EUROGRAPHICS Workshop on Graphics and Cultural Heritage (2021)
A. Chalmers and V. Hulusic (Editors)

Tangible Interfaces for VR Cultural Heritage Application - School House Virtual Museum

Vedad Hulusic[1], Linda Gusia[2], Nita Luci[2], and Michael Smith[1]

[1]Bournemouth University, Faculty of Science and Technology, United Kingdom
[2]University of Prishtina, Faculty of Philosophy, Kosovo

Abstract

Virtual museums are an important medium for the preservation and dissemination of tangible and intangible cultural heritage as well as for education and public engagement. This is even more important now that focus is being shifted from museum exhibits to the visitors' experience and the increased attention given to their mobility, and the plurality of voices and perspectives represented. To enhance experience and participation new techniques are being developed and multiple senses stimulated. This paper offers venues to unpack the potentials of VR as a pedagogic vehicle when creative and cross-disciplinary experimentation is employed in and around digital museums. Grounded in a particular site of memory, and co-produced with a 'post-memory generation', the School House Virtual Museum is associated with private and silenced memories of past civic resistance in Kosovo. Using written and orally narrated stories, images, videos and immersion within a virtually reconstructed physical space, the experience offers a means to explore spaces, narratives, and technologies relevant to a particular cultural memory and heritage. The main aim of the user study, with 37 participants presented in this work, was to investigate the design of the system, focusing on three aspects: usability, User Experience (UX) and education, and the effect of the tangible interface provided to one user group. The results are overall very positive and confirm that the UX holds potential as a learning and education tool whether in museums, schools, or when used independently.

CCS Concepts
• ***Human-centered computing*** → ***Virtual reality;*** *HCI design and evaluation methods;* • ***Applied computing*** → *Education;*

1. Introduction

With the advancement of new capture, storage, display and interaction technologies and techniques, Virtual Museums (VMs) have been increasingly used [VIM21] both as counterparts of existing physical museums [Bri20, Kai15] and as independent platforms for cultural heritage preservation and presentation [MOR19, Son19]. In addition, Virtual Reality (VR) technology has become mainstream and affordable to the general public, allowing for rich, immersive and emotionally engaging experiences, that combine the educational and participatory goals of museums with playful interaction. One of the main advantages of virtual museums is their accessibility, so that ideally anyone, from any part of the world, can engage with the museum content without needing to travel and reach the site physically. Access to museums and collections is already restricted due to limitations in mobility (visa regimes, conflict, economic and other barriers), but became more explicitly visible during the Covid-19 pandemic and global travel restrictions. However, virtual museums rupture some of these barriers allowing their visitors to fully engage with the artefacts, exploring them through various means, including narrated stories (written and oral), images and videos (documentary and artistic), and interaction and exploration of 3D replicas that can be looked into and manipulated in a way that is not possible in physical museums. Artefacts in virtual museums can consist of 3D representations of preserved intact physical artefacts (digital replicas), those damaged and partially preserved, or non-existing, recreated using virtual reconstruction techniques. Traditional methods for digitising intangible heritage are mainly based on scanning textual and the recording of audio and video materials. Once digitised, these materials need to be stored and finally displayed to achieve their full potential. Virtual museums represent a great medium for preservation and presentation of intangible cultural heritage by allowing exploration of curated material in an engaging way within an immersive virtual environment, ultimately engaging and teaching wider audiences.

In this paper we present the School House Virtual Museum (SHVM) based on research in archives, material collected for the period of 1953 – 1998, interviews, and workshops with young people, with a focus on the events of the 1990's in Kosovo. The curated contexts intend to facilitate learning and critical reflection of historical and socio-political contexts contributing to ways in which VMs and educational institutions might design and develop pedagogical tools. In this VR application we used tangible user interface al-

DOI: 10.2312/gch.20211404

lowing users to interact with physical proxies that provide passive haptic feedback. We investigate the system usability and user experience and the effect of the tangible interface on user experience. The main contributions of this work are:

- Investigation of the effect of Substitutional Reality [SVG15] and tangible user interface on user experience in VR cultural heritage applications;
- Employment of creative and cross-disciplinary experimentation between VR technologies and social science methodologies, including innovative and critical, yet safe, explorations of selected spaces, as an alternative means of engaging and co-creating historical knowledge;
- Offering a replicable model to formal and alternative educational institutions, museums and programs on topics of cultural heritage, memory and history;
- Storage of and access to a curated collection serving the public in the absence of a physical museum space, enhancing institutional capacity for dissemination and stakeholder networking towards the conceptual design of a physical museum.

2. Related Work

According to the UNESCO convention for the safeguarding of intangible cultural heritage [UNE03] the main domains that define ICH are oral traditions and expressions, performing arts, social practices, rituals and festive events, knowledge and practices concerning nature and the universe and traditional craftsmanship. Baker has also included political and ideological beliefs that influence cultural practices and history, cybercultures in the digital world, and emerging cultural practices which could or will become the heritage of the future [Bak13]. Recommendations on digital cultural heritage and tourism by Athena Plus [Ath17] focus on some important elements that have been considered when designing the project. They recommend: the involvement of volunteers in the digitisation process; augmenting traditional information and education tools by using innovative technologies in order to make heritage more engaging; E-Inclusion, where usability requirements and user feedback are being taken into account; establishing synergies with all relevant public and private stakeholders at the local, regional, national, and international levels; and analysing user needs and satisfaction.

Museums and virtual museums are considered learning environments and are commonly used for non-formal learning [SFKP09, FD18]. One method of learning in which an individual does more than act as a passive listener, called active learning [BE91], allows enhanced engagement with the content and the learning process, resulting in better comprehension and learning [BF00]. This can be successfully utilised in educational video games [Bar17, HP12], including cultural heritage serious games [AML*10], and through immersive technologies, such as virtual, mixed and augmented reality [TMSG20, SRH*20, vdSLX*19]. In all these media, active learning is promoted as the player is required to play, engage and interact with the content. Another theory, situated learning, which is intrinsic in VEs, suggests that learning is enhanced when it takes place in specific environments and contexts in which the learning materials are used and which are meaningful to the learner [LW91]. Similarly, academic evidence suggests the relevance of civic, cross-disciplinary and cross-sectorial educational models that combine methods of formal and non-formal learning for young people [LSS20]. This is especially true for learning and training aimed at promoting the values of active citizenship, intercultural dialogue and civic participation [DM, LN, SSS]. Specifically, focus on process and not just outcome facilitates parity in participation towards not just representation and recognition but also possible ground for redistribution relevant to underpinning pillars of social justice, including in education and museums [JM17, Vin20].

2.1. Interfaces and Interaction in VR

Virtual Reality has a potential to provide rich experiences by using audio-visual computer-generated or reproduced content typically delivered through a VR headset. As a medium, VR can enhance such experiences and make the immersive through embodiment, flow, engagement, as well as by inducing place illusion - a sensation of “being there”, and plausibility illusion - a sensation of the presented scenario actually occurring [Sla09]. A recent study has shown that high levels of presence, engagement and immersion can be sustained in archaeological VR applications [ŠRC*20].

When interacting with the environment in real life, we typically use our body, such as hands, to grasp, pick, move, squeeze or do something else with the world around us. In VR applications, this is typically not the case. When interacting with the VE, most commonly we either use VR controllers, or hand gestures. While we can feel the controllers in our hands, they do not represent the objects that we might pick or touch. Similarly, when using hand gestures, even though we might see the virtual representation of our hands, we do not have any haptic sensation when interacting with the VE. In order to achieve that, haptic feedback needs to be provided. This feedback can be active, which uses computer-controlled actuators to actively exert forces and provide haptic simulation to a part of the human body. This involved additional hardware, such as Phantom device [MS*94]. On the other hand, the feedback can be passive, not requiring any additional actuators. One example would be to use a rubber band between one’s hand and shoulder, so that once the arm is stretched, the rubber band produces passive haptic feedback. However, in VR systems with passive haptic feedback, this is generally obtained by using physical counterparts to virtual objects [Ins01]. These can be made as low-fidelity proxies and used for tangible user interface. The user then sees the virtual object in the VE and can touch the physical proxy that provides haptic feedback based on its shape and structure. An important element when using tangible interfaces is the mismatch between the two, whether it being the shape, size, weight, texture, or something else relevant to the user [KKL09, SVG15].

Another important part of any interactive system is the user interface. Menu interfaces enable additional, extended functionality to be added to the system. While in conventional 2D systems, using menus is a very common interaction style, different techniques have been explored and taxonomies have been proposed [DH07] for designing 3D systems. One approach is to use common 2D menu types in 3D VR environments, such as pop-up and pull-down menus [JE92, BW01].The other approaches include spin / ring menus [GB05] and diegetic interfaces [SPR*17]. As part of the game world, these interfaces exist and are visible to the player

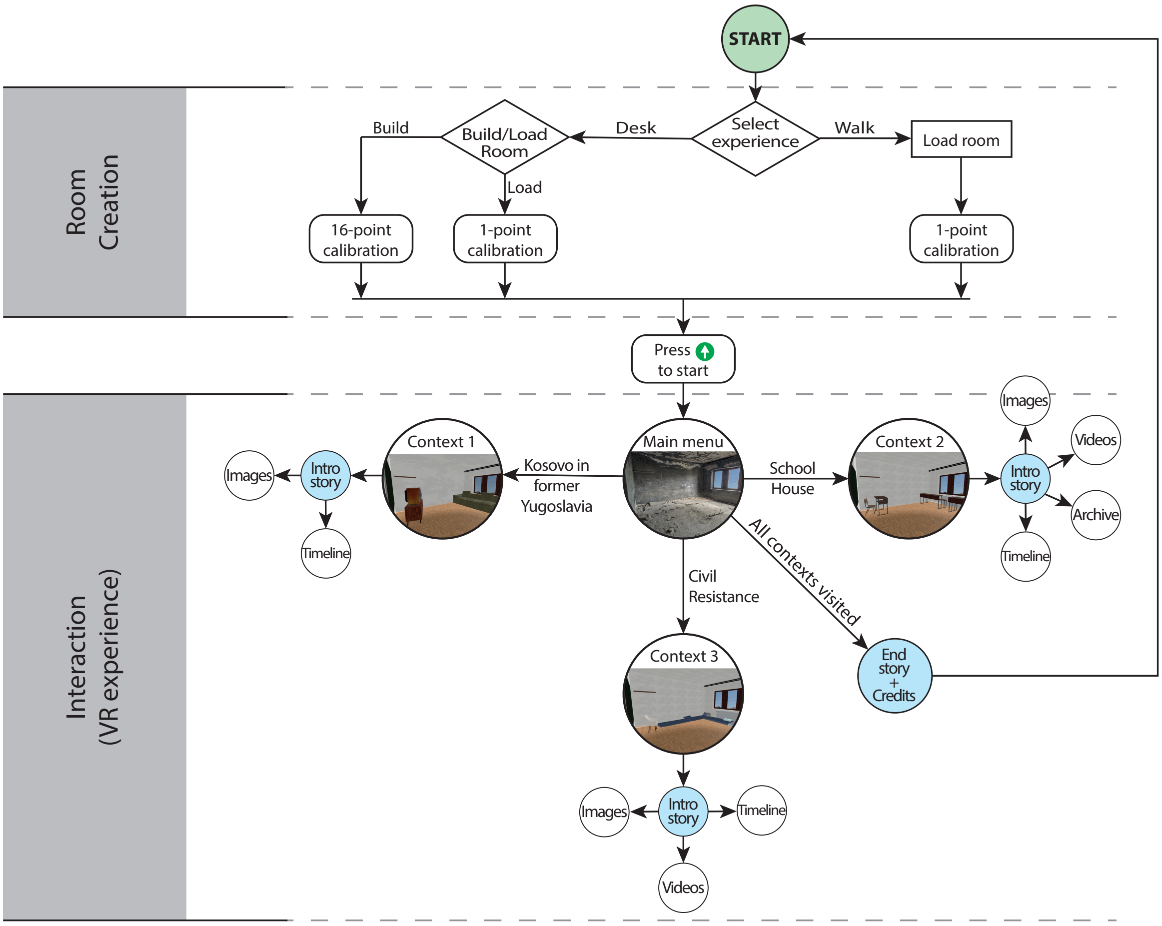

Figure 1: *A flow diagram showing the system structure and the interaction between the user and the system.*

and the player's character. Such interfaces combined with passive haptic feedback can provide a very realistic experience in VR simulations.

3. School House Virtual Museum

In May 2018, the Municipality of Prishtina announced that the house which saw the graduation of ten generations of high-school students between 1991 and 1999 would transform into the "Hertica" School House Museum. This house, as well as 3,000 other similar spaces, were the backbone of Kosovo's civic and peaceful resistance movement to the Milosevic regime. Histories and remembrance of the period have stood in tension with dominant narratives of the 1998-1999 war, and have been a largely silenced history, especially for the "post-memory generation" [Hir12] who have no personal experiences of war or the school-house system and account for almost 50% of the population.

In line with the recommendations outlined in Athena Plus [Ath17], as well as UN SDGs [UN15], and Kosovo's own national cultural heritage strategy [Min16], through a participatory action research framework and methodology we set out to design a museum experience based on a shared concept of museums as open, living and networked spaces, where learning and research is transformative, and where co-creation and inclusion underpin their vision. The SHVM aims to engage multiple voices and actors into further developing the conversation on tools and methods - to disseminate, archive and engage - through new digital technologies in making cultural heritage relevant to public interests.

3.1. Virtual Museum Application

The VR experience is based on three years of research [SHM21, Bou21, Uni21] relying on participatory, interdisciplinary and co-creative methods with students at the University of Prishtina. The three contexts designed for the SHVM – Kosovo in former Yugoslavia, Civil Resistance, Schoolhouse, Figure 1 – have been curated to include historical context and the aura [Ben69] of the time, necessary for understanding the school-house system and the contours of the political and social dynamics, and power structures, that enabled and sustained the civil resistance movement. The chronology of events (timeline in Figure 1), synthesis in video-materials, photos and interview selections, as well as particular care of the soundscape, offer entry points for the participant to connect with

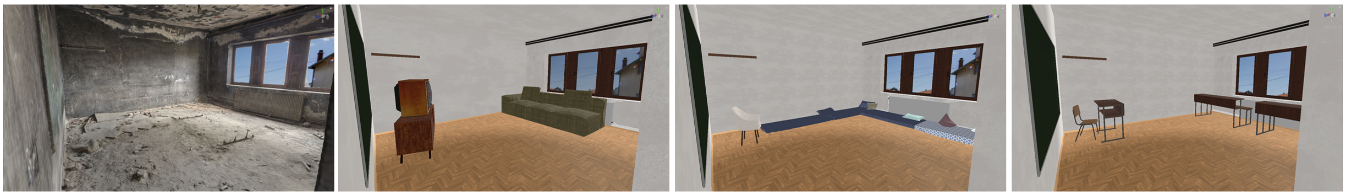

Figure 2: *Four environments used for the main menu, and the three stories/contexts (left to right).*

events of the past. Connection with the space of the school becomes particularly important because it invites questions about the relevance of affect, of witnessing and personal experience in history making and narrative construction. The intersection of the personal with the political, foundational in feminist thinking also serves as ground for reflecting on what is ultimately always a process of selection, when sorting, collating and narrating the research material. As former students of the "Sami Frashëri" High School, the researchers invited the participants to engage in epistemic vulnerability, which is often omitted in official historiographical accounts [Log13].

The chronology and imagery for the first context focuses on the dominant story of modernisation in Kosovo, and socialist Yugoslavia, and selects the centrality of education to this history. The context of civil resistance chooses to explore the practices and extent of social mobilisation and solidarity in opposition to structural and state violence. The narrative is mostly based on archival video-footage, show-casing a time of dynamic and radical social change. The school-house context relies on extensive research, including interviews, personal and public archival materials (media, school documents, letters, etc.) to illustrate how a very unique system was thought and lived and why it became considered the backbone of civil resistance. We recognise that there are many other histories, events and stories to be told, all intersecting, and not fully presented here.

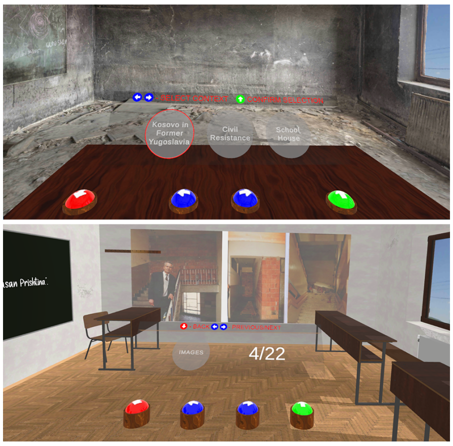

Figure 3: *The two conditions: 'Desk' with the context selection in the destroyed room (top) and 'Walk' with the image section within the School House context (bottom).*

3.1.1. System Design

The project was built within Unity as it allowed quick and easy interaction and integration for the Oculus Quest and Quest 2. The application is split up into two main experiences, *Desk* and *Walk*, Figure 1. The content in both experiences is identical. However, the desk experience utilises tangible interface through Substitutional Reality, whereas in the walking experience the interface floats in space with no tangible elements, Figure 3.

The main menu starts with the player (typically administrator) in an empty void with a large plane underneath them to act as a floor. The menu consists of two options, 'Build room' and 'Load room'. The former will allow the player/experimenter to calibrate the room, so that the position and dimensions of the desk, chair, buttons and rooms can be calculated. The latter will get the saved calibration data and use it to recreate the room. This can only be done after the room has been built once. Upon calibration, the room model created using photogrammetry of the room in its present state is displayed. The room used for all the other contexts is a depiction of what a room would have looked like and is created using the traditional 3D modelling techniques, Figure 2. From here, the player can go to one of the three contexts, each with a different environment which complements the narrative of the time period and the corresponding story, Figure 2. The first has a TV, cabinet and sofa to depict a house and somewhere that is lived in. The second room represents the beginning of the transition into school houses and can be seen by the mattresses and pillows on the floor where pupils used to sit. The room for the last context has school desks and benches looking more like a classroom. The background music for each context has been composed by a sound designer based on found and recorded sound, further generating a situated soundscape through context-specific sounds, e.g. pans and keys, representing resistance and rebellion.

3.1.2. Room Creation

The room is created by using a 16-point calibration process which places the room, desk, buttons and the chair accordingly, Figures 4 (left) and 5. This allows (re)creation and calibration of the room in any physical location and to any desk and chair sizes. The calibration is performed using the Quest controllers. The left controller has floating instructions that will tell the player what step of the calibration they are on and what steps to take. The right-hand controller provides a position and orientation of the device, which is used for calculation of the scale, place and rotation of the room, desk, buttons and chair models. The initial anchors are set by the first click, whereas the scaling for the desk and chair needs to be further assigned by setting the height left, right and rear edge. Once

Figure 4: *The example of room creation (left) and interaction within the VM (right). In both cases the in-game view is displayed in the top-left corner.*

the positions, scale and rotations are calculated from these points, the textures are updated so that the material on these objects look correct.

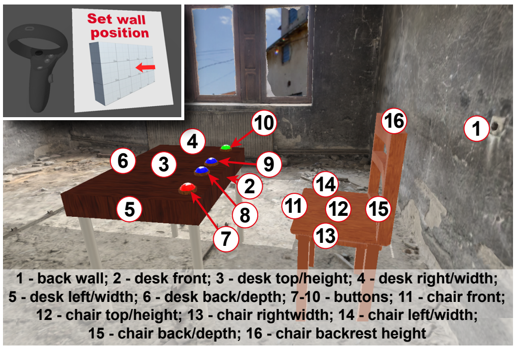

Figure 5: *Calibration of the scene in 'Desk' condition. Top left part displays the instructions attached to the left controller. Numbers show the points of calibration for the room, desk, buttons and chair.*

The walking experiences is calibrated using the same calibration but with only one calibration point - the centre of the rear wall (point 1 in Figure 5) as there is no desk and chair. The buttons are pre-placed manually in a location in front of the player and the content, so that the content does not go through the top of the room model.

3.1.3. Interaction

In both conditions, the main interaction is done using the Oculus built-in hand recognition in order to make the experience more intuitive, usable and immersive. The hands are a mesh that is mapped to the real position of the players hands using outfacing infrared cameras on the headset, and colliders are attached to the mesh bones allowing physical objects to collide with the virtual hands. All user interaction is done with four buttons that are mainly used for *Back/Level up*, *Left*, *Right* and *Select/Level down* functions that allow users to move through the content of the VM, Figure 4 (right). However, in a few instances, such as playing videos, the first and the last buttons are used to Pause and Play the video respectively. The functionalities of the buttons are always written at the top of the front panel in front of the player. The buttons are implemented as game objects that have a spring component attached to them in order to behave like their physical counterparts (in Desk condition) and provide passive haptic feedback. When the button is pressed down, the sphere collides with a trigger. The script attached calls the corresponding function to be called either changing the highlighted UI, selecting a context, selecting an image, video or document to view, or leaving a context or finishing the experience.

4. User Study

The main aims of the user study are to investigate the usability and user experience (UX) of the system, and the effect of the tangible interface provided to one user group. In addition, we aimed to gauge whether the SHVM holds potential as a learning and education tool either in museums, schools, or independently.

4.1. Design

For the experiment, between-subject design was utilised with two user groups, one of which has been exposed to the tangible ('Desk' condition) and one to the intangible ('Walk' condition) experience, Figure 3. In the first condition, the participants could see a chair and a desk, with four buttons on it, which existed in the physical space and whose locations matched those physical counterparts. Unfortunately, due to a cumulative mismatch issue, the physical buttons in the Desk condition have been removed. Besides the basic demographics data, the participants were asked for their VR experience and if they attended any and/or the "Sami Frasheri" house school. For evaluating both the usability and UX two commonly utilised questionnaires were used: System Usability Scale (SUS) [B*96] and the Game Experience Questionnaire [IDKP13]. Our research hypotheses were:

- H1: the UX will be better when using the tangible interface;
- H2: the SHVM can contribute to critical learning based on causal, factual (evidential, not selective) and affective approaches in contrast to only historiographical narratives.

4.2. Participants

37 participants volunteered for the study. Out of 36 participants, 18 were male and 18 female, with the age ranging from 16 to 50 (with an average age of 30.11). One participant declared their gender identity as "agender". 19 participants were assigned to the Desk condition, while the other 18 were assigned to the Walk group.

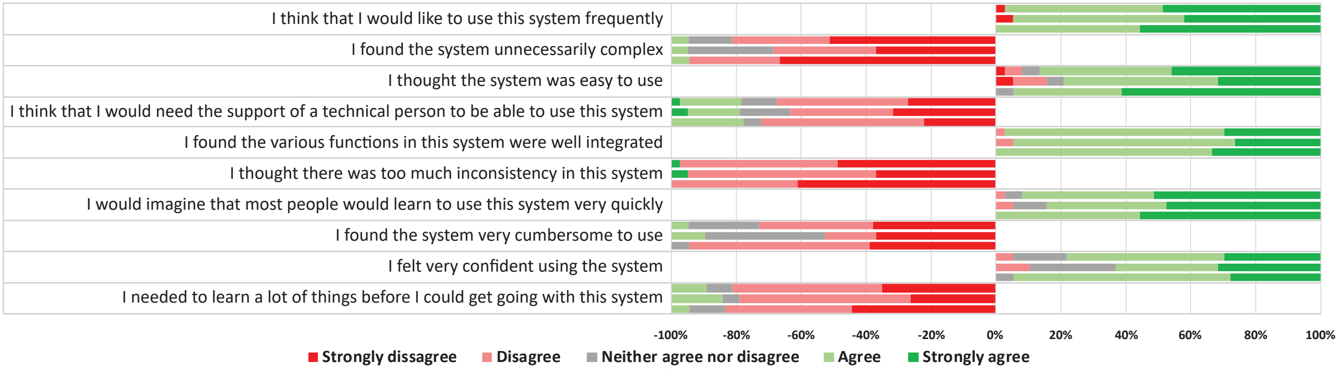

Figure 6: *Questions from the usability questionnaire (SUS) and the distribution of the user responses for all user (top bars), Desk condition (middle bars) and Walk condition (bottom bars).*

On the scale $0-3$ (0-none, 1-basic, 2-moderate, 3-high), the average reported VR experience was 1.08, with 12 participants reporting they have never used VR. Seven participants attended house schools, and only one attended "Sami Frasheri" house school. Finally, six participants were international (two in Desk and four in Walk condition); all other were from Kosovo.

4.3. Apparatus

All the experiments took place in a dedicated, quite test room. The virtual museum was ported to Oculus Quest 2 VR headset. In neither condition did participants use the controllers. After the experimenter prepared the experience, the participants would use the embedded hand tracking feature and interacted with the environment and in-app interface with their hands.

4.4. Procedure

Upon arrival, the participants were greeted and given the participant information sheet and participant agreement form to read and sign. They were then given detailed instructions on how to use the system and asked if they had any questions about the nature of the experiment and their task. This was followed by the experimenter selecting the desired condition in the app and, once ready, giving the participants the VR headset. The participants were told they can take as much time they liked exploring the content of the virtual museum in any order. Upon completion, i.e. once they visited all three contexts, and returned to the main menu, the end story with the current state of the house school and credits were displayed. Finally, they returned the headset to the experimenter and were asked to fill in the questionnaires.

5. Results

The participants spent between 15 and 50 minutes using the application, with the average of 27m45s. The spent around 1 minute and 30 seconds more on average when using the Desk condition (28m29s) compared to the Walk condition (26m56s).

5.1. Usability Study

For testing the usability of the system the SUS scale was used [B*96]. The questions and the corresponding responses from the study are presented in Fig 6. Using the score calculation as suggested in [B*96], the overall SUS score based on ratings of all participants was found to be 79.46. The score for the Desk condition was 75 and for Walk condition 84.17, see Fig. 7. This confirms that the system has been well designed and accepted by the users with some elements still needing improvements. The Desk condition has been rated slightly lower, compared to the Walk condition. This might be due to some minor issues with cumulative mismatch between the virtual buttons and the physical proxies [SVG15]. Also, the usability scores could have been affected overall by the relatively low VR experience among the participants (32% of participants had never used VR before and 27% had used it only once). Nevertheless, the Pearson correlation between the two variables has been found as low, $r(35) = .25, p = .072$.

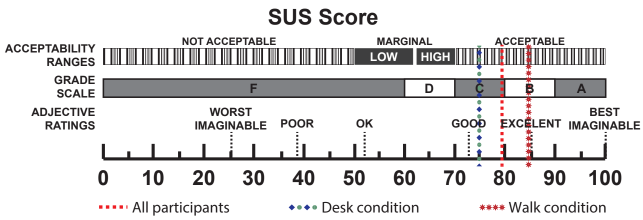

Figure 7: *Grade rankings for SUS scores as proposed by Bangor et al. [BKM09] for all user (red dashed line, 79.46), Desk condition (blue-green circle-square line, 75.00) and Walk condition (orange star line, 84.17).*

5.2. User Experience (UX)

In this study, a subset of 27 questions from the Core module of the Game Experience Questionnaire (GEQ) [IDKP13] was used, covering all seven UX components. The questions were evaluated on a 5-point Likert scale, 1 being 'Not at all' and 5 being 'Extremely'. The average scores for all participants and per condition, across all

Table 1: *UX mean score values per question (Q) and per component (C) on a 1-5 scale, 1 being 'Not at all' and 5 being 'Extremely'. The first column represents the order of the question as found in the original GEQ questionnaire.*

No	Component	Question	All		Desk		Walk	
			Score (Q)	Score (C)	Score (Q)	Score (C)	Score (Q)	Score (C)
2	Competence	I felt skillful	3.42	3.51	3.11	3.19	3.72	3.83
11		I felt competent	3.59		3.26		3.94	
3	Immersion	I was interested in the story	4.89	4.35	4.89	4.44	4.89	4.25
12		It was aesthetically pleasing	4.14		4.32		3.94	
18		I felt imaginative	3.89		4.16		3.61	
19		I felt that I could explore things	4.27		4.32		4.22	
27		I found it impressive	4.49		4.53		4.44	
30		It felt like a rich experience	4.41		4.42		4.39	
5	Flow	I was fully occupied with application	4.34	3.69	4.35	3.85	4.33	3.53
13		I forgot everything around me	3.56		4.00		3.11	
25		I lost track of time	2.94		3.11		2.78	
28		I was deeply concentrated in the application	4.27		4.26		4.28	
31		I lost connection with the outside world	3.35		3.53		3.17	
22	Tension/ Annoyance	I felt annoyed	1.33	1.21	1.33	1.19	1.33	1.24
24		I felt irritable	1.08		1.06		1.11	
29		I felt frustrated	1.22		1.17		1.28	
11	Challenge	I thought it was hard	1.46	1.66	1.47	1.74	1.44	1.58
33		I had to put a lot of effort into it	1.86		2.00		1.72	
7	Negative effect	It gave me a bad mood	1.37	1.39	1.47	1.43	1.28	1.35
8		I thought about other things	1.64		1.56		1.72	
9		I found it tiresome	1.36		1.47		1.24	
16		I felt bored	1.20		1.22		1.18	
1	Positive effect	I felt content	4.17	4.26	3.78	4.07	4.56	4.46
4		I thought it was fun	4.36		4.28		4.44	
6		I felt happy	4.03		3.63		4.44	
14		I felt good	4.17		4.06		4.28	
20		I enjoyed it	4.59		4.63		4.56	

the questions and components are presented in Table 1. The results are overall very positive and fairly similar across the two conditions. The competence was rated relatively high (3.51) given the lack of experience in using VR. The immersion score is very high overall (4.35), and even higher in the Desk condition (4.44). The flow is rated reasonably high (3.69) with a higher score for Desk condition (3.85) than for Walk condition (3.53). However, it might have been negatively impacted as the experiment was conducted in a public space, and there was some external noise (e.g. babble of voices). Tension/annoyance and negative effect have been both rated very low (1.21 and 1.39 respectively). The average score for challenge, based on the two questions was 1.66 overall, which is a positive outcome given that this was the first time one third of participants had used VR. Finally, the positive effect was very high (4.26), with a slightly higher result for the Walk condition (4.46) compared to the score for the Desk condition (4.07).

In addition to the presented usability and UX question, two additional questions were added to the questionnaire as shown in Table 2. The average scores for question 'The buttons felt real' (same Likert scale used as in GEQ) reveals that there was no contribution of the button proxies in the application. However, given that only 7 participant used physical buttons in the Desk condition, this was expected. The other question 'The desk and chair felt real' was asked only in the Desk condition and the high score (3.89) shows that it had a positive effect on user perception of the virtual space.

Table 2: *Questions used to evaluate the presence of the tangible interface and the chair, desk and buttons proxies with the corresponding mean score values.*

Question	Score (Desk)	Score (Walk)
The buttons felt real	3.68	3.67
The desk and chair felt real	3.89	N/A

Finally, at the end of the questionnaire, there was an open-ended question "Is there something you would change, add or remove from the application, or anything you would like to comment". 20 participants (54%) responded to this question, 11 (57.9%) in the Desk and 9 (50%) in the Walk condition. While slightly longer, there responses for the Desk scenario were similar to those in Walk condition. One thing that two participants in the Desk group mentioned is that it would be better to be able to walk around, instead of sitting. Overall, most of the responses were very positive, including comments such as "*The experience was very educational and creative. I learned new things. Visualisation helped me to understand more how house schools were held during the given circumstances. I would highly recommend this experience to everybody.*"; "*I felt I was part of the story for a moment.*"; "*Very impressive, well thought and comprehensive.*"; "*Overall, really cool experience. As someone who had a hard time envisioning that part of the history it made me feel closer to it than ever before.*"; "*Very positive, professional, progressive experience. Inspiring too!*". Participants also said that this virtual museum is very important to learn about and experience this segment of history. A few comments for improving the experience were about having more stories, visual content (images and videos) and classes/rooms, improving the quality of the text to make smaller text more readable, improving the room models and adding more details such as books, school equipment, etc. One participant mentioned it would be better to use the system in a quieter environment. Finally, one participant said they would "*shorten a little bit the videos and reduce the amount of audio-visual material. Focus more on archival material that highlights key events-developments.*".

5.3. The Effect of the Tangible Interface on UX

Since there were two user groups (Desk and Walk) and multiple independent variables, the analysis of covariance (ANCOVA) was utilised. The dependent variable (DV) was the UX score for a particular component, see Table 1, the fixed factor was the condition (Desk, Walk) and the covariates were age, gender identity and VR experience. The result of the Levene's test was not significant for any of the components, hence the assumption of homogeneity has been met. The test of between-subject effects revealed that the age significantly predicts the score for Competence and Positive Effect categories. In both cases the b-value for the covariate was negative, meaning the covariate and the outcome variables had a negative relationship (as the age increases, the outcome decreased). Similarly, VR experience has also been found as significant ($p < .05$) in Flow and Positive Effect categories. In this case, for both categories, the relationship was positive, thus those with more VR experience felt better flow and experienced higher positive effect. Gender identity had significant effect only on competence scores, with male participants self-declaring higher scores. Finally, the effect of condition, i.e. the fixed factor, has been found as significant ($p < .05$) only for the Competence category. This could be due to the fact it takes some time to initially adjust to the idea of tangible interfaces, as well as the mismatch issue and removal of physical buttons in the Desk condition. However, those participants still had passive haptic feedback from the desk and chair. Following these results, we cannot accept our first hypothesis (H1) that the UX will be better when using the tangible interface.

5.4. Education

A critical review [GLS] of textbooks used in schools in Kosovo show that their treatment of cultural heritage is rather limited. These textbooks offer no explanation on the concept of 'cultural heritage', and mainly present tangible/material cultural heritage (sites and monuments). The majority of sites and monuments presented in textbooks lack historical contextualisation and rely on photographic depictions without narrative elaboration. Nothing is said about the importance of museums and cultural heritage and their connection to learning about social and cultural memory and history, values and creative practices, nor do they speak to the relevance of cultural diversity for sustainable heritage models (whether educational, social or economic). The SHVM was thought as a needed intervention, albeit through other means, into this absence and the politicisation of historical narratives in museums and educational curricula and the politicisation of historical narratives in museums and educational curricula.

The number or digital platforms only recently developed in Kosovo by researchers, artists, and organisations, reveals the potential for networking and transforming spaces of learning. Specifically, the study found that a virtual experience connects participants to the material by making an affective and spatial connection by means of "feeling like being there", as one participant noted. Another reported that they "had goose bumps all over" and another participant cried. At the same time, participants' virtual presence in the classroom and engagement with the dense archival and historical chronologies, and video materials, contributed to the desire to "spend more time and learn more", as one participant noted.

The responses received through the questionnaire and informal interviews confirm the reputation of VR as an empathy machine. Whereas this study did not measure results for educational learning purposes, it provided significant indications of venues for further research and design. The aim of using this experience in the classroom would entail further utilising the affective, empathetic connections to the stories as a possibility to move to a more reflexive and critical engagements with the content. Based on post-questionnaire informal interviews, 11 participants with significant experience in cultural heritage and/or educational programs, and 12 educators and students, suggested that the system should be used in schools as well as museums. These would also have to be designed in ways that meet the learning and teaching outcomes and objectives as per the educational level where the tool would be applied.

6. Conclusions and Future Work

In this work we explored the usability and user experience of the new virtual museum developed with tangible user interface and passive haptic feedback. The study has shown that the system is well designed and resulted in a very good user experience. While the usability score was overall lower for the 'Desk' condition with the tangible interface, this is likely to be due to the issue with mismatch that cumulatively increased for each new participant - something not detected while testing by the research team. In fact, looking at the scores provided to the question 'The buttons felt real' by the first 7 participants (5, 4, 3, 2, 2, 5, 5), we can see that it started dropping from from 5 to 2, and after recalibration that removed the mismatch, it went back up to 5. This is unfortunate and will be addressed in the code and further testing. The user experience was similar across the two condition. The only significant difference between the two conditions on UX was found for the Competence component, and the effect of age, gender identity and VR experience has been found to have significant effect on some categories. While this data is valuable, a larger sample and longer exposure through a longitudinal study would be required to make more solid conclusions. Finally, VR and design methods contribute to the creative and exploratory participation of public and the active intellectual, activist, artistic, and political engagement with heritage.

In the future, we will first fix the mismatch issue. Furthermore, we would connect the SHVM UX to the online platform [SHM21] creating more access to archival and research materials, based on user feedback, while extending the VR system so it can pre-load or dynamically load this content and display it in the VM. Finally, when further developed the experience should include guidance on research methods, critical evaluation of sources, guidance on cataloguing materials, and the analytical frame for generating interpretation, and become integrated into the physical "Hertica" School House Museum.

The study has also confirmed interest and possibilities to directly contribute to making cultural heritage a more plural field, specifically as new defining features of museums expand to include focus on education and research embedded in museum experiences that might aim at social justice. With this in mind we will conduct additional research and testing of the SHVM UX and its usability as a pedagogical tool. With an additional user group we will specifically measure learning outcomes through an integrated test for each of the narrative scenarios. Responding to the gaps in the educational and culture system, already noted in this paper, we will aim to develop a learning and teaching methodology for the SHVM, possibly replicable as well, which engages participants in a reflexive exercise regarding both the factual and analytical components of learning. These will include historical chronology, comparison of evidence claims and sources, narrative analysis, etc. This will allow us to test simultaneously the potentialities of VR to function as a learning platform, and its usability for teaching in classrooms, museums, etc., and developing capacities for a critical engagement with research, design and presentation of cultural heritage, sites of memory and historical analysis.

7. Acknowledgements

We would like to thank all the volunteers that took part in the user study. We would also like to thank Paula Callus and Fred Charles for their generous advice during the project, Dritëro Nikqi for SHVM music, Sam Guilmard for help with VR development, and especially Jeta Rexha for her work and support throughout the research process. Special thanks to Dafina Zherka, Shkumbim Brestovci, Lekë Krasniqi, Hazir Reka, Zijadin Gashi, Avdyl Gashi and Alban Kasumi/Lapsi360. The project has been supported by the Bournemouth University, Changing the Story Kosovo Strand phase 2 Making the Museum of Education and phase three Respace.

References

[AML*10] ANDERSON E. F., MCLOUGHLIN L., LIAROKAPIS F., PETERS C., PETRIDIS P., DE FREITAS S.: Developing serious games for cultural heritage: a state-of-the-art review. *Virtual reality 14*, 4 (2010), 255–275. 2

[Ath17] ATHENA PLUS: Digital cultural heritage and tourism recommendations for cultural institutions. https://bit.ly/3hLA36r, 2017. [Online; accessed 15-July-2021]. 2, 3

[B*96] BROOKE J., ET AL.: Sus-a quick and dirty usability scale. *Usability evaluation in industry 189*, 194 (1996), 4–7. 5, 6

[Bak13] BAKER K.: Information literacy and cultural heritage: a proposed generic model for lifelong learning. *Information Literacy and Cultural Heritage* (2013), 117–133. 2

[Bar17] BARR M.: Video games can develop graduate skills in higher education students: A randomised trial. *Computers & Education 113* (2017), 86–97. 2

[BE91] BONWELL C. C., EISON J. A.: *Active Learning: Creating Excitement in the Classroom. 1991 ASHE-ERIC Higher Education Reports.* ERIC, 1991. 2

[Ben69] BENJAMIN W.: The work of art in the age of mechanical reproduction", illuminations. ed. hannah arendt. *Trans. Harry Zohn. New York: Schocken* (1969), 217–52. 3

[BF00] BROWNE M. N., FREEMAN K.: Distinguishing features of critical thinking classrooms. *Teaching in higher education 5*, 3 (2000), 301–309. 2

[BKM09] BANGOR A., KORTUM P., MILLER J.: Determining what individual sus scores mean: Adding an adjective rating scale. *Journal of usability studies 4*, 3 (2009), 114–123. 6

[Bou21] BOURNEMOUTH UNIVERSITY: ReSpace. https://respace.bournemouth.ac.uk, 2021. [Online; accessed 15-July-2021]. 3

[Bri20] BRITISH MUSEUM AND GOOGLE CULTURAL INSTITUTE: The Museum of the World. https://britishmuseum.withgoogle.com/, 2020. [Online; accessed 12-July-2021]. 1

[BW01] BOWMAN D. A., WINGRAVE C. A.: Design and evaluation of menu systems for immersive virtual environments. In *Virtual Reality, 2001. Proceedings. IEEE* (2001), IEEE, pp. 149–156. 2

[DH07] DACHSELT R., HÜBNER A.: Three-dimensional menus: A survey and taxonomy. *Computers & Graphics 31*, 1 (2007), 53–65. 2

[FD18] FALK J. H., DIERKING L. D.: *Learning from museums*. Rowman & Littlefield, 2018. 2

[GB05] GERBER D., BECHMANN D.: The spin menu: A menu system for virtual environments. In *Virtual Reality, 2005. Proceedings. VR 2005. IEEE* (2005), IEEE, pp. 271–272. 2

[GLS] GUSIA L., LUCI N., SELIM G.: Fletorja: The school-house museum toolkit. 8

[Hir12] HIRSCH M.: The generation of postmemory: writing and visual culture of the holocaust. *New York: Columbia UP* (2012). 3

[HP12] HULUSIC V., PISTOLJEVIC N.: "lefca": Learning framework for children with autism. *Procedia Computer Science 15* (2012), 4–16. 2

[IDKP13] IJSSELSTEIJN W., DE KORT Y., POELS K.: The game experience questionnaire. *Eindhoven: Technische Universiteit Eindhoven* (2013). 5, 6

[Ins01] INSKO B. E.: *Passive haptics significantly enhances virtual environments*. The University of North Carolina at Chapel Hill, 2001. 2

[JE92] JACOBY R. H., ELLIS S. R.: Using virtual menus in a virtual environment. In *Visual Data Interpretation* (1992), vol. 1668, International Society for Optics and Photonics, pp. 39–49. 2

[JM17] JOHNSTON R., MARWOOD K.: Action heritage: Research, communities, social justice. *International Journal of Heritage Studies 23*, 9 (2017), 816–831. 2

[Kai15] KAISER FRIEDRICH MUSEUMSVEREINS-KFMV: Virtual Tour Bode-Museum. http://bode360.smb.museum/, 2015. [Online; accessed 12-July-2021]. 1

[KKL09] KWON E., KIM G. J., LEE S.: Effects of sizes and shapes of props in tangible augmented reality. In *2009 8th IEEE International Symposium on Mixed and Augmented Reality* (2009), IEEE, pp. 201–202. 2

[Log13] LOGUE J.: The politics of unknowing and the virtues of ignorance: Toward a pedagogy of epistemic vulnerability. *Philosophy of Education Archive* (2013), 53–62. 4

[LSS20] LUCI N., SCHWANDNER-SIEVERS S.: Epistemic justice and everyday nationalism: An auto-ethnography of transnational student encounters in a post-war memory and reconciliation project in kosovo. *Nations and nationalism 26*, 2 (2020), 477–493. 2

[LW91] LAVE J., WENGER E.: *Situated learning: Legitimate peripheral participation*. Cambridge university press, 1991. 2

[Min16] MINISTRY OF CULTURE, YOUTH SPORT: National Strategy for Cultural Heritage 2017-2027. https://mkrs-ks.org/repository/docs/eng_strategy_for_heritage.pdf, 2016. [Online; accessed 16-July-2021]. 3

[MOR19] MOR: Museum of other realities. https://www.museumor.com/, 2019. [Online; accessed 12-July-2021]. 1

[MS*94] MASSIE T. H., SALISBURY J. K., ET AL.: The phantom haptic interface: A device for probing virtual objects. In *Proceedings of the ASME winter annual meeting, symposium on haptic interfaces for virtual environment and teleoperator systems* (1994), vol. 55, Chicago, IL, pp. 295–300. 2

[SFKP09] STYLIANI S., FOTIS L., KOSTAS K., PETROS P.: Virtual museums, a survey and some issues for consideration. *Journal of cultural Heritage 10*, 4 (2009), 520–528. 2

[SHM21] SHM: Shtëpia-Shkollë-Muze. http://shtepiteshkolla.net/, 2021. [Online; accessed 15-July-2021]. 3, 9

[Sla09] SLATER M.: Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philosophical Transactions of the Royal Society B: Biological Sciences 364*, 1535 (2009), 3549–3557. 2

[Son19] SONY MUSIC ENTERTAINMENT (JAPAN) INC. AND PLANETA: David Bowie Is. https://davidbowieisreal.com/, 2019. [Online; accessed 12-July-2021]. 1

[SPR*17] SALOMONI P., PRANDI C., ROCCETTI M., CASANOVA L., MARCHETTI L., MARFIA G.: Diegetic user interfaces for virtual environments with hmds: a user experience study with oculus rift. *Journal on Multimodal User Interfaces 11*, 2 (2017), 173–184. 2

[ŠRC*20] ŠKOLA F., RIZVIĆ S., COZZA M., BARBIERI L., BRUNO F., SKARLATOS D., LIAROKAPIS F.: Virtual reality with 360-video storytelling in cultural heritage: Study of presence, engagement, and immersion. *Sensors 20*, 20 (2020), 5851. 2

[SRH*20] SELMANOVIĆ E., RIZVIC S., HARVEY C., BOSKOVIC D., HULUSIC V., CHAHIN M., SLJIVO S.: Improving accessibility to intangible cultural heritage preservation using virtual reality. *Journal on Computing and Cultural Heritage (JOCCH) 13*, 2 (2020), 1–19. 2

[SVG15] SIMEONE A. L., VELLOSO E., GELLERSEN H.: Substitutional reality: Using the physical environment to design virtual reality experiences. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (2015), pp. 3307–3316. 2, 6

[TMSG20] TOUEL S., MARFISI-SCHOTTMAN I., GEORGE S.: Analysis of mixed reality tools for learning math in primary and secondary school. In *International Conference on Games and Learning Alliance* (2020), Springer, pp. 112–121. 2

[UN15] UN: United Nations Sustainable Development Goals. https://sdgs.un.org/goals/, 2015. [Online; accessed 10-July-2021]. 3

[UNE03] UNESCO I.: Text of the convention for the safeguarding of the intangible cultural heritage, 2003. 2

[Uni21] UNIVERSITY OF LEEDS: Changing the Story. https://changingthestory.leeds.ac.uk/, 2021. [Online; accessed 15-July-2021]. 3

[vdSLX*19] VAN DER STAPPEN A., LIU Y., XU J., YU X., LI J., VAN DER SPEK E. D.: Mathbuilder: A collaborative ar math game for elementary school students. In *Extended Abstracts of the Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts* (2019), pp. 731–738. 2

[VIM21] VIMM: Virtual Multimodal Museum Plus. https://www.vi-mm.eu/case-studies/, 2021. [Online; accessed 12-July-2021]. 1

[Vin20] VINCENT C.: *Social Justice and Education*. Routledge, 2020. 2