co-design of the 2D film with citizens of Senerchia was crucial for increasing the community's engagement with the story and familiarity with the audio-visual contents. It also helped them to understand the potential of using audio-visual storytelling for memory recollection and the development of future heritage regeneration strategies. This approach allowed the development team to understand the problems that the community of Senerchia is still experiencing 40 years after the earthquake. It also highlighted current limitations in the regeneration of the old town and future needs in the redevelopment of Senerchia and the surrounding area. This preliminary participatory work established a solid base for the creation of an iterative co-design and multidisciplinary process for the development of the VR artefact, characterised by

the capacity to observe and visualise (Kolko 2015; Razzouk and Shute 2012), to allow the end product to:

- explore people's relationship with the place and their heritage before, during and after the disaster;
- define future strategies aimed at building resilience and heritage regeneration;
- communicate and share the co-design experience and strategies developed in Senerchia with other earthquake-affected communities.

The linear storyboard developed for the 2D film was discussed and reconsidered during focus groups/interactive sessions that used the first prototype of the 3D VR application as the central instrument/artefact for brainstorming the effectiveness and limitations of the immersive narratives developed from the linear 2D experience.

While interacting with the 3D systems in Unity (Video 2), we had the opportunity to observe the linear storyboard in the 3D environment and to consider its limitations in the 3D space.



<insert Video 2>

During these interactive sessions we recognised the following gaps/limitations of the system:

Linear storyboard not effective for the spatial distribution of the stories. The linear storyboard was effective for the first part of the 3D immersive environment because of the linearity of the 3D-reproduced space of the old town (Fig. 7), the layout of the old town being compact, with houses side-by-side along the main road (Via Vallone). Here, the stories are distributed on a linear path which works perfectly in the original linear storyboard. The new town, however, has a sparse layout in which the spatial

positioning of the stories does not overlap with the linearity of the original storyboard, so it was necessary to reconsider and adapt the interaction with these stories to reflect this. After considering various options, we decided to divide the VR experience into different sections/blocks:

- stories before the earthquake (Old Town);
- stories during the earthquake (In between virtual space);
- stories after the disaster (New Town).

The user had to interact with the contents of each section before accessing the stories of the following block. Interaction with stories in each section/block is free and non-linear, the user choosing the order, while advancement between sections is linear. This fragmented interaction with the different sections also facilitates the management of the large datasets in the VR system, allowing separate loading of the contents during the different stages of the experience.

Visual representation of the earthquake as a rupture. The virtual context/space of before and after the earthquake was very clear and easy to develop, the morphology and nature of the place and landscape guiding us. The old town was the natural context for the stories describing life before the earthquake, while the reproduction of

the new town was used as virtual space to host stories of resilience and reconstruction after the disaster. The most difficult aspect of the design process was the selection of an effective audio-visual representation that could host the stories of loss and pain at the moment of the earthquake. After experimenting with the saturated visual contents (360 panorama and videos) used in the 2D film, it was immediately clear that this solution was not able to provide the same effective and emotional engagement with the stories as in the 2D film for both technical (poor quality of the 360 B&W video-rendering in Unity) and experiential reasons (same positioning of stories in the 3D space did not provide the rupture effect needed for these during-earthquake narratives).

To reproduce this rupture and moment of sorrow in the VR space, it was necessary to create a detachment between the 'before' and 'after' of the disaster. We decided to recreate a virtual hyper-real suspended space to move the user away from the realistic reproduction of the town for a moment of self-reflection on the impact that this life-changing disaster had on the citizens of Senerchia. This approach, which has already been tested successfully in other VR storytelling projects (e.g. *The Crossing*), immerses the user in a virtual black environment in which it is possible to access the stories of loss and pain of members of the community who lost their loved ones during the 1980 earthquake. This new structure in the VR application also addressed the feedback

received from members of the community who suggested making the separation of the 'before' and 'after' spaces more evident.

Non-linear interaction of the stories facilitated by 2D navigation map. The non-linear and free interaction with the stories within each section required the development of a tool that could guide the user through their experience in the 3D-reproduced environment. This requirement was also mentioned by members of the community who suggested we needed to show clearly the position and spatial relationship between stories in the immersive space. We developed a 2D interactive map of the town that could help users to locate the stories (i.e. hotspots on the map) and decide their non-linear experience/interaction.

7. Conclusions and future developments

Italia Terremotata used a design-thinking and participatory approach that integrated ethnographic research and multimodal storytelling for the development of a place-centred VR immersive artefact. This artefact is at the centre of the co-design process and embeds the place-values that the community assigns to the lost heritage in the digitally reproduced landscape. This value-led approach considers the vulnerability of

communities affected by environmental trauma, with 'vulnerability' and 'empathy' as the central design values of our iterative framework and prototyping process.

This project is a clear example of the relevance of correlating creative design and participatory and practice-based research to produce new and more meaningful knowledge in heritage research. Here the VR artefact becomes a means of fostering discussion between researchers, policymakers, and community members on practice, as well as an open conversation that informs heritage theory and knowledge production (Candy and Edmonds 2018). As McNiff and Whitehead (2002: 4) have noted in relation to active research-generating theories, 'creating ideas begins with practice, and is located within the practice. As the practice evolves, so too does the theory'. They argue that 'practical, experiential theorists should have status equal to abstract theorists in corporate and higher education contexts', since they are in the frontline of social theorising and making holistic cultural, social and intellectual progress (ibid: 20).

The creation of the *Italia Terremotata* VR experience was conceived from the beginning as a creative act aimed at observing the process, rather than analysing the VR artefact after the fact (Skains 2018).

The design concept that we developed with members of the community explored both the physical landscape (tangible heritage) and its 3D digital replica, as well as people's identity, traditions, and memories (intangible heritage) through the co-design of multimodal stories via various media types (360-panorama/audio-video interviews/sound from natural environment/music/poems). The underlying idea of this multidisciplinary and participatory approach was to use the VR artefact as an open laboratory to reconnect people with the abandoned/lost place and build future strategies for heritage regeneration.

This research illustrates not only how a socially relevant design system (VR immersive application) can result from the iterative process, but also how co-design and active participation of the community can stimulate interest and new energy for future work and activities in Senerchia and the surrounding area. The impact of this work on future heritage regeneration is well-demonstrated by the community's engagement in new socio-cultural activities aimed at the preservation of the place, including the concept of a 'Museum of Resilience' that could host people's stories and memories alongside the digital outputs produced during this research.

While the participation of a few members of the community was instrumental and critical for the co-design of the VR application, future developments of this research will include:

- long-term evaluation of the use of VR artefacts for lost-heritage revitalisation with a larger number of participants from Senerchia;
- evaluation of the VR application with other communities in Italy affected by more-recent earthquakes (e.g. L'Aquila 2009, Central Italy 2016);
- creation of an adaptable co-design-thinking framework that could be used by other communities affected by natural catastrophic events.

Investing in the application of our iterative process in other regional contexts both within Italy and elsewhere is a necessary step to develop a flexible approach that fully integrates value-led methods and tools into everyday heritage practice. In order for this co-design approach to be actively implemented and impact on preservation and management policies for lost heritage in the context of natural catastrophic events, it needs to demonstrate its efficacy and adaptability to other regional and national socio-cultural contexts.

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