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Augmented Reality (AR) Maps for Experiencing Creative Narratives of Cultural Heritage

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Figure 1: *Artwork and Augmented Reality (AR) Map with embedded creative narratives of the communities' cultural environment for dissemination to a wider audience*

Abstract

This research investigates how communities can meaningfully connect with Cultural Heritage through creative and digital experiences. It also explores how entry barriers can be lowered for a wider set of audiences to increase their participation in such experiences. For this, the research investigates the use of creative and narrative-based approaches, given the potential for stories to illuminate different viewpoints and interpretations of Cultural Heritage. The paper's main technical contribution is a novel approach for re-telling communities' narratives linked to people, objects, sites and events in the urban landscape as told by the community. The research proposed the novel concept of Augmented Reality (AR) Maps*, which are physical maps with augmented digital narratives and delivered through* Immersive Web *technology. This concept is proposed as a means to document and disseminate the narratives in a way which can enhance the public understanding and appreciation of objects and sites in their communities. The approach has been tested with 32 children in local primary school in the city of Brighton and Hove (UK) in order to understand its suitability for community engagement. The significance of the research is that it demonstrates the potential of both creative and digital approaches for enabling meaningful engagement with the Cultural Heritage, while improving the well-being of the participants as well as their sense of community and place.*

CCS Concepts

*•**Human-centered computing** → **Mixed / augmented reality;** •**Information systems** → Geographic information systems; Web applications; •**Applied computing** → Media arts;*

1. Introduction

In recent years, the development of graphics technologies has focused on easing the task of recording, classifying and preserving cultural assets (e.g. museum objects, heritage buildings). However, there is a current shift from researching how artefacts might benefit from these technologies to understanding how communities can participate in the process of identifying which artefacts to preserve.

Until now, communities have rarely had an input into which

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heritage to preserve. Their participation in this process might provide new insights into which heritage is important for their community. Computer graphics technologies also have an important role to play in this process, but limited research has been done in this area. The research presented in this paper aims to address this gap. In particular, it explores how entry barriers can be lowered for a wider set of audiences to connect with their local heritage outside museum settings. For this, it proposes the use of creative and narrative-based approaches, given the potential for stories to illuminate different viewpoints regarding Cultural Heritage assets. Hence, the term *place-based narratives* is used to refer to the interpretative stories linked to the people, objects, sites and events in the urban landscape as told by the community. As such, the research acknowledges the important relationships between a community and the areas in which they move on a daily basis, which can greatly enhance the public's understanding and appreciation of objects and sites.

The contribution of the research is twofold, firstly by proposing an approach for the development of place-based narratives through community involvement; and secondly by deploying novel technologies which can re-tell the narratives. The technical contribution combines both digital technologies and physical printed material. In this research, this development is referred to as an *Augmented Reality (AR)* Map. This is defined as a physical printed map, such as a map of a geographical area or a building, with embedded augmented digital 3D scenes in order to provide additional layers of information to the user. The technology has been developed using an *Immersive Web* approach to ensure wider accessibility of the content.

The *Augmented Reality (AR) Map* concept is proposed to appeal to the user's curiosity and add further layers of understanding to the Cultural Heritage material. It is hypothesised that this approach is of interest to the community both in terms of user engagement and with regards to the information transmitted. By using their mobile devices, users can trigger additional information without being distracted from the main information conveyed by the map. Interaction with the digital 3D scenes embedded in the map might include the ability to visualise and interact with the narratives of communities recorded as a mixture of content including text, images and 3D content.

By encoding the narratives as a digital element of the experience, these narratives can have a life of their own, evolve to take into account other viewpoints and survive the lifespan of the physical element. Moreover, the printed element can also serve as a physical memento of an experience, such as a visit to a neighbourhood. In this way, the research conceptualises a transmedia storytelling based interpretative framework for cultural heritage. This idea can be extended to enrich cities or artefacts in museums with multiple interpretative narratives.

The approach for creating and re-telling place-based narratives has been deployed with a community of school children in the city of Brighton and Hove in the UK. The children engaged through an artistic process to generate place-based narratives of their daily journeys between home and school. Thereafter, the narratives were converted into an AR Map.

The paper is organised as follows: Section 2 presents related work in this area, Section 3 presents the methodology used in this research to facilitate the creation of narratives by the community, while Section 4 describes the technology developed for the Augmented Reality (AR) Maps. Section 5 discusses preliminary evaluation of this research, and finally Section 6 presents conclusions and further work.

2. Related work

Related research on community engagement with heritage includes the framework proposed by Göttler and Ripp [GR17], which formulate different levels of community engagement with built heritage assets, including awareness, exploration, participation and transfer. It proposes the use of digital communication technologies to enable a multi-directional communication between heritage organisations and communities. This communication can be underpinned by a variety of engagement initiatives and a mixture of digital content, including stories, photographs and geographical information. Other approaches have demonstrated how communities can be engaged in creative process for co-designing artworks [RJW18], and other digital experiences of heritage [ACS*19, FLD14, APLBB18].

There has also been previous interest in combining AR with printed material, for example in children's books which contain a QR code for displaying AR content. Moreover, physical maps have been proposed as backgrounds for embedding digital content which relate to the geographical location, such as photos, video and their metadata [MOP*09, TDCB17].

This research advances the research agenda on community engagement with both tangible and intangible heritage in urban space. Our emphasis is on the development of technological solutions which enable the incorporation of multiple views and perspectives, including those of experts and non-experts. For this, the following section will describe methods for engagement which are accessible to a variety of audiences, followed by digital technologies for documenting and re-telling these experiences.

3. Methodology for engaging communities with their CH through place based narratives

The methodology of the research was designed by a multi-disciplinary team of experts including Cultural Heritage (CH) professionals, members of a civic group, education specialists, artists, well-being professionals and computer scientists. In the initial stage, the research focused on children as it is possible to engage with them through formal education. In particular, the research engaged with children between the ages of 10-11 studying at a local primary school, in the year before they move to secondary school.

Figure 2 illustrates the methodology for conducting the research, which includes the following stages: design of the experience, creative development of narratives, capturing narratives through digital technology, wider engagement with the community and evaluation.

During the design of the experience, the team aimed to understand how children could engage with their cultural environment while addressing subjects in the curriculum, stimulating their creativity and addressing their well-being needs. Particular attention was placed on identifying any particular issues concerning the children who will be involved in the experience, including any educational or well-being issues that they might be experiencing at that point in time. These

Figure 2: *Methodology for engaging with communities deployed by the research*

issues are context dependent and are likely to be affected by external factors including community cohesion, socio-economic situation and pressures from friends and family.

Thereafter, an artist facilitated ten workshops at the school in order to enable children to create narratives. These workshops used creative methods and psycho-geography techniques to explore the journeys children make from home to school five days a week. Psycho-geography refers to the study of the effects of the geographical environment on the emotions and behaviours of individuals [Cov06].

The focus on the daily home-school journey was chosen due to the fact that these journeys are a practical everyday routine. It is common that people don't pay much attention to the places, objects and details they pass along the route. As such, the workshops facilitated the exploration of a series of questions:

- How do the children feel about travelling the same route five days a week, every week?
- How much are children aware of the physical environment around them on these journeys?
- Where do children look when they walk?
- What do children daydream about?

As a result, children were encouraged to look up, down and all around their local environment. They were encouraged to try to look at the streets where they walk in a different way. In doing so, children became historians, journalists, archaeologists in reverse, creative observers of everyday life. Narratives, both of the children's personal lives and of elements in the geographical landscape, were created as a result of this process. These *place-based narratives* used a mixture of physical, visual and textual material.

There was no involvement of digital technologies at this stage, as it was decided children could explore more freely their environment without the mediation of a digital device. Instead, each child produced a decorated box which represented their house as illustrated by Figure 5. This was the first observation task as many children had not, until that point, really paid attention to the façade of their houses. Boxes were used both as markers and containers of the child's personal narrative. There were no limitations on what material children could use to capture their narratives. As a result, crafted elements were created from a mixture of materials such as clay, cardboard, foam, plastic, wire, foliage, feathers. Figure 3-left illustrates a mixture of the crafted material which was produced. Children also produced drawings or collages using a mixture of material (e.g. foliage, printed images), illustrating their journeys (see example Figure 8). Some children wrote textual content with stories of people, objects, sites and events they researched on.

Finally, all elements were organised according to their geographical location on a physical 3D map. This crafted artwork piece celebrates the individual interpretative narratives and the collective journeys made by the children all converging at the shared community of school (see Figure 3).

Figure 3: *Crafted objects produced during the workshops documenting place-based narratives*

The next steps in the methodology are explained in the following sections.

4. Augmented Reality (AR) Map Development

Normally, the outcomes of psycho-geography and participatory approaches, which are not mediated by technologies, are lost shortly after the process of engaging with communities. The reason is that, as demonstrated by the resulting crafted objects (Figure 3), while the materials which are used are amenable to creative approaches they are not necessarily easy for digitisation. Hence, results from these participatory approaches are normally disposed of shortly after their display and are rarely disseminated to a larger audience in their original form.

This research explored the role of graphics technologies for i) the digitisation of the narratives produced in order to support their documentation and preservation; and ii) re-telling these narratives to others. These audiences include other members of the same community, audiences who are new to the geographical area and other stakeholders who might have an interest in better understanding which elements of the cultural landscape are significant to the community.

While the process for digitisation is better understood by the research community - in terms of deciding which technologies to use for which artefacts - the requirement to re-tell the narratives has not previously been fully explored. Thus, there are many potential digital experiences which could be used for this purpose.

A novel approach for re-telling these narratives is proposed. This approach combines elements of a physical and a digital experience. The digital element is intended to serve as a canvas for users to interact with the journeys and find more information relevant to the narratives through hyperlinks.

From early on in the research, it was clear that communicating the geographical location was critical to re-telling the narratives. However, using precise geographical information, such as in a Geographical Information System (GIS), was not possible without having to reveal the exact location of the address of members of the community. Hence, the idea of providing the content geographically in-situ was discarded. Instead, the research incorporated an experience very familiar to people when visiting a new location. This is the communication of specific information through a printed map (e.g. a tourist map or a building map). Printed maps allow the abstraction of geographical/spatial information while enabling the reader to orient themselves in the space. Augmented Reality (AR) is then used to embed the digitised narratives without losing their geographical information. AR also has the advantage that multiple interpretations can be embedded in parallel to the same visual information.

The research also considered the need to create physical media which is cost-effective to produce and distribute to a large audience. As such, all physical elements of the experience can easily be reproduced by the user by printing a PDF map. Moreover, the digital element is easily accessible from a web browser on a PC, tablet or smartphone so that there is no need to install .

The Augmented Reality web-application renders a 3D scene with the crafted houses, which are positioned over the printed map in a similar way to the crafted artwork (see Figure 9). When the user clicks or taps on each of the houses, an animation is triggered to simulate the box being opened. The content inside the box is then rendered on a viewer for the viewer to inspect in more detail.

The following sub-sections will describe in detail how the different components of the Augmented Reality (AR) map were developed.

4.1. Development of printed graphical map

process for the printed map: mapnik, openstreetmap data, rendering of scene, The development of a printed map addressed various requirements as described below:

- Display information on the street layout in a way which is easy for the user to understand.
- Not reveal the precise geographical location of the houses.
- Be self-contained in terms of telling the user how to access the digital element of the experience.
- Include a marker for the Augmented Reality which is not too distracting.

In order to address the first two requirements, a customised rendering of a map was created. This map displayed information, which is geographically accurate, but detailed information, such as street names, were omitted. The open-source mapping toolkit Mapnik [Pav] was used to generate the map. This toolkit, with binding in Python, can programmatically generate rendering of geographical maps with the appearance the user wants. For this, an XML stylesheet is created which filters only the information of the streets for rendering and provides other information such as colour and line thickness. Thereafter, a Python script processed this stylesheet to produce the final rendering. Geographical data of Brighton and Hove (UK) was retrieved from OpenStreetMap [Ope19] in the OSM data format. This data was then used as input to the script in order to produce the rendering of the map in PNG format (see Figure 4).

Figure 4: *Rendering of map using Mapnik toolkit*

The rendering of the map was further processed in the GIMP image processing tool [GIM19] to include as additional information the names of relevant geographical references. All references were extracted from the children's narratives and included historic buildings, libraries, museums, parks, cemetery and sculptures. Instructions on how to access the website with the AR experience were also included.

Furthermore, a fiducial code or marker with the logo of the school was included as illustrated in Figure 11. The marker serves both as a way to identify the geographical location of the school as well as to enable the AR content. Other markerless solutions were considered. However, AR over the web does not yet have the performance required for marker-less AR, which is normally distributed via apps and often reliant on Google's ARCore software. Hence, not wanting to compromise in web-based delivery, the logo-based marker was considered a suitable solution.

Finally, general information about the project was included for printing as a double-sided page (see Figure 11). In this way, the double-sided page is a self-containing output of the project.

4.2. Digitisation of 3D scene for AR

There were several considerations made in order to digitise the physical artwork using 3D technologies. These decisions were driven by the fact that the content was going to be rendered as augmented content on the map. Hence, important requirements were to keep high framerates as well as to include content from every child. This meant that the houses and their content were prioritised for digitisation. Other crafted objects, such as those containing foliage, feathers and wire were deemed too challenging for their digitisation during this stage of the project.

The first task was to produce the 32 3D models of the boxes as well as to digitise all content inside the boxes. A mixed approach was used to create the 3D models of the houses. Given the fact all houses are based on a physical box which can be represented by a cuboid (see Figure 5), the use of 3D scanning or photogrammetry was discarded in favour of 3D modelling the boxes using the modelling tool Blender [Ble19].

Figure 5: *Example of physical model houses crafted by children depicting their own houses*

In the Blender program, simple primitives, such as cubes and planes, were used to create the shape of each house. The geometries of the houses each began as a simple cube, with additions such as balconies, porches or roofs being created through the addition of planes.

The textures for each house were created from images taken with a digital camera. The camera used was a mirrorless Sony a7R III with a Sigma 1:1.4 DG macro lens. The houses were placed on a 360 electronic turntable, with two Elinchrom 1000 ELC Pro HD lights with Elinchrom Rotalux softboxes used to provide diffuse lighting. This setup ensured that the textures for each side of the cuboid could be captured with some degree of automation while ensuring high quality results.

The number of photos required for each house depended on the geometry of the house. Some houses required only one image (of the façade) with a simple cardboard texture used for all other faces, while others needed up to four (one for each side). Many of the houses required additional images due to features such as roofs or gutters. The images were taken at an angle perpendicular to each face in order to avoid any perspective effect.

After all the houses had been photographed, the next step was to

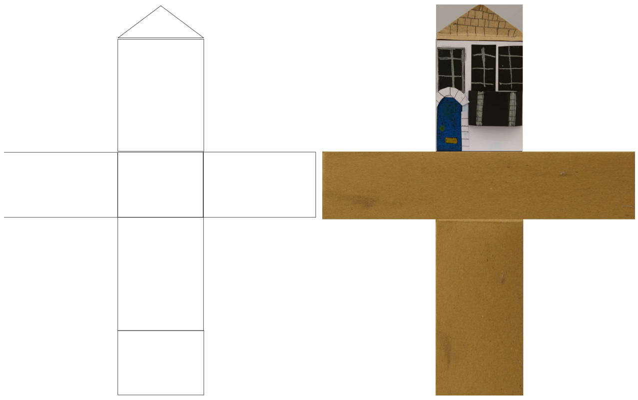

Figure 6: *Example of unwrapped texture of house*

create the texture for each 3D model. This was done using the photo editing software paint.net [dot19]. First of all, a rough blueprint (see Figure 6-left) of each house had to be drawn with approximately the right measurements so as to avoid distorting the texture when applying it to the mesh. The images on each side were cropped to fit in this blueprint as illustrated in Figure 6. The resulting textures were then imported into Blender. The 3D models were UV Unwrapped and aligned with the texture. The final 3D model is shown in Figure 7.

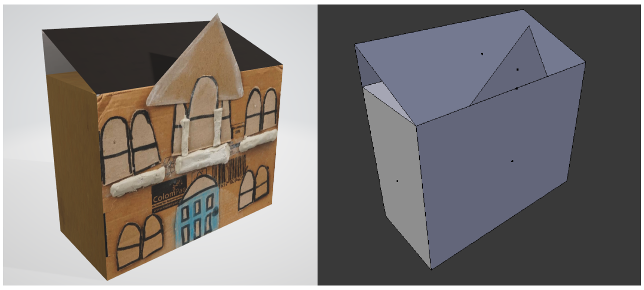

Figure 7: *3D model of houses with and without texture*

A further modelling task was to produce an animation for each 3D model. This animation simulates the house 'roof' opening and closing in a similar way which people can open and close the physical box. This was implemented using keyframes and transformations on the roof sub-objects, and each animation lasts for 60 frames. Four animations were modelled which correspond to the four different states a house can be in:

- **Open:** The roof has been rotated 180 degrees by its base, exposing the inside of the box.
- **Opening:** Transition animation interpolated between open and closed.
- **Close:** The initial state.
- **Closing:** Transition animation interpolated between closed and open.

The drawings and other written content inside the boxes were scanned using a flat-bed scanner. Figure 8 shows examples of this digital content. Further editing was done to the images in order to blur personal information, for example names and addresses. The images were applied as textures to 3D planes so that they can be visualised as a 3D model.

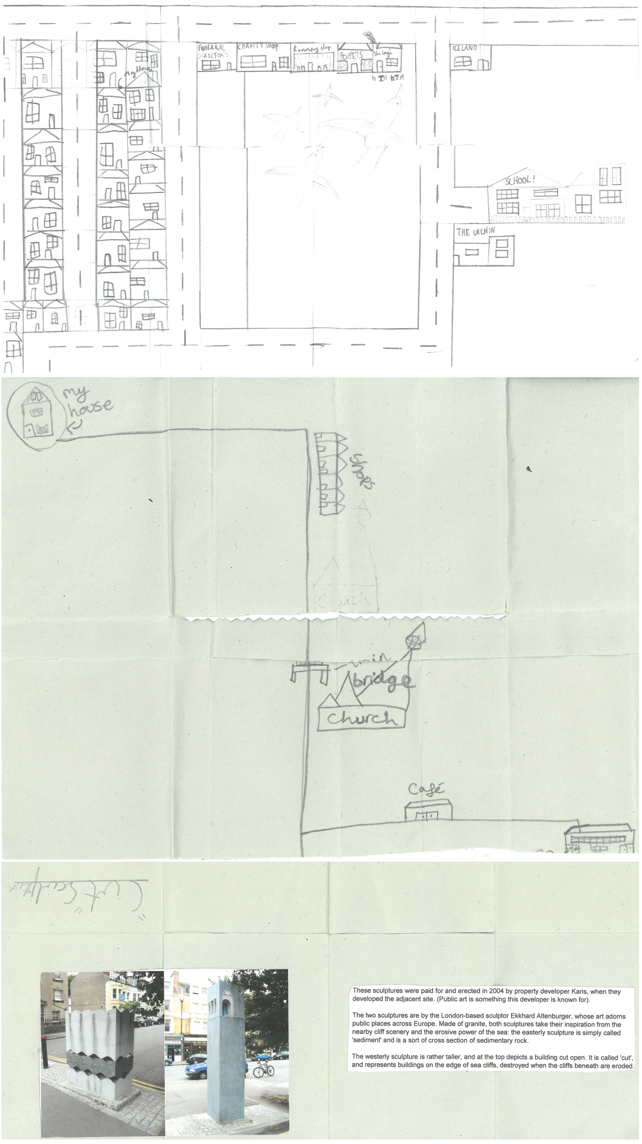

Figure 8: *Drawings of children detailing local geographies, journeys from home to school and objects in the environment.*

Moreover, objects crafted in clay were 3D scanned using the Artec3D handheld 3D scanner. Additional 3D models were accessed from a relevant project [RMA09]. This project undertook the digitisation of public sculptures in the same geographical area using a crowdsourcing approach and published the resulting 3D content on the web.

All content had to be post-processed in order to make it web-ready for the AR experience. This required developing workflows for the production of 3D meshes to be of suitable size/quality for distributing them over the web.

Moreover, the textures had to be optimised for web delivery as the initial images were produced with very high resolution and file size. This was done by running them through the imageoptim web service [Kor19].

The glTF file format was used for encoding the 3D models and their animation for the AR experience. glTF (GL Transmission Format) is a common specification for the efficient transmission and loading of 3D scenes and models, especially by web applications [Khr19]. It reduces both the size of 3D resources and the execution processing required to decompress and use them. It stores a full scene description in JSON format, which includes node hierarchy, cameras, and materials and it also contains descriptor information about animations and meshes.

4.3. Web based Augmented Reality (AR)

together: AR.js, data file, carrousel, etc In order to make the AR maps easily accessible, the research makes use of an *Immersive Web* approach, which refers to virtual world experiences hosted through the browser, covering both Virtual Reality and Augmented Reality experiences developed for AR-enabled devices [Med]. The WebXR API is currently the experimental specification for both augmented reality and virtual reality devices [Web19].

Currently, web-based AR technologies make use of API such as WebRTC and WebVR to enable to deliver AR through the web browser. Other frameworks which are available include Argon.js [Geo19], AR.js based on A-Frame [MNM], Awe.js, [awe19], 8th Wall [8t19]. All of these frameworks make use of Javascript and some of them offer markerless capabilities (e.g. 8th Wall) through a paid service.

Although AR installed as an application on a mobile device often offers better performance, it was deemed that a web-based approach will enable more people to access the experience from a diverse set of devices and platforms. For instance, frameworks such as Vuforia [The19] are not web based and require of payment to be used without watermarks.

Ar.js and A-Frame were used as a framework to develop the web-based experience as they are open source solutions. A-Frame is an open-source web framework for building both Virtual Reality (VR) and Augmented Reality (AR) experiences based on Three.js. A-Frame is an entity component system framework and it allows to create 3D scenes using HTML and Javascript. Most 3D operations are performed by A-Frame in memory with minimal overhead and are rendered with WebGL [Moz], which binds to OpenGL or Direct3D. A-Frame is meant to give suitable latency and framerate with browsers, such as Firefox with WebVR.

extends a line from an origin in a direction and checks for intersections with other geometries. In the project the Aframe raycaster is used, which is built on the Three.js raycaster. On collision with an object, the raycaster triggers an event on said object.

The AR.js API is used to render all elements of the scene which includes the houses and other additional 3D content. The marker on the printed map is used to position the 3D scene on the printed map (see Figure 9-top). In order to enable user interaction with the 3D models, the Three.js raycaster is used. The system triggers a different behaviour according to the type of object that is clicked:

Figure 9: *AR Map experience showing the different house models and a sculpture in the geographical area (left), animation to open the house is triggered when the user taps on a house model providing a visualisation of the child's map shown in Figure 8*

- When the user taps on a house, the animation to open or close the house is triggered (see Figure 9-bottom). After playing the animation, the content which belong to each box is displayed on the Universal Viewer [Uni19]. The implementation includes the capability to add hyperlinks to direct the user to explore further information on the web.
- When the user taps on a 3D model of a sculpture, the object acts as a hyperlink to relevant information, which has been curated by a researcher.

The framerates and latency achieved with the current development were tested in various platforms (see Table 1). Latency is an expression of how much time it takes for a packet of data to get from one designated point to another. As expected, the framerates vary with the processing power and graphics card capabilities. The highest framerate achieved is of 60 frames per second (fps) on a mobile phone (see row 2 in Table 1). Although the responsiveness on mobile phone for racytracing performed worse on a mobile device than on a laptop or PC.

High framerate and low latency is the ideal and these seem to have a direct correlation to the CPU/GPU for mobile devices. 60fps/16ping seems to be the best across all devices. However, the fact that a Google Pixel 2 and 3 both have the same despite differences in CPU/GPU suggest improvements are minor for these newer models. The lower framerate shown by the MacBookPro and ASUS Zenbook indicate that the APIs are well optimised for mobile architectures.

Device	Framerate (fps)	Latency (ping)
Google Pixel 3 (Octa-Core, Adreno 630 1 MB, 4 GB LPDDR4X)	60	16
Google Pixel 2 (Octa-core, Adreno 540 1 MB, 4 GB LPDDR4X)	60	16
Pocophone F1 (Octa-Core, Adreno 630, 6 GB)	60	16
MacBook Pro (Intel Core i9, Radeon Pro Vega 20 4 GB, 32 GB DDR4, 720p camera - 30 fps)	50	17
Nexus 5X (Hexa-Core, Adreno 418 512 KB, 2 GB LPDDR3)	32	42
Nexus 5X (Hexa-Core, Adreno 418 512 KB, 2 GB LPDDR3)	32	42
ASUS ZenBook UX330UA (Intel(R) Core(TM) i5-7200U CPU, RAM 8 Go)	30	20
Galaxy Tab S3 (Quad-core, Adreno 530, 4GB of RAM)	18	50

Table 1: *Testing web-based AR application in various devices of scene containing 1,176 triangles*

5. Preliminary evaluation

An evaluation took place before the start of the project to provide a baseline from which to measure the project outcomes. During this survey, children were asked about their well-being, confidence and overall resilience in life. Another evaluation took place after the school workshops, which showed that the proposed process can lead to children reporting feeling better about themselves and their mood. For instance, there was a 45% increase in children reporting feeling very happy, 18% increase in children reporting liking themselves, a 15% increase in children reporting that they coped with difficult situations happily or very happily, and a 15% increase in children feeling liked by other people. During this evaluation, the AR Maps were not evaluated as these were not yet developed.

In July 2019, a 'celebration' of the artwork and the children's journey took place at the Hove museum (UK). During this day, all children were invited to bring their families and friends to show the artwork and talk to the researchers developing the AR application. The setup in the museum included three areas: 1) an area to display the artwork and to engage with the AR experience (see Figure 10-top), 2) an area for visitors to engage in the creative process for creating their own journeys (see Figure 10-bottom), and 3) an area for visitors to experience a creative application in Virtual Reality. It was considered that this provided a good mixture of hands-on and creative digital activities to engage visitors.

It was the first time the families and friends had seen the artwork and the first time the children had seen the AR Map experience. Hence, we printed a large amount in 80 gsm recycled paper and we distributed them amongst the visitors of the museum and sent extra copies to the school.

Figure 10: *Setup at the Hove museum for the celebration of the artwork and release of the AR application, top) area with the original map, bottom) area where people can engage in the creative process*

Initial feedback from the children provided evidence that the experience was engaging because of the Augmented Reality aspect. Children were keen to test the printed map on their phones and look for their house and their stories. Most children were very proud to see the content they had produced being rendered on the screen when they touched on the house and were happy to tell others about the journeys that they made every day. For others who had no direct connection to the children, the AR experience was very interesting. They would randomly tap on houses and inspect the content others had created.

During the testing, we also found technical issues with the AR aspect. The most common issues were related to size of the screen to experience a large amount of visual content and the responsiveness of smart devices with less powerful CPU/GPU. Despite the cross-compatibility of the AR framework, there were also issues with iOS devices including iPhones and iPads. Furthermore, the testing also made evident that clearer instructions on the printed map were needed. Some people will immediately switch their cameras on (without going first to the website) and be surprised that there was no content displayed. All of this feedback is currently being incorporated into a second release of the AR Map experience.

6. Conclusions

This paper presented novel research for the development of approaches and technologies which enable communities to meaningfully engage with their cultural environment in creative ways. Thus, the paper describes the methodology for deploying the approach which is tested with a local community in Brighton and Hove (UK). As a result, children engaged in a creative process to look at their community in new ways and produce narratives.

The paper demonstrates how mobile and augmented reality technologies provide a novel element for re-telling these narratives to wider audiences. These experiences combine physical maps, such as those widely used for tourists, with augmented 3D using Immersive Web technology.

Feedback from users demonstrate the potential of these approaches to raise awareness of the cultural elements of the local area as well as to improve the well-being and happiness of children who engage in the process. In addition, the AR elements triggered the curiosity of users to explore the different narratives, while becoming aware about other people's viewpoints of their local environment.

Further work involves the usability evaluation of the Augmented Reality aspect in order to understand how to overcome issues such as latency and user-friendly access to the content when this is viewed from a mobile device. Another area to explore is how to ease the digitisation of the material created, including those objects created in different materials. Children should become involved in this process as it will enable them to enhance their digital skills as well as to find novel ways to create links between the material created and content on the web which is curated by heritage experts.

Ultimately, the research contributes towards enabling communities to participate in the identification and preservation of cultural heritage. This will facilitate the democratisation and promotion of a better understanding of the multiple meanings of heritage.

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Figure 11: *Printed graphic for AR experience containing: left) rendered map by mapnik, AR pattern and instructions for access, and right) general information about the project*