Creative Experiences for Engaging Communities with Cultural Heritage through Place-Based Narratives

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This research explores technologically advanced means to enhance audiences' connection with cultural heritage assets through participatory creative methods which particularly reinforce young people's sense of identity and well-being, during sensitive "transitional" periods of their lives. Hence, the research investigates how communities can meaningfully connect with cultural heritage through creative experiences, while aiming at lowering the entry barriers to increasing audiences' participation. For this, the research deploys narrative approaches to illuminate different viewpoints, and interpretations of cultural heritage within communities. The contribution of the paper is twofold, as it includes a novel approach for developing and re-telling communities' narratives linked to people, objects, sites and events in the urban landscape. At the same time, it proposes a workflow to digitise and communicate these narratives through *Augmented Reality (AR) Maps*, by proposing methods for digitisation and producing physical printed elements for the experience. These physical elements are then augmented with digital narratives, delivered through *Immersive Web* technology. This concept is proposed as a means to document and disseminate the narratives in a way that enhances the public understanding and appreciation of objects and sites. The approach was tested with a class of children in a local primary school in Brighton and Hove (UK) to understand its suitability for community engagement, targeting young audiences. The significance of the research is that it demonstrates the potential of the synergy between 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.*

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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 (collection-oriented) to understanding how communities can participate in the process of identifying and interpreting the heritage which is relevant to them (audience-oriented).

For instance, until now, communities have rarely had an input into which heritage to document or preserve. Participating in this process might provide new insights into which heritage is important for them. But most importantly, it would allow people to explore the benefits of engaging in such a process, as well as exploring their own identity and sense of belonging. In this way, engagement with heritage becomes an active experience and has the potential to lead to improvements in people's well-being and resilience.

Computer graphics technologies have an important role to play in community engagement activities. They can be used to generate visually rich digital representations for people to interact with and can underpin a high-level of creativity in the process of engaging with heritage. However, limited research has been done in this field. This paper aims to address this gap. Following our research presented in [13], this paper expands towards exploring how entry barriers can be lowered for a wider set of audiences to enhance the connections with their local heritage outside museum settings. In particular, the paper expands the theoretical context in which the research is conceptualised, as well as presents alternative digitisation pipelines allowing to capture a wide variety of creative narrative forms.

In this research, the term *place-based narratives* is used to refer to the narratives linked to 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 spatiotemporal context in which people move and function daily. Exploring and helping these relationships to emerge can greatly enhance the public's understanding and appreciation of objects and sites.

The main contribution of the research is the development of creative and narrative-based approaches for engaging with heritage through the exploration of their local community. Given the potential for stories to illuminate different viewpoints regarding Cultural Heritage (CH) assets, this approach can easily be deployed with a variety of traditional and non-traditional museum audiences, such as young children, people with disabilities, people with mental health problems and others. The methodology of the research is based on an iterative process, in which we firstly explore and propose the conceptual approach for the development of place-based narratives through community involvement; and secondly we deploy novel technologies and workflows to support this process while re-examining concepts and technologies as they emerge from the creativity sessions and participants' narrative input.

The technical contributions of the research include a workflow to digitise creative narrative forms produced during the engagement sessions, as well as digital experiences to communicate these narratives to a wider audience. Given the emphasis on place, we use *Augmented Reality (AR)* Maps, which are physical printed maps, such as a map of a geographical area or a building, with embedded augmented digital 3D scenes to provide additional layers of information to the user. The technology has been developed using a cross-platform *Immersive Web* approach to ensure the content can be accessed more inclusively.

The *Augmented Reality (AR) Map* concept is proposed to appeal to the user's curiosity and add further layers of understanding to the narrative content. This approach triggers the interest of the audiences and works as the "hook" both in terms of user involvement and engagement, as well as in terms of learning or appreciation [12]. By using their mobile devices, users can trigger additional information without being distracted from the main information conveyed by the map. Interactions with the digital 3D scenes embedded in the map include the ability to visualise and interact with the narratives recorded as a mixture of content including text, images and 3D objects.

By encoding the narratives as a digital element of the experience, these narratives have a life of their own; evolve to take into account other viewpoints; survive the lifespan of the physical element; and form a vivid, present depiction of heritage that can be further deployed to a wider audience. Moreover, the printed element of the map 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, whilst representing different voices and embracing diversity in the heritage context.

The approach for creating and re-telling place-based narratives was piloted with a community of school children in the city of Brighton and Hove (UK). The children firstly engaged through a creative process to generate place-based narratives of their daily journeys between home and school. Thereafter, the narratives were converted into AR Maps that the children and their families could experience and share.

The paper is organised as follows: Section 2 presents related work in this area, Section 3 presents the proposed methodology for the creation of narratives by the community, while Section 4 presents a pipeline to easily digitise physical craft produced during the narrative process. Thereafter, Section 5 describes the technology developed for the Augmented Reality (AR) Maps. Section 6 discusses preliminary evaluation of this research, and finally Section 7 presents conclusions and further work.

2 RELATED WORK

2.1 Narratives, place and identity

This research explores creative ways to engage people with the heritage of their local communities while providing benefits such as enhancing their identity and sense of belonging. As such, the research is contextualised within the concepts of *narrative*, *identity* and *place*.

Narratives, have been recognised as powerful tools to communicate information about artefacts, collections, buildings, sites, life experiences and beyond while supporting communities in the interpretation process [23, 34]. Creating a narrative or telling a story is one of the oldest activities and still amongst the most powerful ones in terms of engaging communities with content. This happens because narratives are fundamental in the ways human beings understand and make sense of themselves and the world. As Bruner [8] suggests, one of the ways that people think follows a narrative mode. The narrative mode can be described as a good story that verifies a person, a place, an event or the world.

Stories or narratives might include real or fictional facts that are related to tangible or intangible CH assets [19]. A narrative in a CH site or place might revolve around an individual object, an important historical person, an interesting building or a story about it. The narrative can present information about this place with a certain level of detail under a theme (e.g. such as the journeys of the children from home to school). The narrative might also combine multiple objects and present many stories under such themes. The wealth of narratives, though, can be vast and many narratives can illuminate multiple views or interpretations, adding in this way many layers of information about life experiences.

Narratives have also different aspects and expressions. Hence, a narrative is defined as *the showing or the telling of events occurring over time* [9]. As proposed by Chatman's [10] there is also a distinction between narrative structure, manifestation (the specific medium in which the narrative is presented), content and expression (the various media through which stories can be communicated). Therefore, we acknowledge that narratives are not always encoded linguistically, but can also be shown through audiovisual media and artefacts [32]. This interplay of media becomes even more obvious if we consider the constant negotiation between the physical and digital boundaries in people's lives and identity [21].

The term *transmedia narrative* has been previously used to signify the dispersal of narrative content over different media, including websites and more traditional media such as TV or film. Lynch [25] explores *transmedia narrative* in terms of an entwining of forms, which is at once concerned with the materiality of the real world, and the ephemeral nature of the digital one. The blurring of physical and digital boundaries is particularly relevant to children and young people's lives.

The study of identity is also related to the spatial dimension in narratives, as the links between identity and place exist. As Harold et al. [35] identified, the places a child grows up in, those that he or she comes to know, prefer, and seek out or avoid contribute significantly to their identity.

Therefore, the place-based narratives this research emphasizes, have the potential to enhance children's connections with place; support individual identity building; enhance community relations; and consequently result in strengthening young people's sense of belonging, resilience and well-being overall.

2.2 Participatory narrative development for AR

In the context of CH research, where the focus on the preservation of objects and environments is extended to engage with the communities linked to this heritage, previous research has sought to effectively engage people in interactive multisensorial experiences. Such experiences have often been developed by adopting participatory approaches that allow multiple voices to be heard. For instance, related research on community engagement includes the COBA framework proposed by Hauer and Ripp in Göttler and Ripp [18], which formulates different levels of community engagement with built heritage assets, including awareness, exploration, participation and transfer. The use of digital communication technologies to enable multi-directional communication between heritage organisations and communities is emphasised within this framework. Hence, communication can be underpinned by a variety of engagement initiatives and a mixture of digital content, including stories, photographs and geographical information. More relevant approaches have demonstrated how communities can be engaged in creative processes for co-designing artworks [36], and other digital experiences of heritage [3, 5, 14].

Digital approaches for creating and communicating narratives over digital media have been extensively studied in the field of Information and Communication Technologies (ICT). Within this domain, the terms *immersion* and *interactivity* refers to the ability of media to enable users to explore non-linear narrative content, while being fully involved in multisensorial experiences. Such experiences reflect the current world, where the boundaries between physical and digital are constantly becoming blurred.

As far as it concerns previous research to involve children in the participatory creation of AR by combining physical and digital assets, various tools and methods have been proposed. Alhumaidan et al. [4] present the co-design of a collaborative learning experience with primary school children through cooperative inquiry. Low-tech prototyping and evaluation are essential steps in the collaborative approach to design an AR book, however, they mostly focus on the functionality of tools. Thus, even though digital content is combined with the physical environment, users are not supported in developing diverse narrative interpretative forms that connect them to places and CH assets. Similarly, Kang et al. [22] propose a platform that allows children to prototype and test complex engineering systems (i.e. a bicycle) using paper and a digital simulation environment. The functionality, though, supports building predefined systems to enable children to learn how machines work. In [30], Oberhuber et al. move further to explore how children engage in combining physical and digital assets to develop an AR treasure hunt game. The use of media is less rigid here and allows the creativity of children to emerge. Other relevant efforts [37, 38, 41] involve children in the design of an AR experience at an inspirational or operational level without directly connecting the children's physical narratives to the AR environment or further investigating their collective interpretations and communication to wider audiences.

Finally, previous research has highlighted the combination of AR with printed material. Some examples include children's books containing a QR code for displaying AR content, as in [4] Other examples, such as in Willis et al.

[44], propose tools for interactive storytelling and bringing tangible objects to life by using printed media and mobile technology. Likewise, physical maps have been proposed as backgrounds for embedding digital content related to a geographical location, such as photos, videos and their metadata [28, 39].

This research significantly advances the state of the art by enabling young people to creatively develop narratives linked to the built environment, and its heritage, using physical artefacts and digital methods. Thus, emphasis is on the development of enabling technologies to capture, communicate and enhance both the individual and collective interpretations of the environment as they emerge.

The following sections will describe methods for engagement which are accessible to a variety of audiences, followed by digital technologies for documenting and re-telling narrative 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 CH professionals, members of a civic group, education specialists, artists, well-being professionals and computer scientists. The research focused specifically on children on a transition stage from childhood to early adolescence as this is a critical period due to multiple developmental changes and changes in the environment (i.e., transition from primary school to secondary school) with an age range between 9 and 12 years. The research engaged with children studying at a local primary school, in the year before they move to secondary school, to test the methodology.

Figure 1 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 experiential framework, the team aimed to understand how children could engage with their cultural environment while taking into account the curriculum, stimulating their creativity and addressing their well-being needs. Attention was placed on identifying any particular issues concerning the children who were involved in the experience, including any educational or well-being issues affecting them at that point in time. These issues are context-dependent and are likely to be influenced by external factors including community cohesion, socio-economic situation and pressures from friends and family.

Thereafter, an artist facilitated ten workshops at the pilot school 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 [11].

The focus on the daily home-school journey was chosen because these journeys are a practical everyday routine. Commonly, 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 at 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 look differently at the streets where they walk daily. In doing so, children became historians, journalists, archaeologists in reverse, creative observers of everyday life. Narratives, both of the children's personal lives and 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.

Fig. 1. Methodology for engaging with communities as deployed by the research

At this stage, there was no involvement of digital technologies, as it was decided children could explore more freely their environment without the mediation of a digital device. Instead, we used crafted elements that represented the narratives around the journeys children undertake from home to school. We used the concept of *home* as a starting point for triggering the imagination and creativity of children. Thus, each child produced a decorated box that represented their house as illustrated by Figure 2. This was the first observation task that enabled children -many of them for the first time- to pay attention to the façade of their houses.

Box-houses were used both as geographical markers and containers of additional elements of the child's narrative. There were no limitations on what material children could use to capture their narratives of their journeys. 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 materials. Children also produced

Fig. 2. Example of physical model houses crafted by children depicting their own houses

Fig. 3. Artwork and Augmented Reality (AR) Map with embedded creative narratives of the communities' cultural environment for dissemination to a wider audience

drawings or collages using a mixture of materials (e.g. foliage, printed images), illustrating their journeys. Some children wrote textual content with stories of people, objects, sites and historical 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).

4 DIGITISATION OF ARTWORK

Usually, 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 to support their documentation and preservation; and ii) re-telling or sharing these narratives with others. Further audiences include other members of the 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.

Several considerations were taken into account to digitise the physical artwork using 3D technologies. Decisions were mostly driven by the fact that the process should be scalable to deal with a large number of crafted elements, and the crafted material was going to be rendered as augmented content on the map. Hence, important requirements were: to design workflows that enabled to digitise a variety of craftwork from every child; to produce high-quality 3D content; and to enable the production of good quality representations while keeping interactive framerates. This meant that the box-houses and their content were prioritised for digitisation amongst other crafted elements. Other crafted objects, such as those containing foliage, feathers and wire, were deemed too challenging for their inclusion in the AR experience.

Two methods for digitising this type of visual content are proposed. In both methods, we used a mirrorless Sony a7R III camera with a Sigma 1:1.4 DG macro lens. The box-houses were placed on a 360 electronic turntable, with two Elinchrom 1000 ELC Pro HD lights with Elinchrom Rotalux softboxes that were used to provide diffuse lighting. This setup ensured that the process had some degree of automation while providing high-quality results.

Afterwards, we produced 3D models both by a 3D modelling approach and an image-based 3D modelling method, also known as Structure from Motion (SfM). The latter process was deemed to be the most suitable for large-scale digitisation in a way that maintains the visual quality of the narrative forms. Both methods will be explained in the following subsections.

4.1 Digitisation by 3D modelling

Given the fact that all crafted objects are based on a physical box which can be represented by a cuboid (see Figure 4), we experimented with 3D modelling the boxes using the modelling tool Blender [7].

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

The textures for each box-house were added from images taken with the digital camera. The number of photos required for each box depended on its complexity. Some 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 box-houses required additional images due to features such as roofs or gutters.

The next step was to create the texture for each 3D model. This was done using a texture blueprint for each box and fitting cropped images from each side of the box. The resulting textures were then imported into Blender. The 3D models were UV i=unwrapped and aligned with the texture. The final 3D model of a house is shown in Figure 4.

A further modelling task was to produce an animation for each 3D model. This animation simulates the roof opening and closing in a similar way people use to open and close the physical box. This takes advantage of the simplicity of the modelling approach and enables the generation of interesting effects during the AR experience.

The animation 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 box-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.

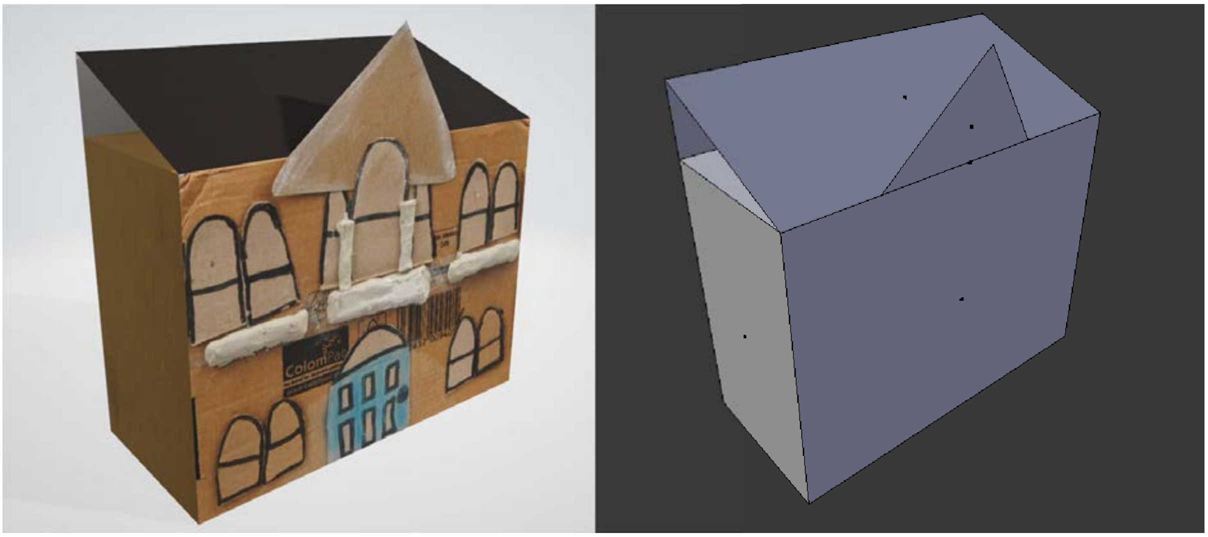


Fig. 4. 3D model of house with and without texture

4.2 Digitisation by image-based 3D modelling

This method is proposed as a means to deal with a large number of crafted items, as we have developed technologies to enable semi-automation of the image-based workflow. The main motivation behind this is that it allows us to process a wider variety of shapes, without having to deal with modelling every customised crafted item. The main challenge in this workflow is to ensure the visual quality of the items by capturing both the shape and the colour accurately.

As mentioned before, all box-houses were created using a similar cardboard box as a starting point. Then each house was customised using coloured paper and crayons. Although the areas coloured with crayons displayed some shine when catching beams of light, most boxes were fairly non-reflective. To ensure colour fidelity of the artefacts, we improve the method proposed by Gaiani et al. [15]. This ensured that the 3D models which resulted from the process had a good and uniform quality, particularly with regards to the cardboard textures.

For the colour characterization in the lighting environment in which we performed the digitisation, we made use of the X-Rite ColorChecker. The X-Rite ColorChecker automatically detects the colour and produces an ICC profile which is then applied to all images.

Thereafter, the workflow required an operator to take a set of images using the automated setup. For this, each box-house is placed on a turntable with a white background and photographed every 20° over three full 360° rotations. The camera is also rotated 90° as shown in Figure 5, generating in total between 54 - 60 images. During the photogrammetric acquisition, we also made use of a measuring bar with circular cross-type targets. This allows introducing scale to the 3D model when it is later processed.

The digital images were shot using ISO 100, and an aperture of F/11. The images were shot in RAW and later processed using the ICC profile before exporting them as JPEGs to be used during the image-based 3D modelling. The sets of images were then automatically processed by a Python script employing the Agisoft Metashape API [2]. This script reads the images from a folder, processes a 3D model, detects the targets captured in the image, and applies a transformation to the 3D model. The transformation includes scaling and translational values to produce the final 3D model, as shown in Figure 6. All these steps are fully automated.

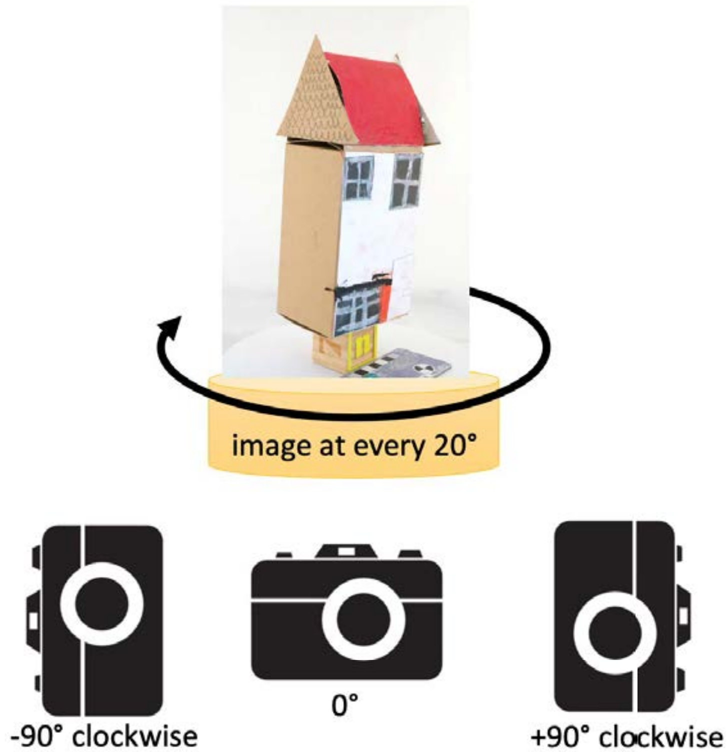


Fig. 5. Camera is rotated 90° to capture three sets of 360° rotations

Fig. 6. 3D model of a box-house generated through a photogrammetry automated process

Next, a manual process is required to remove the excess geometry, including the measuring bar. Finally, the resulting 3D model is decimated to a size of 5,000 triangles and a texture with a reduced resolution. All content is then post-processed to make it web-ready for the AR experience.

The glTF file format is used to encode the 3D models, and their animation if available, for the AR experience. The glTF (GL Transmission Format) is a common specification for the efficient transmission and loading of 3D scenes and models, especially by web applications [24]. This format 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 Measuring colour fidelity

The workflow also ensuring the acquisition of a consistent colour for the 3D models. For this, we assumed that the cardboard texture would have very similar colours in all 3D models.

Our method uses small patches (80 by 80 pixels) extracted from textures of two different 3D models, as shown in Figure 7. For this, we selected areas that correspond to the non-decorated areas of the cardboard boxes, assuming that these two areas must be similar in colour.

To understand the perceived differences between colours from the two different textures, we use the ΔE (Delta E) measurement. ΔE is a metric for understanding how the human eye perceives colour difference, which was proposed by the International Commission on Illumination (CIE) [20]. On a typical scale, the Delta E value will range from 0 to 100. The difference of less than 1.0 between the two colours means that the difference is not perceptible by human eyes. Any values above 11 indicate colours are more similar than the opposite, while a value of 100 means that colours are the exact opposite. We assumed that getting values below 11 meant the changes in texture colour would only be perceptible through close observation or at a glance in the worst-case scenario.

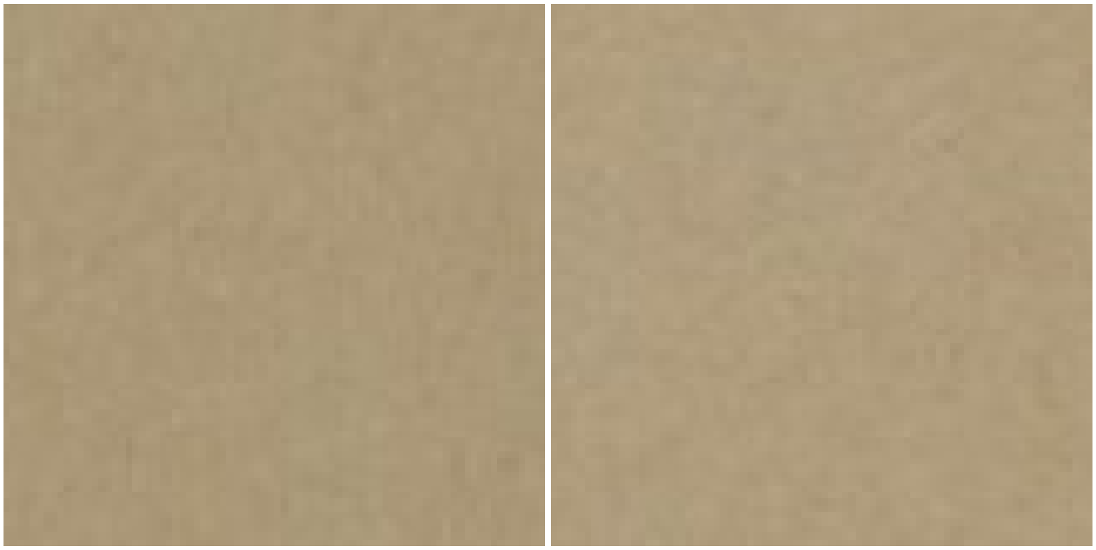
Firstly, we select the best set of colours in the texture patch to compare. For this, we calculate the dominant colours on a given patch using K-means cluster analysis using Python. As a result, we produce a distribution of the five (5) most dominant colours as illustrated in Figure 7b.

Thereafter, we compare the most dominant colours of one texture to the most dominant colours of the other texture by calculating ΔE for each combination. This requires converting each colour in a texture patch to the CIELAB colour space. This colour space allows to express colour as three values: lightness, a* from green to red, and b* from blue to yellow. After representing the colour in the CIELAB space, we then apply the CIELAB 2000 ΔE algorithm using Python colormath library.

Table 1 presents a comparison across the five (5) most dominant colours for textures A and B. All colours present a similarity of under 3.5, meaning there is only a perceptible difference amongst the textures when very closely inspected. It should also be noted that, when comparing colour to another colour with a similar percentile, they are very similar in their ΔE value.

	A_0 (38.94%)	A_1 (28.66%)	A_2 (18.78%)	A_3 (8.05%)	A_4 (5.58%)
B_0 (34.00%)	**1.528**	2.092	0.944	2.719	0.266
B_1 (28.42%)	0.959	**1.515**	0.427	2.145	0.478
B_2 (19.84%)	2.121	2.685	**1.531**	3.31	0.806
B_3 (10.89%)	0.403	0.893	0.458	**1.514**	1.104
B_4 (6.84%)	2.845	3.408	2.254	4.032	**1.528**

Table 1. ΔE value comparison for the top five colour values for each texture patch



(a) Two 80 x 80 pixel texture patches from different 3D models

(b) Five most dominant colours on the texture and percentage distribution

Fig. 7. Texture patches used to evaluate the quality of colour fidelity across different 3D models resulting from the image-based 3D modelling process

The evaluation results demonstrate that our method for generating textures for the 3D models produce good and uniform quality in terms of colour. This allows to follow a standardised process that can be deployed for large-scale content, while ensuring the visual quality of the outcomes.

5 AUGMENTED REALITY (AR) MAP DEVELOPMENT

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

Our approach combines both physical and digital elements of a CH experience. The digital element is intended to serve as a canvas for users to interact with the journeys and find more information about 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 address of the members of the community. Hence, the idea of providing the content geographically in-situ was discarded. Instead, the research incorporated a means which is 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 space. Augmented Reality

(AR) is then used to embed the digitised narratives without losing their geographical information. AR has also the advantage that multiple interpretations can be simultaneously embedded into the same visual information.

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

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 8). When the user clicks or taps on each of the houses, an animation is triggered to simulate the box being opened if this is available. This interactivity allows for the content inside the box to be rendered on a viewer for the user to inspect the elements of narratives in more detail as well as to see links to other related content.

Fig. 8. AR Map experience showing the different house models and a sculpture in the geographical area; animation to open the house is triggered when the user taps on a house model revealing a visualisation of the child's map

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

5.1 Development of printed graphical map

The development of the printed map addressed various requirements as described below:

- The map should display information on the street layout in a way that is easily understood by the user.
- The map should not reveal the precise geographic location of the houses.

- The map should be self-contained in terms of telling the user how to access the digital element of the experience.
- The map should include a marker for the Augmented Reality which would not be too distracting.

A customised rendering of a map was created to address the first two requirements. This map displayed information, which is geographically accurate, but detailed information, such as street names, was omitted. The open-source mapping toolkit Mapnik [33] 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 filtering only the information about the streets for rendering, while providing other information, such as colour and line thickness. Next, a Python script processed this stylesheet to produce the final rendering. Geographical data of Brighton and Hove (UK) was retrieved from OpenStreetMap [31] in the OSM data format. This data was then used as input to the script to produce the rendering of the map in PNG format (see Figure 9).

Fig. 9. Rendering of map using the Mapnik toolkit

The rendering of the map was further processed in the GIMP image processing tool [17], and we included the names of relevant geographical references as additional information. All references were extracted from the children's narratives and included historic buildings, libraries, museums, parks, a 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 10. The marker serves both as a way to identify the geographical location of the school as well as to enable the AR content. Other marker-less solutions were considered. However, AR over the web does not have yet the performance required for marker-less AR, which is normally distributed via apps and is often reliant on proprietary software. Hence, not wanting to compromise the web-based delivery, the logo-based marker was considered a suitable solution.

Finally, general information about the project was included as a double-sided page (see Figure 10). In this way, the printout of the double-sided page is a self-contained output of the project.

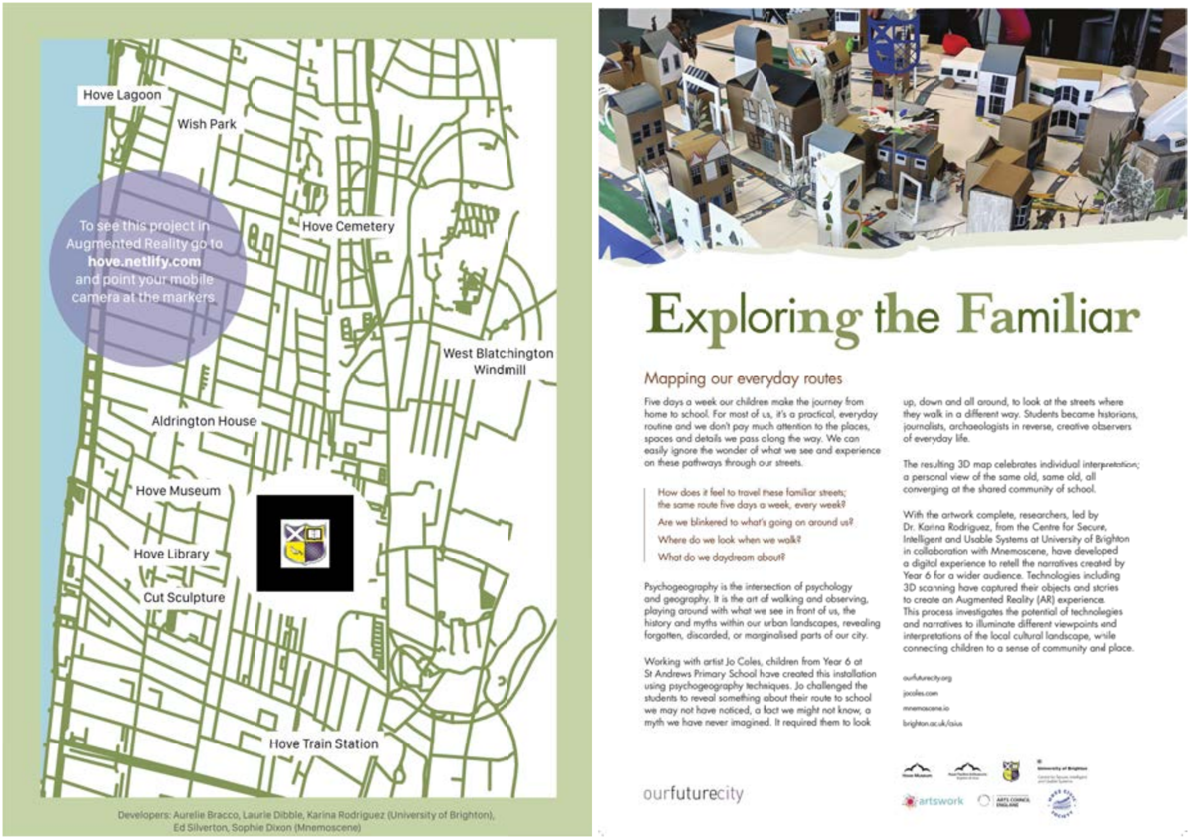


Fig. 10. Printed graphic for AR experience with: rendered map, AR pattern and instructions for access (left), and general information about the project (right)

5.2 Web based Augmented Reality (AR)

The research makes use of an *Immersive Web* approach to make the AR maps easily available across a variety of devices. This cross-platform approach refers to virtual world experiences hosted through a browser, covering both Virtual Reality and Augmented Reality experiences developed for AR-enabled devices [27]. The WebXR API is currently the experimental specification for both augmented reality and virtual reality devices [43].

Nowadays, web-based AR technologies make use of APIs, such as the WebRTC and WebVR to enable the delivery of AR through a web browser. Other available frameworks include Argon.js [16], AR.js based on A-Frame [26], Awe.js, [6], 8th Wall [1]. All these frameworks make use of Javascript and some of them offer marker-less 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 experience would enable more people to access it from a diverse set of devices and platforms. For instance, frameworks such as Vuforia [40] are not web-based and require payment to remove watermarks.

AR.js and A-Frame were used as a framework to develop the web-based experience as they are both open-source. 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, allowing the creation of 3D scenes using HTML and Javascript. Most 3D operations are performed by A-Frame in memory with minimal overhead and are rendered with WebGL [29], which binds to OpenGL or Direct3D. A-Frame is meant to give suitable latency and framerate with browsers, such as Firefox with WebVR.

In the project, the A-Frame 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 employed to render all elements of the scene, including 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 8-left). The Three.js raycaster is deployed to enable user interaction with the 3D models.

If animation is available for a given 3D model, the system triggers a different behaviour according to the type of object that is clicked:

- When the user taps on a house, the animation to open or close the house is triggered (see Figure 8-right). After playing the animation, the content which belongs to each box is displayed on the Universal Viewer [42]. 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.

If no animation is available, the system simply opens the viewer with additional content and links.

The framerates and latency achieved with the current development were tested in various platforms (see Table 2). 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 60 frames per second (fps) on a mobile phone (see row 2 in Table 2). However, the responsiveness on a mobile phone for raytracing performed worse on the mobile device than on a laptop or PC.

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
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 2. Testing web-based AR application in various devices of scene containing 1,176 triangles

6 PRELIMINARY EVALUATION

An evaluation took place before the start of the project to provide a baseline 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. The collected feedback showed that the proposed creative process made children feel better about themselves and improved their overall mood. Critically, the process triggers creativity and engages children in a process of observation of their physical environment. This renewed awareness certainly has a powerful effect on children's view of themselves. 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 had not been developed yet.

In July 2019, a "celebration" of the artwork and the children's journeys took place at the Hove Museum (UK). On this day, all children were invited to bring their families and friends to the museum to show them their artwork and talk to the researchers who developed the AR application. The setup in the museum included three areas: 1) an area to display the artwork and engage with the AR experience (see Figure 11-left), 2) an area where the visitors could engage with the creative process and create their journeys (see Figure 11-right), 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.

On the "celebration" day, families and friends saw the artwork for the first time. That day was also the first time the children experienced the AR Map. Hence, a large amount maps were printed in 80 gsm recycled paper and distributed amongst the visitors of the museum, while extra copies were sent to school.

Fig. 11. Setup at the Hove museum for the celebration of the artwork and release of the AR application and area with the original map (left); area where people could engage with the creative process (right)

Initial feedback from the children provided evidence that the experience was particularly engaging because of the Augmented Reality aspect. Children were keen to test the printed map on their or their carers' phones and were eagerly looking for their house and their stories on the map. Most children were very proud to see the content they had produced being rendered on the screen, after touching on their house. Moreover, they were happy to tell others about their narratives and share information about the journeys they make every day. Others, who had no direct connection to the children, found the AR experience very interesting too. Hence, they would explore as well as tap on houses and inspect the content that children had created.

During the testing, we also noticed some technical issues concerning the AR aspect. The most common amongst these were related to the size of the screen to experience a large amount of visual content, as well as 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 made it evident that clearer instructions on the printed map were needed. Some people would immediately switch their cameras on (without going first to the website) and be surprised that there was no displayed content. All this feedback is currently being incorporated into a second release of the AR Map experience.

7 CONCLUSIONS

This paper presents a novel approach for engaging children in a transitional stage in their lives with a narrative and placed based approach to enhance their connection with their physical environment, including its cultural heritage. As such, the paper presents the development of approaches and technologies which can enable young audiences to meaningfully engage with their cultural environment in creative ways.

The paper described the proposed approach, as well as how this can be deployed with a local community. For this, we demonstrated how this has been tested with children in a school in the city of Brighton and Hove (UK). During this process, children engaged in the exploration of their community; the conception of narratives evidencing their daily journeys from home to school; the production of these narratives by using creative means; and the experience and sharing of these narratives through the AR map with members of their communities and beyond.

The paper demonstrated how mobile and augmented reality technologies provide a novel element for re-telling communities' 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 demonstrates the potential of these approaches to raise awareness about the cultural elements of the areas where communities live. Moreover, the proposed framework can positively affect participants, in this instance children, while enhancing their sense of belonging, well-being and happiness. Particularly, the AR elements seem to have triggered the curiosity of users to explore different narratives, while becoming aware of other people's viewpoints with regards to their local environment.

Future work for the research involves the usability evaluation of the Augmented Reality aspect 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 further ease the digitisation of the material which is difficult to capture; specially crafted objects which are made of feathers, wire and generally craftwork that present certain complexities. Children could also become involved in the digitisation process. This not only would enhance their digital skills, but would also support the emergence of new links between the crafted materials and CH content that could be curated by heritage experts.

Ultimately, the research contributes towards enabling communities to participate in the identification, preservation and dissemination of cultural heritage content. Such active community involvement contributes towards the democratisation of CH, while supporting at the same time the emergence, exploration and understanding of the multiple and diverse meanings of heritage information.

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