Location-Based Virtual Reality Experiences for Children: Japan-UK Knowledge Exchange Network

Final Project Report

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Section 1:
Background to the Study

1.1 Introduction

Location-based VR are site specific experiences that aim to bring together materials beyond those in the virtual space to carefully curate an experience for an audience who are likely to use the content only once or a few times. As a result, location-based VR experiences are emerging predominately in two areas; gaming arcades and museums/art galleries.

The overall intention of this knowledge exchange (KE) project was to bring together a network of academics and digital gaming industry partners in Japan and the UK to join up knowledge, begin researching the current state of VR experiences and technologies, and to understand the best methodologies for including children in the design of VR experiences for them. This was undertaken so that this knowledge can be applied to areas in which VR is evolving for children, such as entertainment, education (e.g. Yamada-Rice et al, 2020) and health care (e.g. Tarrant et al, 2018; Won et al 2017; Arane, et al 2017; Yamada-Rice & Love 2019).

The project focus built on previous studies by various members of the network around children and VR, such as a commercially-funded study led by the Principal Investigator, Yamada-Rice entitled '*Children and VR (CVR)*' that shows how 8 to 12-year-olds use VR in highly tactile ways, that cross virtual and physical domains and that this is the case even when the content has not been designed with this intention and thus indicates a desire for mixed reality as opposed to purely digital immersive experiences (Yamada-Rice, et al, 2017). Further, market research data from Dubit Global Trends (2018) that supported the CVR study provides initial insight into how the technology fits into children's everyday lives to suggest that location-based virtual experiences are likely to be sought because they are more inclusive and engaging than devices and content currently available for the domestic market. Also, many households are too busy or don't have enough space or money to set up VR experiences in the home. Indeed, many studies across the years have shown how children have always combined physical and digital media together in this way (e.g. Marsh's (2014) work on how children played with physical materials alongside the 1950s TV show- Davy Crockett, to more contemporary TV viewing combined with physical play in Marsh et al (2005). Also, in relation to children's app use Marsh et al (2015)). Such studies combined with the findings of this one suggest there is a market for location-based VR experiences if the right content can be made for children.

In the health sector, Yamada-Rice has been leading a project to produce a mixed reality play kit, working with Co-Investigator Love including using VR to help children have an MRI scan without a general anaesthetic. Thus beginning work on the inclusion of VR in the context of child health (Yamada-Rice & Love, 2019). Love also undertook an AHRC/EPSRC Research and Partnership Development project for the Next Generation of Immersive Experiences which focused on setting design standards for children's use of VR in the context of museum experiences.

Co-Investigator Potter studied children and VR during the 'Playing the Archive' project, a study addressing the nature of historic play recorded in archives, contemporary spaces and technologies of play (Potter & Cowan, forthcoming 2020).

In the domain of Digital Storytelling research, Co-Investigator Dare explores the social imaginary of virtual reality, in particular, tensions between VR works which invoke empathy and those which appear to operate through less conscious processes, such as fear and reflexive, pre-conscious responses.

Co-investigator Main has researched the use of digital sensors to mediate mixed-reality experiences between virtual and physical spaces, and studied the attitude of users towards sensor-enabled interfaces through his 'Countermeasures' project (Main, 2019).

The partnership with industry and academic leads in Japan was sought because of the way in which they are leading the development of location-based VR experiences. Japan has dedicated arcades for virtual content (i.e. *Shinjuku VR Zone (a facility created by members of the Location-based VR Association; Sky Circus, Ikebukuro)*, many of which contain experiences designed and produced by Hashilus where two core network partners Ando and Miyoshi are located. Additionally, Japanese academic research and development focuses on the next generation of experiences, such as that being carried out by Co-Investigator, Narumi who is undertaking research and development in areas such as virtual embodiment through physical additions to virtual content (e.g. Nagao et al, 2017).

It was also considered that the chance to undertake KE activities with Japanese partners would be important because research on semiotics and related social practices shows how unlike English, Japanese communication practices foreground emotional expression rather than objects and time (e.g. Shelton & Okayama, 2006). This is particularly relevant to VR because the medium is increasingly considered a good match for content that centres on emotions which are important to both gaming, entertainment and health design, and is emerging as the key affordance that is separating this medium from others that have gone before.

1.2 Aims, Objectives and Research Questions

The knowledge exchange network project had four overarching aims:

Objective 1: to establish a sustainable network of academics and industry partners and related long-term pathways to impact

In terms of commercial development VR technology and content is driven by the gaming industry and then adopted to other areas such as entertainment, education and health. Academia is both theorising and critiquing the technology while practical disciplines of art, design and computer science do this through the creation of content, interfaces, and

exploring new contexts for the use of VR. Knowledge therefore needs to be shared across the two sectors. In order to address this objective, answers to the following questions were sought:

1. What are the established networks of each member?
2. Are there links that can be made between these networks that could lead to long term research and development?
3. What are the mutual areas of interest in the field of location-based VR experiences for children?

Objective 2: to share best practice about children and VR

There is concern about how the medium will affect children's vision, balance and sense of self. Simultaneously, children are adopting VR content not designed for them because age appropriate experiences are underdeveloped. Therefore, the KE activities also included opportunities to share best practices in this area, and in doing so, answered the following research questions:

4. What best practice guidelines exist in the UK and Japan for children's use of VR?
5. What further research needs to be undertaken in order to advance best practices and design standards in the field?

Objective 3: to understand the current state of the field and identify areas for future development

In addressing Objective 3, we sought to understand how placing cutting edge VR experiences into the longer history of immersive experience design could bring about greater understanding of the medium and help identify areas for future research and development. Social science theorists such as Hodge & Kress (1988) and Kress (2010) show how all forms of communication, that is modes and the media used to deliver them, are products of the cultures that create and use them, and as a result often have historical roots in other communicative media. Van Leeuwen (2013) suggests this is the same for other materials such as toys and thus related social practices like play and gaming. As a result, the network sought to look at similarities and differences between the current state of location-based VR in the UK and Japan. We asked:

6. Can any of the techniques used in other immersive media be applied to the new generation of VR experiences?

To do this, the network provided the opportunity to consider the affordances of a range of immersive experiences with differing histories from traditional to new, such as opera, film and magic.

Objective 4: to explore ways of including children's ideas in the next generation of location-based immersive experiences

The last objective relates to questions that connect to the development of research methods that can be used to understand children's engagement and interaction with location-based VR experiences, and how they can be brought into the design of future content. Specifically, we sought answers to the following research questions:

7. What methods have already been used to understand VR?
8. Are there means by which we can include children in the design of future immersive experiences?

1.2 Methodology & Approaches to Data Analysis

Objectives One and Two were met by bringing the network participants together for two, one-week knowledge exchange events in the UK and Japan. Each of these events were made up of talks by academics and industry professionals from the network and wider field. Additionally, the network members took part in a range of location-based VR experiences on offer at that time in Tokyo and London, as well as explored a range of non-VR immersive experiences that were chosen as a means of exploring how VR connects to wider histories of immersive storytelling, such as in theatre, film or older forms of gaming. An overview of these activities are presented in Table 1 (UK) and Table 2 (Japan) below with further details included in Appendix 1:

Academic Talks/Workshops	Industry talks	VR experiences	Non-VR Immersive experiences
-**Children & VR**, *Yamada-Rice, RCA* -**VR Stories for kids**, *MA Information Experience Design Students, RCA* -**Shadow Play VR**, *Scholder, RCA* -**Immersive Design Standards**, *Love, GSA* -**Sonic Immersion**, *Lewis, RCA* -**Worlding**, *Dare, RCA* -**Playing the Archive**, *Cowan & Potter, UCL* -**Reflection on Immersive Play in Punch Drunk**, *Colvert, Roehampton Uni* -**Exploring touch in VR**, *Giannoutsou, UCL* -**VR to prepare children to have an MRI,** *Curtis, Uni of Sheffield, Yamada-Rice, RCA & Clarke, Dubit* -**VR and AR in Playing the Archive,** *Signorelli, UCL* -***Young children's use of TiltBrush in VR***, Marsh & Nisha Uni of Sheffield - **Physical Digital Immersion**, *Main, RCA*	-**Immersive Technologies at the Royal Opera House**, *Mees, ROH* -**Physical Play as Immersive,** *Rodrigues, Glück Workshops* -**Future Aleppo**, *Pearson, Red Thread Media* -**VR to prepare children to have an MRI**, *Clark, Dubit* -**Storytelling: Immersion and Emotion,** *Norrington, Storycentral* -**Moments of Surprise and Delight,** *Caddock, imotion* -**Developing multiplayer VR for Sony PSVR**, *Thandi XR Games & Douthwaite WEARVR*	-**We live in an Ocean of Air,** *Saatchi Gallery* -**Examples of VR/ Immersive narratives from MA IED storytelling elective** -**Otherworld,** *London* (full list in Appendix 1) -**Nintendo Labo VR** (full list in Appendix 1)	-**Stanley Kubrick: The Exhibition**, *Design Museum, London* (Immersion in Film), -**Living with Colour**, *Japan House* (Immersion through colour), -***Magic & Illusion***, *Wellcome Trust* -**Van Gogh: the immersive experience**, *York St Mary's church* -**AI: More than Human**, *Barbican*

Table 1: Knowledge Exchange Activities, UK

Academic Talks	Industry talks	VR experiences	Non-VR Immersive experiences
-**Haptic Shape Illusion**, *Narumi, Uni of Tokyo* -**The IIC Tokyo Design Lab**, *Pennington, University of Tokyo* -**VR experiments in Narumi Lab**, *University of Tokyo* - **VR experiments in Living Lab Komaba**, *University of Tokyo*	-**The work of the Location-based VR Association Japan**, *Miyoshi* -**Location-based VR development,** *Ando*, *Hashilus* -**VR Development in Music,** *Sony Music*	-**Shadow after Shadow**, *Kota, University of Tokyo* -**VR Zone Shibuya** (full list in Appendix 1) -**VTube change of Emperor event** -**Hashilus Fort** (full list in Appendix 1) -**Sky Circus** (full list in Appendix 1) -**Mazaria** (full list in Appendix 1)	-**Borderless**, *TeamLab* -**Robot Restaurant**, *Shinjuku* -**Tea Ceremony** -**Shiota Chiharu: The Soul Trembles**, *Mori Art Museum* -**International Manga Museum**, *Kyoto* -**Joyopolis Game Centre,** *Odaiba* **-Tokyo Design Lab** **- Mandarake** **- Institute of Industrial Science and Technology** **- Computer Vision Lab (Oishi Lab)** **- Living Lab Komaba** **- Sony Music** (full list in Appendix 1)

Table 2: Knowledge Exchange Activities, Japan

Throughout the project, knowledge exchange activities were recorded using a variety of multimodal means that included video, photography and audio. These recordings were used to produce a series of reflective blog posts. In turn, the blog posts became a form of data transcription of the research activities and at the end of the KE activities they were analysed using thematic analysis to draw out common themes (Braun and Clark, 2006). Initial ideas emerging in relation to the key themes were further explored through the creation of a series of two-page graphic narratives. Doing so, drew on methods previously used by the creator of these comics, Yamada-Rice, in work where she argues that 'the full-bodied nature of this type of [VR] engagement necessitates a certain type of materiality that graphic narratives make possible]' (Yamada-Rice, 2018, p.2/4). In making this point Yamada-Rice (2018) drew on the work of Jones and Woglom (2016) who write:

> ...this and other graphical texts make something possible ... [such as] the ways in which different modes of texts [bring about] different ways of thinking.
>
> (Jones and Woglom 2016, p. 3)

The graphic novelist Sousanis (2017) states comics are a suitable medium for understanding and displaying complex ideas and stories. The nature of location-based VR which facilitates experiences that cross physical and virtual domains, drawn from real and imagined worlds, which in turn have derived from social and historic practices contain 'complex ideas and stories'.

Richard Nash who has a practice making artists books, joined the network to take this a step further and explored secondary analysis of the data through the development of an artist book. In the first stage, he delivered series of workshops with participants from the

Figure 1: Random Generated Comic Pages Bound into a Zine (Image and Zine by Nash, 2020)

research group focussing on a narrative collage methodology (Kostera, 2006) to explore the shared experiences and identified research themes. The initial workshop focussed on visual storytelling through a series of defined exercises that were brought together using a collaborative workflow tool built in Processing 3- software for coding within the visual arts. The co-design process created a fragmentation and modularisation of the research which was combined into a single non-sequitur narrative form. The analysis revealed the overlapping reflections of each participant as well as a crossing of reflection and imagined fiction (Figure 1):

He continued to explore further the possibilities of this in relation to the artists' book or book-artefact as an immersive experience. In relation to the conventional book as an immersive experience, Ryan (2015) states:

> ...when VR theorists attempt to describe the phenomenon of immersion in a virtual world, the metaphor that imposes itself with the greatest insistence is the reading experience.
>
> (Ryan, 2015, p. 61)

Furthermore, the meta-critical and performative nature of the artists' book, in its varied forms and structures, calls for a different form of engagement (Drucker, 2004) which was important to this study. Thus, Nash formalised methods he had previously used in the creation of 'On Innards Publication' (Couch et al, 2015) (Figure 2). This focussed on approaches to creating a hybrid artists' book and research journal where embodiment became intrinsic to every facet of the book form as well as dictated a form of audience performance in navigating the complex woven narrative and tactile format.

Figure 2: On Innards Publication (Couch et al, 2015)

Beyond the end of the network Nash will continue his secondary analysis by packaging the comic pages into a hand-finished pamphlet stitched zine, which will be sent via post for each individual participant to add their own further critical and reflective analysis through textual, visual and material interventions. This material will form the basis for

further development of the artists' book as an immersive experience linking the physical artefact and virtual environments.

The combined analysis identified the following core themes in relation to the current state of VR in the gaming industry: (1) the virtual unreal, (2) illusion and magic, (3) physical materials and details and (4) emotions and social. Details of the findings of each of these themes are discussed in Section 2. Section 3 shows how these findings were applied to co-design a narrative for a location-based VR experience with children and then to develop it for children to explore during the V&A Festival of Play (July 2019). Finally, Section 4 summarises the key findings, implications for best practice guidelines and makes suggestions for further research.

Section 2:
Main Findings

At the time of the study (2019) the desire for location-based VR content was more advanced in Japan where there were a number of dedicated arcades and spaces such as the 'Shibuya VR Zone' and 'Sky Circus' (see Appendix 1). By contrast, in the UK at the start of this project the first VR arcade of the latest wave of VR content 'Otherworld' created by Dream Corporation, had only just opened. However, rather than containing location-based content it disseminated 12 different VR experiences originally designed for Sony PlayStation VR in 14 individual booths. In other words, it brought content designed to be used in homes to a public space thus making it different from the Japanese spaces where location-based VR were designed specifically for public gaming rather than home use. The remainder of this section uses this context to discuss an overarching theme from the data analysis which is how the two countries' gaming industries predominantly use virtual reality technology to realise the unreal (2.1). Following this, the remaining three key themes from the data analysis showed how this can be realised through a focus on Illusion and magic (2.2), physical materials and details (2.3) and through the creation of emotional and social experiences (2.4). Each of these will be discussed in separate sections next.

2.1 The Virtual Unreal

At its best, content developed for virtual reality produces an intense sense of immersion in a storyworld or simulated environment, within a continuum of practices which arguably began with spoken story-telling traditions, through to theatre, writing, puppetry, dance, art, photography and cinema. Like these other forms, virtual reality technologies do not give us a direct replication of an external reality, even the suggestion of such would preclude the subjective, phenomenological nature of reality. Mandy Rose (2018) has written of 'the idea that the latest generation platform presents reality without mediation or construction' (n.p). Adding: 'as VR meets nonfiction today, Bazin's myth of total cinema is again at play when people talk of 'being there' as if present at events represented in VR' (ibid, n.p). But VR is an artful construction, one which requires as much skill to deploy as filmmaking or photography, including skills relating to perceptual, attentional and wider phenomenological techniques. As Quian Quiroga (2010) states:

> ...magicians continuously demonstrate in very engaging ways one of the most basic principles of brain function — how the brain constructs a subjective reality using assumptions based on relatively little and ambiguous information.
>
> (Quian Quiroga, 2016, p.390)

Data analysis showed that many of these immersive techniques employed in the experiences that we tried were used to make unreal experiences possible. For example, in the UK, we took part in VR content on Sony's PlayStation Platform at Dream Corporation's 'Otherworld' VR centre. The interior design of 'Otherworld', even the name, set the experience within a modern sci-fi theme in which staff dressed in white and drinks and

games were ordered via an ipad embedded in tables where customers waited to enter individual booths to play with the VR games (Figure 3):

Figure 3: Dream Corporation's 'Otherworld'

In addition, VR content was pre-selected by customers from a menu displayed on the embedded ipads. The menu aesthetic was based on Japanese anime style graphics (Figure 4)

Figure 4: 'Otherworld' VR experience menu

The combination of the interior design and menu aesthetics can be seen to transport the customer to a space different from the London landscape outside. Further, Appendix 1 shows how 10 out of 12 VR experiences on offer were unrealistic such as going on an adventure with a tiny mouse (*Moss, Polyarc*) or living as a life-sized fisherman puppet (*Fisherman's Tale, InnerspaceVR*). Thus the imagined world design was curated through the entire experience, on-boarding customers as soon as they entered the space.

The only UK location-based VR experience included in the project was 'We live in an Ocean of Air' by Marshmellow Fest and installed in the Saatchi Gallery. The description for which shows how VR technology was also used to immerse the user into an experience that could not be experienced in the physical world:

> *...virtual reality experience where the invisible connection between plant and human is revealed through breath. In a 20 minute experience ... transports users to an ancient forest and witness the majestic power of the largest organism to ever exist - the giant Sequoia tree...where the invisible exchange of oxygen and carbon dioxide is beautifully brought to life. (https://www.saatchigallery.com/)*

In Japan all of our experiences were based on unreal and imagined worlds (see Appendix 1).

Understanding that the VR entertainment industries of both countries appear to favour the creation of content with 'unreal' themes perhaps unsurprisingly connects with a study on children and VR (Yamada-Rice et al, 2017) which found that these were also the types of experiences the child-participants favoured. Also, it could be said that the VR medium responds to the fact that:

> Only a range of the existent can be conveyed through linguistic memes, much like only a range of the colour spectrum can be perceived by the human eye. No matter what the evolution of our technological prosthetics will be, there will always be shades and things that will remain immune from language and from colour detection.
>
> (Campagna, 2018, p. 4)

In other words, VR offers the opportunity to materialise ideas that are hard to convey through other means.

Our study also sought to understand how the findings might relate to social and historical practices building on Kress' (2010) notion that all contemporary communication practices (of which VR is one) are related to historical ones. In relation to this, an early connection can be drawn between the unreal and 'more-than-human' histories of each country. This was explored in the comic analysis shown in Figure 5. The comic explores how in Japan, the historical link to 'more-than-human' worlds could be seen to rise from the Shinto religion with a belief system based on an otherworldly-ness of spirits and gods residing in many things including other living creatures and nature, but also extending to

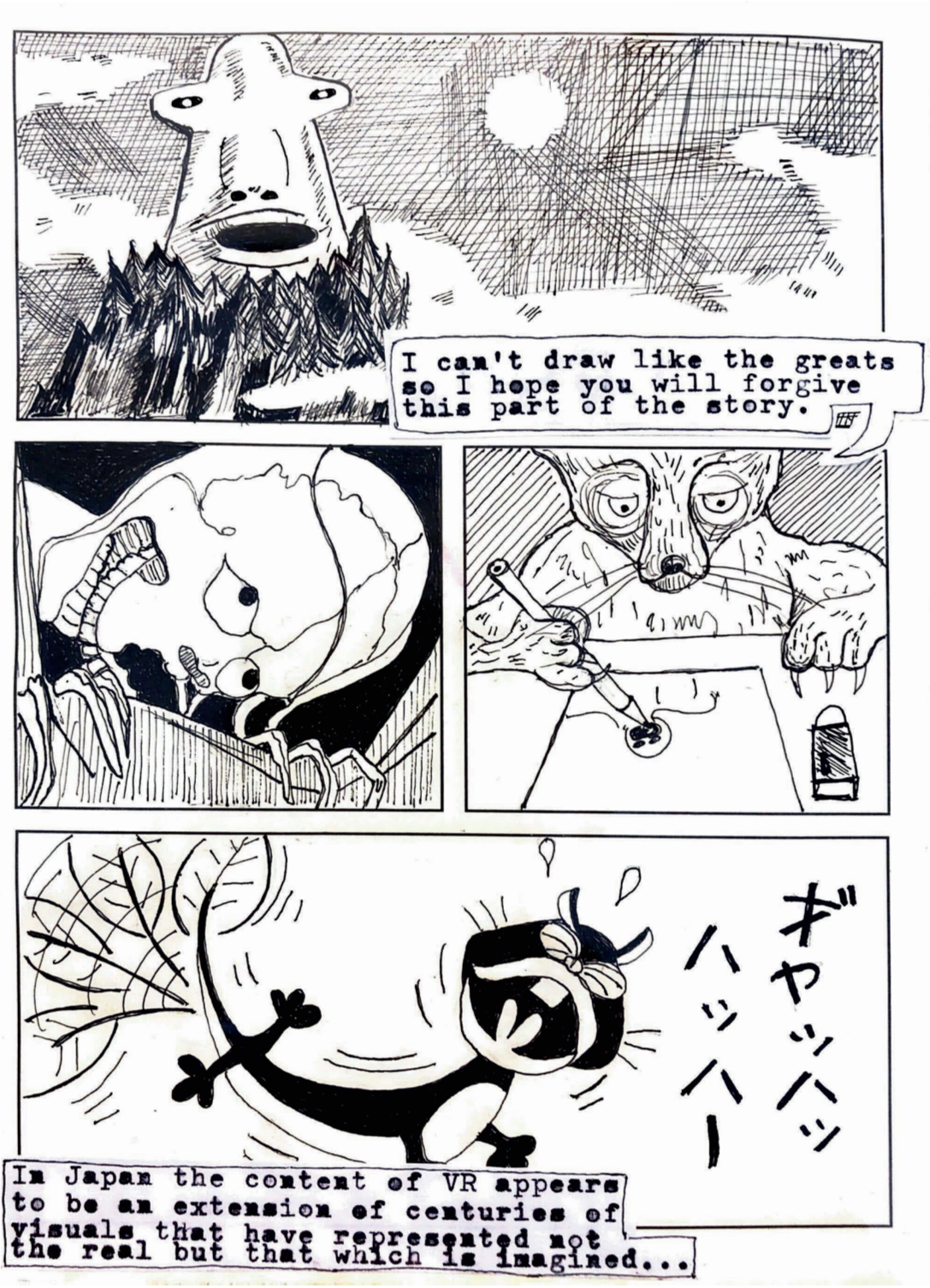

Figure 5: Comic Analysis: 'Virtual Unreality' (Image by Yamada-Rice, 2019)

Figure 5: Comic Analysis: 'Virtual Unreality' (Image by Yamada-Rice, 2019)

machines and other inanimate objects. It also makes reference to examples of 'more-than-human' worlds captured in Japanese art history from Hokusai's Kohada Koheiji (1833) (left-hand page, panel 2) to manga artists such as Fujio Akatsuka (left-hand page panel 4):

The comic then explores the extent to which these examples from art history have derived from Shintoism (right-hand page panel 5):

> In the Japanese religion of Shinto, Kami are Divine forces or spirits of nature that surpass human intelligence. There are more than 8 million kami that live in natural forms including the sun, oceans, mountains, trees, rocks and animals. They are also believed to live in tools, technologies and extraordinary people. According to Shinto beliefs, all these entities respect each other and live in harmony.
>
> (AI: More than Human, Exhibition at the Barbican, 2019)

Such alternate worlds could also be said to derive from the Japanese Edo Period when the country was predominantly closed to the rest of the world but was also a period of peace and thus the arts flourished meaning depiction of anything non-native were depicted from imagination (Guth, 1996).

Thinking in this area was partly inspired by the Barbican exhibition 'AI: More than Human', which began with a contextual section dedicated to Shintoism and the connection between human and non-human things in Japan. This was then used as a framework for thinking about the connection between people and machines in an era of rapid AI development.

> In Japanese culture and art, life breathes in people, living creatures and artificial objects alike. This perspective is reflected in animation, games and technology.
>
> (AI: More than Human, Barbican)

The exhibition continued from this starting point, to draw on objects from popular culture to show how such ideas have been integrated into other aspects of Japanese life. For example, the Manga and Anime series entitled '*Doremon'*, which is the name given to a robot-cat that travels back from the 22nd Century to help a boy. The exhibition stated that Doremon has had tremendous influence on Japanese robotic philosophy and technological development:

> In fiction, characters can be humans, animals, machines or artificial objects with human emotions. From early childhood, most Japanese people are accustomed to stories where non-human entities coexist with people. This has greatly influenced Japanese attitudes towards technology.
>
> (AI: More than Human, Barbican)

Further, on a field trip to the Kyoto International Manga Museum an exhibition highlighted how stories from manga cross into other platforms such as toys. Theo Van Leeuwen (2013), in relation to his work on semiotics and multimodal practices, has also shown how toys such as Lego are a reflection of wider social, cultural and historic practices. Such ideas surfaced during one of the non-VR immersive experiences included in the study, a visit to a theatrical performance at the Robot Restaurant in Shinjuku. This was a live performance filled with fictional characters based on Japanese historical stories and mashed together with robots (Figure 6):

Figure 6: Fish Fight at the Robot Restaurant

One core network member mentioned that the show reminded him of children playing in front of a TV show, bashing toys together as they re-enacted the story. Figure 7 was an attempt to explore this idea further and trace elements of it, such as the fish fight shown in Figure 6 to other historical practices and platforms. Panel 1 shows a Kaiju monster toy from the TV show 'Ultraman'. Perhaps these are both a reflection of the wider connection between Japan and the ocean, where colourful and imagined images have historically been flown by fisherman, and fish are offered up to the gods (top three panels on page 2).

What do these ideas mean for understanding site-specific VR experiences? We suggest that it questions whether in an era in which VR, XR and AI are simultaneously emerging, and in some contexts merging, that there are other cultural histories that can allow us to theorise the connection between human and non-human entities including machines and robots to think about how we design for these evolving technologies of which virtual reality is one.

In addition, experiences such as the robot restaurant remind us that humans have long been exploring physical forms of immersive storytelling. This was also highlighted by our trip to the Royal Opera House (ROH) where we learned that in order to create otherworlds the producers of content shown at ROH transported audiences to other realities through a combination of physical and digital means. Walking backstage at the ROH is a beautifully surreal experience, which leads you swiftly past groups of busy technicians, walls of

Figure 7: Comic Analysis: Fish Fights (Image by Yamada-Rice, 2019)

electrical buttons and levers, and vast complex equipment. Like VR, the Royal Opera House is creating deeply immersive work but unlike VR developers has been doing so since 1782, thus offering another example of historical practices that could provide knowhow to help develop this new wave of immersive experiences.

Finally, it should be noted that previous work on children's digital play also illustrates how children are also producers of content that transports them to 'other worlds', through creatively mashing together whatever physical and digital resources they have available to them. In the 'Tech and Play' project (Marsh et al, 2015) the researchers witnessed a young child playing 'Paw Patrol' through a carefully curated combination of physical toys from the TV show and sound from the Paw Patrol app. This DIY approach to immersive storytelling and play was also witnessed in some of our field trips to Japanese gaming arcades where the physical and digital resources were pushed together, often in a prototypal stage. In relation to children and VR previous work by Yamada-Rice, Rodrigues and Zubrycka (2020) shows how embracing DIY and maker cultures could provide a way for children to become actively involved in the VR process.

Materialising the unreal is also evident in UK magic history. The importance of techniques from magic and illusion are explored next.

2.2 Illusion and Magic

The role of techniques from illusion and magic in creating effective content for a range of media is increasingly recognised by cognitive neuroscientists and behavioural psychologists (Quian Quiroga, 2016). It is no surprise, therefore, that the same techniques are also effective for optimising Virtual Reality experiences. Thus this section reports on how the findings showed illusion was an important part of making the virtual creation of an unknown world real.

In part notions of illusion and magic arose from our discussion with two of the Japanese core network members, Kei Miyoshi, Director and Chief Secretariat of Location-based VR association and Akihiro Ando, Representative Director of Hashilus who are both magicians. They were explicit in making a relationship between their magic skills and their development of VR experiences. They apply techniques from magic and illusion to maximise the dramatic and immersive impact on users. The carefully crafted showmanship could be seen in the way in which they used physical materials to create illusions and enhance the immersive experience such as wind machines for a flying carpet experience (see Saloman's Carpet in the Appendix 1).

Hashilus not only design VR content but they also design and build physical machinery that connects to the virtual content and enhances it. Many of these machines used ideas from magic for user comfort such as to minimise nausea and dizziness. They also showed how techniques from the domain of magic can make VR experiences more cost-effective, producing powerful spatial and experiential impact via illusion, localised attention, top

down processing and insight into how humans make decisions. This connects to work by Macknik et al (2010), who have coined the term 'neuromagic' to describe how magicians deploy their insights into human cognition and phenomenology, addressing, as a number of other researchers have done:

> ...concepts that have long been discussed in magic theory, particularly misdirection, and those that are routinely studied in cognitive neuroscience, such as attention and...different forms of memory.
>
> (Quian Quiroga, 2016, p.390)

To better understand virtual reality, an understanding of how we relate to the wider construct of reality, and the enduring traditions of magic and illusion provide a fruitful set of practices and knowledge for VR researchers to expand that understanding. Experiences such as the Jurassic Park style scooter ride (Dino Kickway, see Appendix 1) developed by Hashilus use optical illusion and subtle movement on a small platform, exaggerating the sense of physical and emotional movement, essentially optimising the experience and the space. Likewise, a kind of sonic sleight of hand is frequently deployed in Japanese VR, with voices creating a sense of momentum and emotional magnification (more can be found on this in section 2.4).

In addition to the work at Hashilus, many of the most cutting-edge, effective VR experiences we encountered in Japanese academic research laboratories also appeared to deploy techniques from magic and illusion although they did not articulate the direct connection as Miyoshi and Ando had done. For example, they showed us examples of how most users with good vision would feel the physical shape to be the same as the one they were looking at VR regardless of it being different (Matsumoto et al, 2017).

These are techniques which are increasingly recognised by cognitive neuroscientists (Macknik et al, 2010) who are investigating visual as well as auditory and multisensory illusions in which as Kim & Shands, like Macknik et al (2010), observe:

> ...people's perceptions contradict the physical properties of the stimuli, have long been used by psychologists to study the mechanisms of sensory processing. Magicians use such sensory illusions in their tricks, but they also heavily use cognitive illusions.
>
> (Kim & Shams, 2009, n.p)

As another example, Co-Investigator Narumi's research lab also developed a spiral staircase. In the VR world the user climbs the staircase into the sky and meets Pokemon characters along the way (Nagao et al, 2017). Conversely, in the physical world stair rods are placed in a circle on the floor around a pole. As you step on the stair rods a feeling of ascending or descending a staircase kicks in even though you remain walking on the flat. As magic researcher Gustav Kuhn (2019) writes:

> ...most magic tricks rely on exploiting surprising and powerful cognitive errors, and magicians have informally learned to understand psychological principles that push our cognitive processes to breaking point. By understanding these conjuring techniques and their underlying cognitive mechanisms, we can then gain valuable knowledge of how the mind works.
>
> (Kuhn, 2019)

A very much more visceral interface was the use of a subtle, tingling electrocution around the vestibule of each ear to evoke the illusion of roller coaster movements in tandem with a VR roller coaster ride (Aoyama et al, 2015) (Figure 8). Using the VR with and without the electrical shocks produced very different sensations, the shocks added a vivid sense of movement, albeit unpleasantly vertiginous while standing. Obviously, such techniques are unsuitable for use with children but serve to highlight the extent to which experimentation on crossmodal interfaces is needed.

Figure 8: Galvanic Vestibular Stimulation (Electric stimuli for VR) (Aoyama et al, 2015)

Other labs at the University of Tokyo such as 'Living Lab Komaba' are also experimenting with physical materials as a means of enhancing the virtual experience such as hover drones to create a deeper sense of flying, a haptic microscope and colours created by aggregated interactions in VR. In 'Open Sky', Paul Virilio writes of 'dismantling the necessary conditions for sensory experience' (Virilio, 1997, p.45). Works such as those being developed in the University of Tokyo labs, combined with the disruptive ability of magicians such as Kai and Ando show the potential of VR to generate far more challenging and discursive works than most current, mainstream VR.

An exhibition at the Wellcome Trust entitled '*Smoke and Mirrors: The psychology of Magic*' allowed us to begin theorising VR as an extension to the UK's history of magic too. The exhibition revealed many useful insights into magic and our wider understanding of human perception and attention. The exhibition also reminded us that our desire to believe in other worlds is often heightened by big real world issues, for example the show told of how seances were popular at a time of World Wars in the UK where people died young and families had a desire to reconnect to the dead (Figure 9). More recently, Lloyd

Parry (2018) writes that after the 2011 Japanese tsunami, parents who had lost their children in the waves and could not retrieve their bodies often went to spiritual mediums to ask for help in communicating with their dead children. Campagna (2018) calls 'magic the therapeutic path of embracing a particular, alternative reality-system' (p.8). The above examples would seem to suggest humans particularly tune into this when 'logical' solutions do not provide an answer to the problems faced.

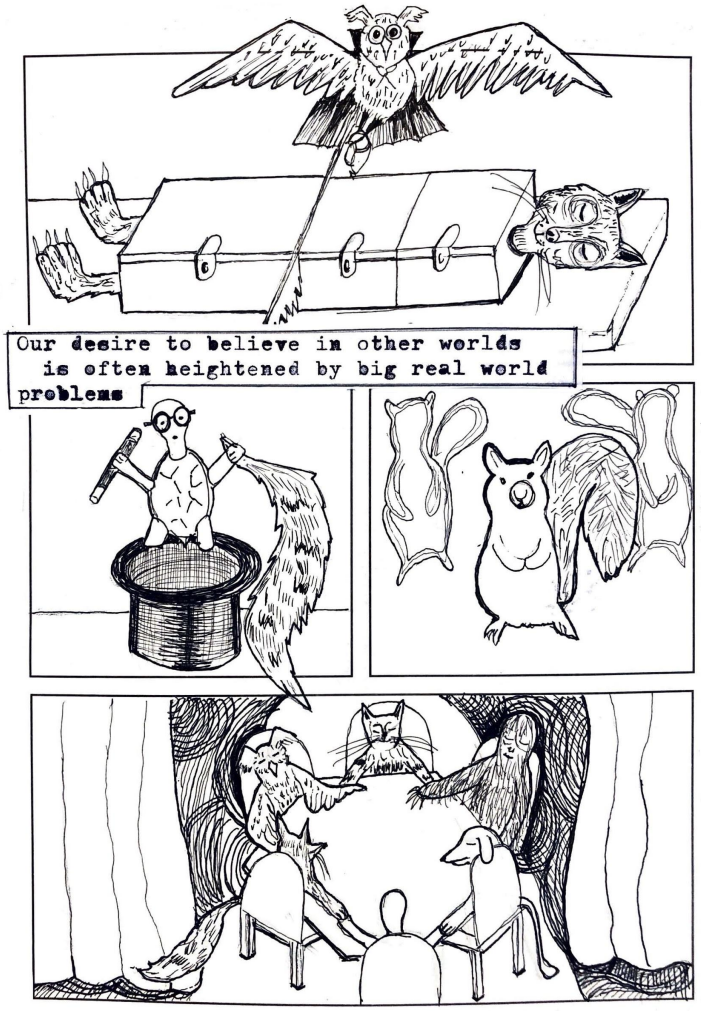

Figure 9: Comic Analysis: Magic (Image by Yamada-Rice, 2019)

Historically, magic has been neglected or marginalised by researchers, but the exhibition represented a new awareness of magic's value to academics and to anyone concerned with human decision making, perception and attention all of which seem to acutely connect to the development of virtual experiences. The show, as with the Japanese experiences listed above illustrate the importance of physical materials and details to magic and illusion. These are discussed next.

2.3 Physical Materials and Details

Physical materials were an essential part of allowing users to scaffold into the best VR experiences. Further, this was done through a blending of everyday and fantastical elements.

Decisions about what to include as physical elements to a location-based VR experience were well illustrated by both a visit to Hashilus Fort where their development takes place and the Royal Opera House. Figure 10 shows ideas about which key elements of an existing intellectual property in this case 'Attack of the Titans' needs to remain in the transduction of the narrative from a manga comic to a location-based virtual experience. In other words, which elements if removed would break users' attachment to the original story.

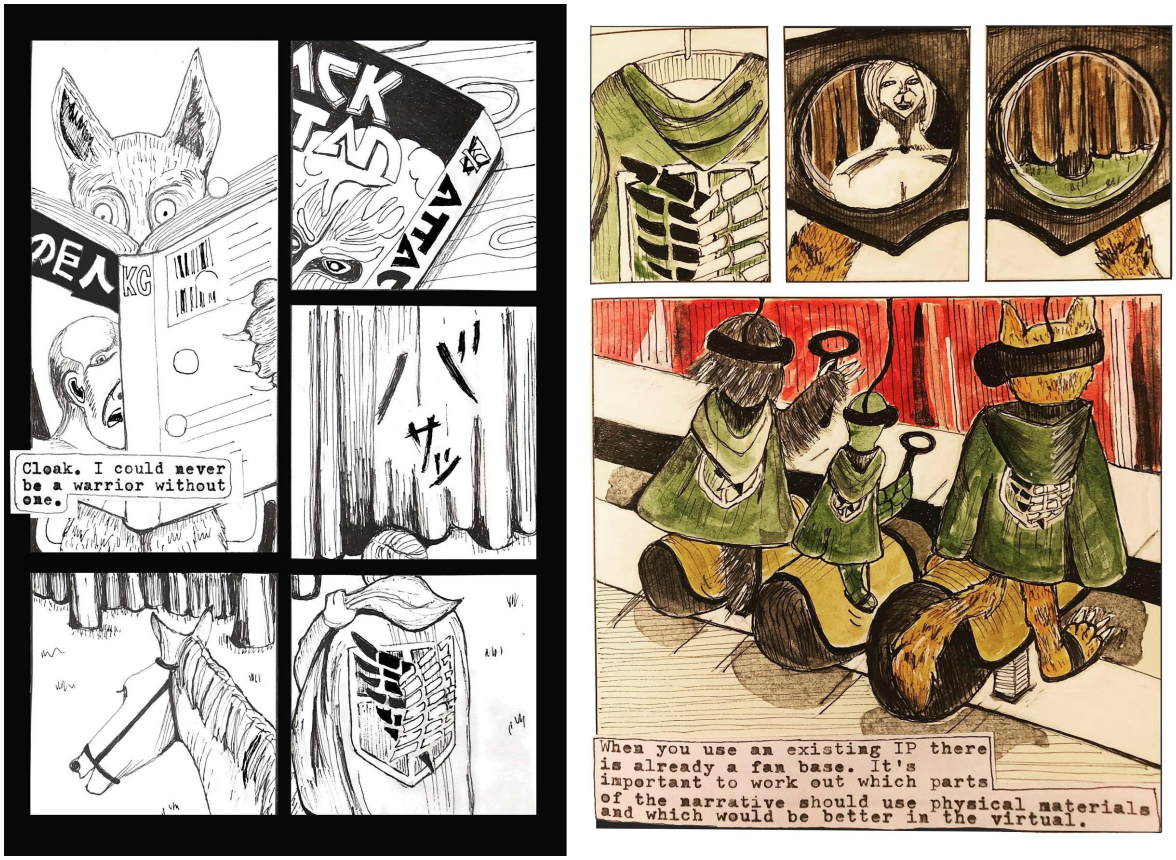

Figure 10: Comic Analysis: Attack on Titans (Image by Yamada-Rice, 2019)

At the Royal Opera House, Annette Mees, Head of Audience Labs, reminded us that the story of Cinderella is so well-known in the UK, that when altering the narrative to a ballet the only element that must remain is the trying on of the glass slipper; all other elements can be negated and still, allow the audience, to recognise it for the story it is. As is shown in the comic analysis for the Attack of Titan's experience (Figure 10) Hashilus chose to use a horse simulator and a fabric cape to link users with the experience of trying to escape Titans in the virtual world (see also Appendix 1). In doing so, the developers made use of the best match between narrative and the affordances of physical and virtual

materials, i.e. bringing the imaginary to life in VR and scaffolding the user into this with tangible and familiar physical objects like the horse and cape.

The trip to the ROH also made us realise the extent to which objects carry the story. Walking backstage it was clear each object had its own specific role to play in a narrative told as well as having its own personal story of how it came to be there, and had been carefully crafted and maintained by artists and technicians to fulfil that role.

Across the best of the VR experiences, as well as by proclaimed storytellers like the ROH and Stanley Kubrick (as seen in an exhibition of his work during KE activities), it was clear that the key to the connection between physical objects and narratives appears in the detail. The textures and intricate decorations help you place its purpose and status, and kick-starts the imagination into piecing together narratives around the object. At the ROH the level of detail is amazing. Looking at the subtle decorations on the props and costumes, you begin to wonder how many of the audience members will be able to make out the painstaking detail of each object.

Attention to detail emerged across the datasets and like other themes that emerged could be traced back to historical forms of immersive storytelling (Figure 11):

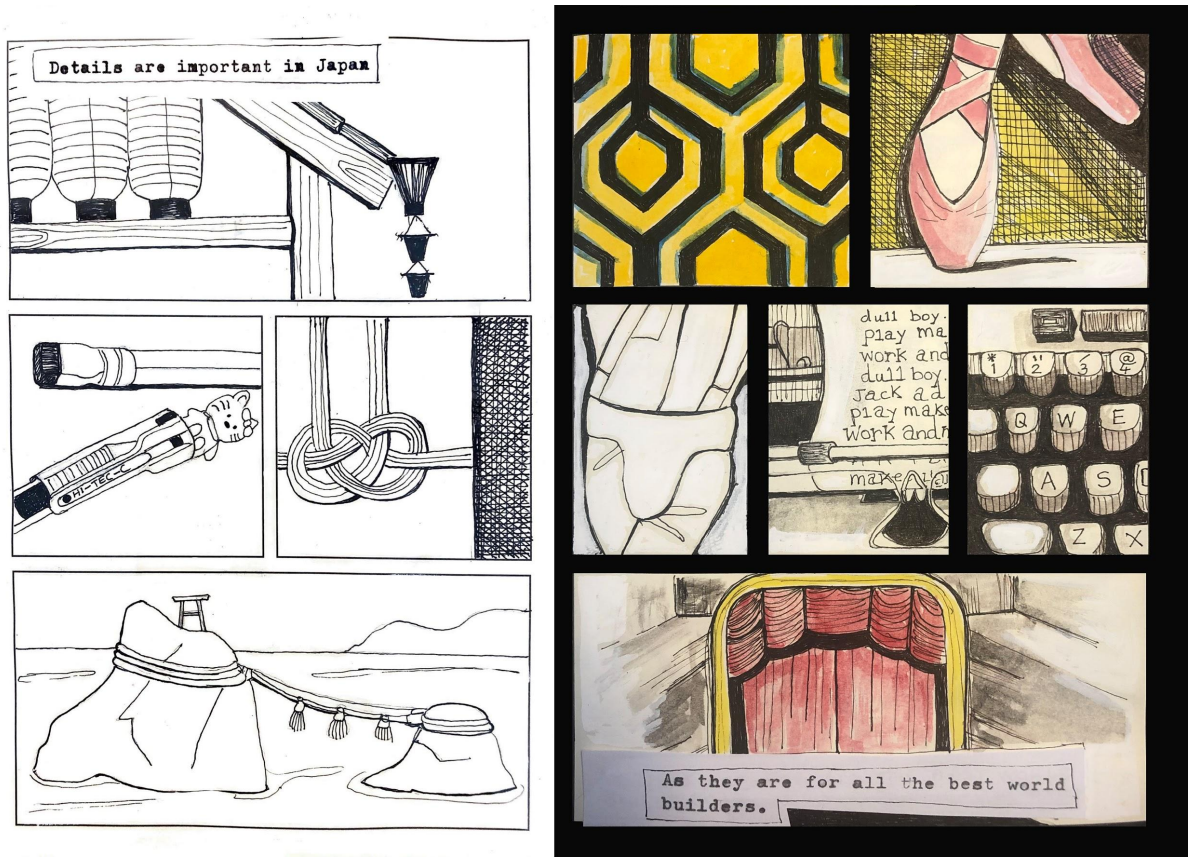

Figure 11: Comic Analysis: Details (Image by Yamada-Rice, 2019)

Traditional forms of immersive storytelling such as theatre and film-making further make it possible to understand how costume makers, artists and designers use minute

attention to detail to immerse actors in the story world of the film. At ROH unexpected and convincing details, like the embroidery on the lining of a jacket help create small moments of persuasion, which in turn help the performers create a convincing reality for the audience. The experience of the narrative is channelled through the cast on the stage, and perhaps that cast should be considered an audience in their own right. Similarly, ideas are evident in film- making too, for example in the Lord of the Rings films the costume designers went to the trouble of embroidering complex symbols and language into the inside of costumes, and even creating elaborate, character-appropriate undergarments for each actor to wear beneath their costumes. As with all of the objects created for the film, these hidden elements were carefully designed to be richly meaningful, and consistent with a complex visual mythology for the film, but they were never intended to be seen by cinema-goers. So why go to the trouble? "There's no point to doing it" according to actor Ian Mckellen, "other than to make me believe, as I put the costume on, that they're real clothes. Which I do." (Lord of the Rings Behind the Scenes Video: <https://m.youtube.com/watch? feature=youtu.be&v=rQqNfEot8sQ&t=174>)

This is particularly relevant to VR where the user takes on a hybrid role in which they are both experiencing and acting in the narrative. As a result, it can be useful to think about how performers are immersed in their environments, and try to create as many persuasive moments of detail for them as possible. Small revelations of detail, carefully placed, can do a lot to encourage the suspension of disbelief, and help build convincing realities. What opportunities are there in VR for literally or metaphorically recreating that experience of stepping into a character's clothes, and observing telling details of their lives?

These thoughts were further reinforced with the visit to the Stanley Kubrick exhibit at the Design Museum. Here was a director for whom attention to detail took on extra dimensions. The obsessive detail created for each of his films has clearly contributed to the richly textured worlds visible on screen, and enduring power of the films. The power of little details is perhaps most evident in the production design for 2001: A Space Odyssey. With science fiction, the skill of world-building is more critical, with unreal VR environments the need for details is also apparent. Like Kubrick's building of only some aspects of his film 2001, i.e. the opening scene, the minute details serve to nourish the audience through parts of the story that have less detailed props. The same is true for VR, such was described by the cloak and horse in Hashilus' 'Attack on Titans' experience.

At the next stage, it would be interesting to see what might happen if such attention to detail were to be applied to the kind of physical materials being made in the science labs of Tokyo University that were discussed in the previous section. The next section outlines how attention to detail in specific objects must sit within decisions about connecting physical and virtual environments together in one experience.

As is shown in Figure 12 we navigate VR experiences in role as new characters. Therefore, in order for a VR experience to be social, a player needs to understand what character they are playing in the game. However, given the cognitive tricks that VR presents through

Figure 12: Comic Analysis: Fighting Zombies in VR (Image by Yamada-Rice, 2019)

magic and illusion as discussed earlier, the emotional self from outside the virtual experience also can kick in to serve as a contrast to the story, as can be seen in Figure 12 where the user feels a sudden sense of fear.

It has already been shown how physical materials can be used to heighten the user's senses in the virtual environment. For example, Hashilus used fans to blow air on the face of the player to make them feel like they are really travelling, and a real carpet to stand on for a magical carpet ride. In more immersive VR experiences – Hashilus also created a movable swing and cannon to create physical feedback for the player.

Kenner (2003) describes how children scaffold their knowledge of communication practices in zones that move outwards from those closest to them such as their bedrooms to those less familiar in the wider world. Mackey (2010) suggests children do this at the same time as coming to understand the physical world too. In this way an 'on-boarding' room with familiar materials and objects can be seen to scaffold VR users into less familiar virtual spaces. This is needed because the very nature of VR requires the player to put on a headset which removes them from the physical world. It can make a player feel vulnerable and self-conscious- especially in a very public setting like a game arcade. As VR technology is still very new for many, it can also be a frightening step into the unknown. These feelings can be counteracted by well-designed on-boarding; the preparation of the player before the VR headset is put on.

The physical space and elements attached to a VR experience heighten and support a user's experience before a headset is even put on. Real world scenes made with physical materials can help transport the player to the game context before they enter the virtual world. For example, in the co-operative VR game Dragon Quest four members of the network team had to fight and slay a mythical creature. Ahead of this they went to an on-boarding room in the style of a medieval castle. There they heard the backstory of the game before the VR equipment was introduced. In this room players were also given a weapon built of physical materials that was then tracked and visible in the virtual world.

2.4 Emotions and Social Experiences

This section explores the social and cultural elements involved in the creation of immersive and memorable VR experiences. We engage with stories, games, and experiences as ways of developing or continuing our relationships with each other, and as ways of participating in social life. People also coalesce around material, virtual, and imaginative environments, with these environments providing the backdrop to, or motivation for, the playing out of new or familiar roles, and the spontaneous emergence of social life.

VR games have the possibility to create shared moments of 'enchantment' (Burnett and Merchant, 2018) through the ways in which various digital, material, emotional, and social elements come together. Game developers create environments, rules, and aims that guide player action, however this action is ultimately dependent on the interests,

motivations, and relationships of these players. In playing a number of location-based VR experiences we became interested in how these experiences fit with existing relationships, and are made meaningful by spontaneous creative (Carter, 2016) and playful social interaction. These relationships and interactions shift depending on whether an experience facilitates collaborative or competitive play, as these shape the various roles, practices, and identities available to the players.

The project team played a number of location-based VR experiences at the Hashilus headquarters in Tokyo. We participated in this space as a group of people interested in exploring a range of location-based VR experiences, but also as guests of the Hashilus team who were conscious that we had a pleasant and enjoyable experience, and as people with diverse backgrounds and interests. In a number of games the group worked collaboratively to achieve a shared goal set out by the game designers, whilst also spontaneously and playfully interacting with each other in ways that were motivated by our interests and our awareness of our peer group. For example, in the game Gold Rush (https://youtu.be/BQPkeZiic5M) the group worked together in a virtual environment to throw balls and smash pots in order to collect gold and then ride on a minecart. During this process the group also spent a significant amount of time exploring the sensation of picking up the digital balls with our controllers and then bouncing them off the heads of the digital avatars of other group members. The virtual environment was mapped over our physical one. This meant that the game registered these impacts in the digital environment, and our bodies went through the motion of throwing the balls 'at' our peers, but nothing was actually thrown or hit in the physical one. This playful experimentation with the affordances of the game world was accompanied by much laughter and discussion. This action emerged from the groups pre-existing relationships, identities, and interests, and was further involved in sustaining and developing these social aspects beyond the completion of the games objective. In other games, where the group took turns to play and elements such as high-scores were present, this joking and laughing continued as we responded to our own or our colleague's actions. However, the social dynamics differed significantly in light of the ways in which social norms about healthy or acceptable competitiveness influenced the group's actions, identities, and interactions. Here then, the ways in which shared participation in gaming/VR experiences can be seen to extend beyond simultaneous interaction with a digital environment, and the social texture of shared involvement, are of significance to conversations about immersion and engagement with location-based VR.

Location-based VR experiences are installed in particular entertainment contexts, and in many of the experiences we engaged with, our experience was facilitated by an attendant assisting in the on-boarding process. This could involve helping us with technical equipment or playing a role in immersing us in a narrative world. Therefore, the digital and physical actions of location-based VR users are visible to audiences that may involve their friends or peers, and also those who are there in a professional capacity. This sense of a user's performance being visible to others, or subject to commentary and participation from outside of the virtual environment, has an impact on the immersion, actions, and experiences of those participating in an location-based VR experience. Lin and Sun (2011)

discuss the ways in which onlookers influence the ways in which the actions of players of rhythm games in arcades become framed, as onlookers expand and enhance gameplay by adopting the role of 'focussed audience member or learning apprentice' (Lin and Sun, 2011, p.134). The interactions between gamer and onlooker is 'complex and dynamic' (ibid), and involves the shifting and changing of roles, identities, frames, and personas in relation to the unfolding of action in virtual and material contexts. Our experiences at Hashilus also draw into focus the ways in which the particular game/experience, and the specific cultural context in which this experience/spectacle takes place and impact on this social dynamic.

During all the location-based VR experiences we played at Hashilus headquarters, our hosts were very careful in how they helped us get ready to participate in these experiences. However, they also worked hard to curate our experiences, not only through this attentive introduction to each experience, but also by providing a very vocal and enthusiastic audience. For example, in playing a LBVR football game based on the famous manga *Captain Tsubasa* our experiences of taking on the role of a world-class striker was extended and enhanced by the ways in which our onlookers (whether our colleagues, or members of the Hashilus team) adopted the role of an audience that appreciated the feats of athleticism that our physical actions created in the virtual world. When we kicked a physical ball, in the virtual world it would blast through the air like a fireball. Anime goalies and defenders would crumple in useless piles in response to our powerful kicks. In the physical context, as players we stood on a platform, with a headset on, and kicked a ball that would move a limited amount because it was essentially attached to a collection of ropes.

For our onlookers both the digital and physical environments provided entertainment, as fireball footballs add to the sense of spectacle, and watching the lumbering actions of others in VR headsets can be quite amusing. Whilst we could see a digitally rendered view of our immediate surroundings, in essence players have very little visual awareness of the real physical environment. In the game world, we could hear a digital stadium crowd cheering when we scored, and characters from the losing team would approach us to graciously comment on their defeat. Simultaneously, we could hear others in our physical environment loudly cheering when we scored, commiserating when we missed, and praising successes. This combination of imagined and real audiences amplified the immersive location-based VR experience. In the sense that as we played became more conscious of the presence of our invisible physical audience. Bell et al (2018) explore how for individuals participating in a piece of digital fiction in a gallery setting, the elements of their physical environment (e.g. sounds, movement of other people) impacted on how these individuals were cognitively 'pushed' further into, or 'popped' further out of, a digital story-world, and so they argue extra-textual elements are of significant importance to narrative immersion. The physical football audience could have potentially served as a disruptive reminder of the physical environment, which could ‘pop’ our attention away from our role as a skilled striker. However, we found that it ‘pushed’ us further into the game-world as it made us take our own in-game actions much more seriously. In this

sense then, the feedback from onlookers is of significance in creating positive and immersive location-based VR experiences.

Our audience was also situated in a Japanese context, and our whole time at Hashilus was influenced by ideas about cultural hospitality. With the care and diligence that our hosts paid to our location-based VR experiences reflecting the notion of 'Omotenashi', where going the extra-mile to anticipate needs is central. This notion was explicitly discussed by Hashilus during our meeting, but was also present in the ways in which attendants prepared us to participate in LBVR experiences when we attended Japanese entertainment centres, such as *Joypolis*. In all our experiences in digital story-worlds, through innovative interfaces we were always situated as part of larger social groups (even when playing as a group, individually, collaboratively or competitively), and the roles of player or onlooker were influenced by the specific cultural contexts in which we were situated.

Section 3:
Development of a Location-based VR Experience for Children

During the networking activities we explored how a story-worlding methodology (Bartle, 2003) could be used to prototype VR content. We started with a well-known children's book 'Where the Wild Things Are' by Maurice Sendak in order to imagine what a 360-degree virtual version of the narrative might look like. We worked in small groups to materialise our ideas using cardboard, tape, toys that could be repurposed and modelling clay to create rough-and-ready prototypes. The process allowed us to consider such things as on-boarding, selection of physical or virtual materials, scale, emotions and social interactions across the narrative design. We then took turns to imagine how a child-user might move through and experience this well-known story in VR.

Towards the end of the Knowledge Exchange project, a group of MA Information Experience Design Students at the Royal College of Art (Izabela Duszenko, Juliette Coquet, Sindi Breshani, Dimitri Menexopoulos, Anna Tuhus and Feiqi Wang) built on these story worlding methods to include children directly in the design of VR content which they then went on to develop. The overall intention of doing so was to explore how a VR experience for children could be informed directly from the network findings. Also to test if it might work as a means of including children directly in the design of VR content being made for them using methods of hands-on making. Using making as a means to generate ideas for VR content is similar to an earlier exploration by Yamada-Rice et al (2020) to allow children to create objects with physical materials and then try to replicate those in a VR environment created using the software 'Tiltbrush' (Google). Tim Ingold (2013) writes of the value of coming to know the world through our hands and physical processes of making. It also responds to recent research by Thestrup and Pedersen (2020) on children's use of makerspaces that shows how physical making can be a valuable pedagogic approach which they term 'makeative' (p. 24).

The VR experience which came to be known as 'The Village', took inspiration from the V&A's Museum of Childhood collection in order that the final work could be exhibited as part of the Museum's Festival of Play, July 2019. Specifically, the students chose Rachel Whiteread's collection of around one hundred and fifty dollhouses as a starting point. In this way, they started with a traditional means of immersive play that has a long history of bringing the unreal to life and reconfigured what this type of play might mean in a virtual space. Additionally, the students felt that the affordance of VR which allows it to create 'illusions and magic' with regards to scale could be successfully explored with this theme.

Researchers Potter and Yamada-Rice observed the MA students undertake a workshop with primary-aged children to create characters and narratives for the VR content using Whitereads' doll houses as inspiration. To begin with each child was given a different paper replica of one of the houses from the V&A collection and asked to create a story of what they thought was happening in and around the house, encouraging them to use physical making in response to questions such as: What could we find inside? Who are we

going to meet?, What has happened in this place? In this way the paper houses acted as a 'cultural probe' that is a 'package of...materials- designed to provoke inspirational responses' from research participants (Gaver et al, 1999, p,22). Such methods have previously been used by other past Information Experience Design students to facilitate involvement of user groups in research (Classie & Sun, 2015).

In response to the 'cultural probes' created by the students the children expressed their ideas through drawings and three-dimensional models, with the help of prompt cards and tokens designed by Sindi Breshani (Figure 13):

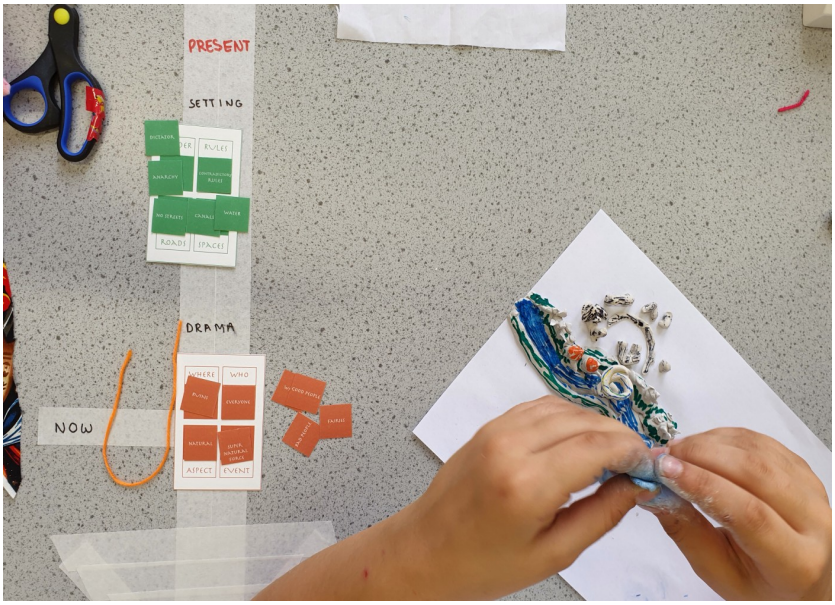

Figure 13: Workshop (Image by Sindi Breshani)

The children's characters included a king who built the village a long time ago to protect his family from a witch, who cursed the village creating a solar eclipse. Other characters designed by children included a calculator man, a scientist, fireflies, dragons, a gecko and a rooster. Along with a narrative history of events that had taken place in the village.

The team designed, and then, Juliette Coquet rendered the virtual village (Figure 14). In the VR village the user is able to enter the houses and come to understand who lives there. In doing so, each house was allocated a particular character and related narrative that the user can only hear once inside the individual homes. The narratives and sound scape composed by Dimitris Menexopoulos (https://www.menexmusic.com/solo#!) were also based on those designed by children.

Using the project findings about physical materials and details the students set about imagining how these could be used to help on-board and transition child-users into the virtual village. To do so, Duszenko began turning four of the characters (The Witch, The King, The Calculator Man and The Scientist) into physical toys.

Figure 14: The Village VR (Image by Sindi Breshani)

The characters both in VR and as materialised toys were based almost exactly on the children's designs in terms of colour palette but also the narratives that they made. For example, when making the King the child-creator stated that: *"A long time ago there was a king who wanted to help his family."* Thus, Duszenko created four smaller characters to create a family unit. Each of the king's children was an individual, slightly different in shape and size but with similar characteristics. Similarly, when thinking of colours and how the characters would look, she adhered to the children's design ideas and suggestions, for instance 'the king doesn't have a body' and 'he needs big gems on his boots', even little details such as little legs and little arms of characters came from one child's suggestion 'I need a head and some tiny legs and two tiny arms.'

Figure 15: The King as rendered in VR (Image by Sindi Breshini)

The toy and VR character designs matched in order to bring out a smooth transition from physical to virtual domain (Figure 16):

During the design process Duszenko played with the toys and created short scenarios like: 'The naughty King plotted with his family a kidnapping of the Calculator Man's baby'. Emotional expression also became important to the design of the characters and reflects the finding from the network activities that showed how social and emotional aspects of the experience were important, so questions were asked of the characters such as 'how do the characters feel and how do they make you feel?' Their responses were then incorporated into the toys by elements such as the size and form of the eyes, the mouth, cheeks etc.

Duszenko's attention to detail in design and production closely mirrors that described as important in the findings. For example, she states:

> ...that the most important aspect for me, is for a child to connect to any toy I design and to have fun playing with it. When making prototypes I usually try to play with them myself, working out how a child would handle the item. Whilst building The Calculator Man the idea came to me to add a little object or

Figure 16: Toys (from left to right: Calculator man, Witch, Scientist and the King and his family) (Image by Izabela Duszenko)

> accessory to the toy. In our lives the objects that we are surrounded by come to represent us, with this in mind I carefully studied the narrative created by the school children and created for The Calculator Man a playful little calculator, which much to my delight was recognised by many children during the V&A Play Festival as a baby calculator and started many new conversations between the children about family.
>
> (Duszenko, 2019, n.p)

However, it's worth noting that not all details were planned; children who used the toys at the Festival of Play also found that the toy's angular shape allowed them to be stacked and used for construction and building. This acts as a clear reminder of the importance of adults designing for children to check in with their intended audience regularly and undertake user testing.

The overarching aim of creating toys was to provide the opportunity for children to connect with a character from the VR narrative and get to know it in a tactile manner before entering their houses in VR. Thus making the transition from physical to virtual environment smoother. Additionally, involving children in the narrative who were waiting to use the VR experience.

The importance of good on-boarding is something that has been discussed throughout this report; the students took this one stage further and considered the potential role of off-boarding' something that was not part of any VR experience undertaken in the knowledge exchange activities. As a group of experience designers, they paid attention to how children might want something tangible to remember the experience by. They came up with the idea of creating a boarding pass to travel to 'The Village' which could be stamped at the end of the experience and taken home (Figure 17):

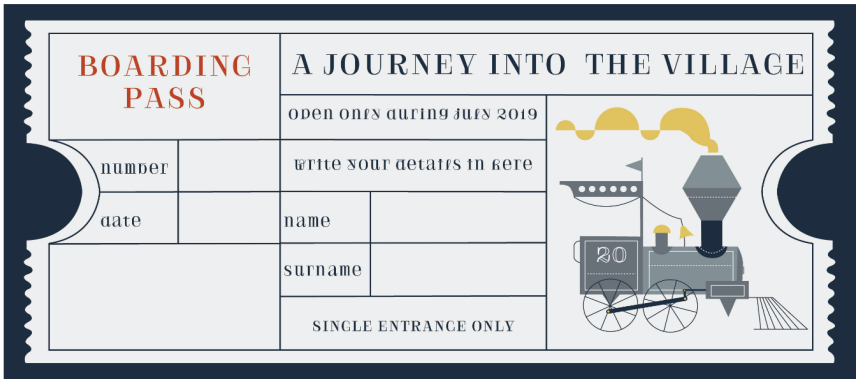

Figure 17: Boarding pass

Design and development of 'The Village' shows how making as a form of research methodology can be used to involve children in the process of location-based VR experiences being designed for them, and in these early stages of development might bring up new ideas or development not previously considered by adults as was the case here.

Section 4:
Conclusions and Recommendations

4.1 Relating Key Findings to Best Practices

One of the objectives of this network was to develop a set of guidelines and best practices around VR development for children. Figure 18 acts as a reminder that although we rush to do this in almost every area, best practices usually take decades or even centuries to be refined and therefore should be checked and re-evaluated often. However, we have begun the process of thinking about what our research findings seem to indicate for initial ideas about best practice for development and use. At the next stage these would need refining in relation to VR development and user testing.

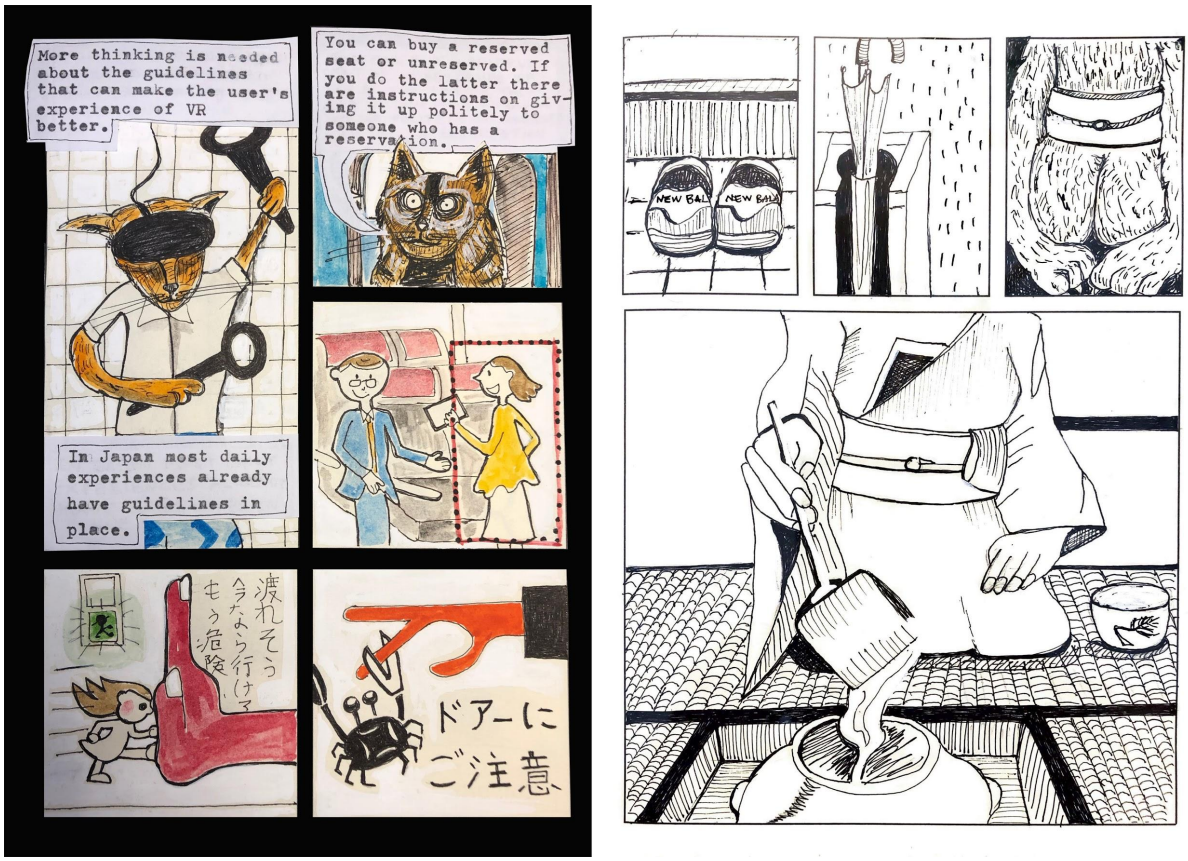

Figure 18: Comic Analysis: Best Practices (Yamada-Rice, 2019)

1. Children may not be familiar with VR technology so it is important to make them feel comfortable with the unknown. This can be achieved by careful on-boarding before the VR headset is worn. Showing a short game trailer to give them an insight into the world they will be entering can help them feel reassured. In an arcade setting, the 'shop front' of the game can give children visual clues to the type of game experience it will offer. Using video screens to share what the player can see for those who are not playing can provide insight into the gaming experience and create opportunities to join in as a viewer too and also act to reassure adults who might be accompanying children.

2. The safety of children is paramount in game design. Help children keep safe and feel in control by explaining the safety rules before gameplay begins. Safety information can be presented in a variety of ways depending on the age of the child and where the experience is taking place. A short explanation by the person manning the game is best for arcade experiences and a list of safety rules to read through can help for older children. If the game is for personal use; supporting material such as a clear pictorial poster or a short video showing you how to keep safe while playing will be necessary.

3. It is important to make sure children are comfortable while playing the game. Equipment must be set up to be comfortable to use. Allow time for the player to adjust their headset and calibrate their position before the game begins. A VR player can't see others when they are in an experience, but they can be seen. It is important to make the player feel less vulnerable so they can more easily suspend their disbelief and enjoy the game rather than worry about how they appear in the real world. Offer players modesty skirts if they need to sit down during the game, and eye masks to put under their headsets for good hygiene if the devices are shared.

4. As part of in-game on-boarding, explain the visual clues the game will offer if the player is outside the gaming area. It is better to pause the game when this happens so they can easily return to the spot needed before resuming the game. Offer the player a cue or a way of signalling how to leave the game, or what to do if they feel uncomfortable at any time. This is especially important if the game is in an arcade setting, and like a rollercoaster, it cannot be stopped until the end of the experience. One of the most empowering things to tell a child is that they are welcome to shut their eyes if they feel uncomfortable and ask for help if they need it - they may not feel able to otherwise.

5. Allow the player to see themselves in the game before they begin. A player may be able to see others in a game but not always themselves. It's confusing when the player is part of a story, because they don't really have a sense of self, or know who they are. Hashilus solves this by using a 'mirror' at the start of the game, so the player can see themselves. It is very reassuring, allows the player to be part of the story and gives the player agency.

6. Physical props during gameplay can help heighten the virtual experience. Dressing up in the real world to play the part of the character in the virtual can provide children with a visual and physical connection to a game. Use real-world props to heighten the action in the virtual world for example, a fan to blow air on the face of the player to make them feel like they are really travelling, and a real carpet to sit on for a magical carpet ride. In more immersive VR experiences - the props can move in-time to the virtual experience. For example a swing or a cannon to create physical feedback for the player like that created by Hashilus.

7. Audio design can help support the player and increase the immersion. A running narrator or 'voice of God' may be necessary, or a guide for the player and help when they need it. The player is more vulnerable with a VR set and the extra reassurance and

commentary can really help the player feel less alone and more supported to enjoy their game experience.

8. Scale can be used in a playful way in character development. For example when confronted with a 'baddy' the player may only see a foot at eye height. In VR they can look up to see the giant towering over them, or the dinosaur at real scale. However, careful thought should be put into introducing these for younger and more sensitive players.

9. Careful world design can help children feel like they are exploring a large area but are still in the confines of the playable space. One way this was achieved in 'Dragon Quest' was to create a series of levels that required the player to move forward or backwards slightly but presented them with a whole new landscape. Each level used a cliff edge to mark the barrier - if the player fell off the edge, they'd lose a life in the game, but they'd also be outside the playable space.

10. Off-boarding once the game experience has ended should be considered too. Showing the player the final score or the end of the journey as well as instructions about how to safely remove their headset should also be considered as part of the design. It can take time to adjust back to the real world. A memento to show they have completed an experience in an arcade can be a lovely transition back to the real world.

4.2 Areas for Future Research and Development

The findings generated from the network activities offer huge potential to the development of the next generation of immersive location-based content specifically for children in multiple areas and indicate opportunities for future research in the areas in addition to entertainment: (1) theory, (2) education and (3) child health.

Theory
Much of the report is based on early concepts around the connection between research and magic. The role of techniques from illusion and magic in creating effective content for a range of media is increasingly recognised by cognitive neuroscientists and behavioural psychologists (Quian Quiroga, 2016). It is no surprise, therefore, that the same techniques are also effective for optimising Virtual Reality experiences, a phenomenon we have observed first-hand. Many of the most cutting-edge, effective VR experiences we also encountered in Japanese research laboratories and those created by our partners Hashilus deploy techniques from magic and illusion, techniques which are increasingly recognised by cognitive neuroscientists (Macknik et al, 2010). It would seem there could be real worth in understanding more deeply how theories of magic and illusion could provide a framework for developing the next generation of location-based VR experience.

Education
It's long been commonplace for education technology enthusiasts to write about the 'potential' of any new piece of equipment or interface to impact on education in some way,

and for some of us working in education this has felt like an endlessly deferred future. In the case of Virtual Reality and Augmented Reality, the benefits to formal aspects of the curriculum are not always clear cut, except perhaps most usefully in novel ways of imparting information through experiencing immersive environments. However, the networking activities in both the UK and Japan have given rise to some fruitful suggestions for areas of future research which might fill some of the gaps in our understanding. In listing these, we take the position that education is inclusive of, but wider than, formal schooled learning and connects to cultural experiences of the digital as well as playful and agentive exploration on the part of the learner. We consider these below across the three domains of Affordances, Storying and Play.

In relation to affordances research could usefully be directed at understanding how each of these related but distinctive forms of technology offers opportunities to create experiences which match the human need to make sense through narrative exploration, particularly in collaborative versions of these environments. Of the available technologies, there were arguably times when the nature of Augmented Reality allowed for greater shared immersion in real-time and for the laminating of experiences. After VR experiences it is common for people to speak about them and to compare notes. Sharing a physical space and a screen and being unencumbered or closed off in a VR headset, can mean greater shared experience in real time and more resources from which to make meaning. But this is purely hypothetical, of course, and VR has also been found to have social benefits (Yamada-Rice et al, 2017) which could also bear repeated investigation. However, much greater resource in terms of longitudinal and multi-case study research could be directly applied to the affordances of each technology, in the original sense of an 'affordance' as potential within a landscape for action (Gibson, 1977). With this in mind research questions could be usefully directed towards functionality, usability and provisionality, the ways in which the known benefits of makerspaces could be built into VR experiences.

For learning, we saw in the work of PunchDrunk, how Mixed Reality engenders an agentive approach to story and to (Colvert, 2018) and we recognise in this and our own experience of the importance of the whole world around a VR experience (the on-boarding and the off-boarding. Similarly, previous research with children has found that real world objects used in conjunction with the technology generate high levels of engagement which, in turn, suggest possibilities for active storytelling in situations requiring high levels of empathy and engagement. A research project focused on storytelling in VR, AR and MR and which developed these earlier projects further, in the light of the engagement with the network, would be very interesting and could have significant research and pedagogic impact.

In relation to play children's playground games are layered with cultural significance, ritual, storytelling and experiences which sometimes draw on the lifeworlds of the participants In observing children creating new games from these resources for meaning-making, we have begun to see how these laminates work together and how the playground itself becomes a meaning-maker space (Potter & Cowan, forthcoming in 2020). It would

be really interesting to work with this view of play in the context of VR, AR or MR, with a focus on how playful experiences in these technologies encourage rich world-building and design experiences. How does this, in turn, enable children to make sense of particular aspects of their world, their feelings and so on? At the time of writing we are still going through a global pandemic and the consequences for quite young children of being 'locked down' on their relationships and personal development. How might VR, AR or MR, sensitively developed alongside children, enable this to be mitigated in some way? These are all questions of great potential impact and we have already identified partners through the network who could be drawn into such a project.

Health

VR is already being used in many areas connected to adult health and wellbeing. Yamada-Rice and Love (2019) are part way through an Innovate UK funded project working with Dubit and NHS Trusts to produce a play kit which includes VR to help children have an MRI scan without a general anesthetic. The possibilities for combining VR and play for other health context are boundless and would take advantage of the fact that play has been documented as an effective way to promote health and wellbeing (Tonkin 2014) by allowing children to make sense of their experiences, express fear, normalise unusual events and thus reduce anxieties (Jun-Tai 2005; Jun-Tai 2008; Erikson 1963). Sensory-perceptual play is also emerging as a way of recovering from trauma (Holmes et al, 2009). VR with its immersive properties might serve to deepen this ability.

Collaboration across each of these knowledge domains, and between cultures as we were in the network, suggests there is huge potential for bringing all of these elements and questions together. Storying, play and technological artefacts can be used to mutually constitute and create opportunities for new educational experiences within and across cultures, but further research in all three domains suggested above would beneficially enhance our understanding of the evolving environments of VR, AR and MR.

Finally, we would like to note that in the midst of the current global pandemic it is hard to predict what will happen next for virtual reality technologies, but we can speculate that the rich, communal experience of location-based VR may see a shift into domestic settings, if, for example, social distancing continues and the rewards of flat screen-based experiences diminish.

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Appendix 1: VR Content included in the Project

Hashilus, Japan

- Gold Rush VR: https://hashilus.co.jp/products/goldrush-vr/
- Dino Kickway: https://hashilus.co.jp/products/dino-kickway/
- Captain Tsubasa Burning Striker: https://arthands-vr.com/2018/10/15/taito-corporation-is-holding-location-testings-for-location-based-vr-attractions-vr-attack-on-titans-the-human-race-and-vr-captain-tsubasa-burning-striker/
- Attack on Titan: The Human Race: https://arthands-vr.com/2018/10/15/taito-corporation-is-holding-location-testings-for-location-based-vr-attractions-vr-attack-on-titans-the-human-race-and-vr-captain-tsubasa-burning-striker/
- Oshare Happy Time: https://hashilus.co.jp/products/happy-oshare-time/

Joypolis, Japan

- Zero Latency: Outbreak Origins: https://tokyo-joypolis.com/language/english/attraction/1st/zerolatency/index.html
- Tower Tag (VR Nerds): https://tokyo-joypolis.com/language/english/attraction/towertag.html

Sky Circus, Japan

- Tokyo Bullet Flight (Hashilus): Tokyo Bullet Flight: https://hashilus.co.jp/works/tokyo-bullet-flight/
- Swing Coaster (Hashilus): https://hashilus.co.jp/works/swing-coaster/

Shibuya VR Zone

- Salomen's Carpet (Hashilus) - https://hashilus.co.jp/works/salomon-carpet/
- Jungle Bungee VR
- MU VR
- Truck Coaster VR

Mazaria VR Zone, Japan

- Mario Cart VR: https://bandainamco-am.co.jp/others/mazaria/en/activity/activity.php?ac=mario-kart
- Taiko no Tasujin VR Dance: https://bandainamco-am.co.jp/others/mazaria/en/activity/activity.php?ac=taiko-no-tatsujin
- Dragon Quest VR: https://bandainamco-am.co.jp/others/mazaria/en/activity/activity.php?ac=dragon-quest

University of Tokyo, Japan

- Computer Vision Laboratory (Oishi Laboratori): https://www.cvl.iis.u-tokyo.ac.jp/index.php?id=mr

- Cyber Interface Lab: http://www.cyber.t.u-tokyo.ac.jp/?source=post_page----------

Sony Music

- VR experiences in relation to Sony Music artists

Marshmellow Fest, UK

- We live in an Ocean of Air

Otherworld, UK

- Moss (Polyarc)
- Rick and Morty: Virtual Rickality
- Job Simulator (Owlchemy Labs)
- Accounting Plus (Crows Crows Crows)
- Superhot (Superhot Team)
- Fruit Ninja VR (Halfbrick Studios)
- Sprint Vector (Survios)
- Tiltbrush (Google)
- Beat Saber (Beat Games)
- Everest VR (Sólfar Studios)
- Fisherman's Tale (Innerspace VR)
- Google Earth VR (Google)

Imotion, UK

- Feed a Titanosaur

XR Games, UK

- Angry Birds Movie 2 VR: Under Pressure

Nintendo Labo VR

- Starter Kits: https://store.nintendo.co.uk/nintendo-labo/nintendo-labo-vr-kit.list?search=Nintendo+Labo+VR