Cocreation of The Lookout

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Declaration

This work has not been previously accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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Abstract

This thesis focusses on the creation of an interactive, outdoor public display blueprint to be adapted and deployed within the development site of Swansea city centre. The main purpose of this display was to inform the public of the scale, nature and detail of the major redevelopment of the Swansea waterfront area to the east of SA1 which is part of the ongoing Swansea Bay City deal. In addition to being a source of information, the design of this display had two underlying themes; to be fun and engaging and to be as inclusive as possible for as many people as possible.

To achieve this, a human-centred methodology has been used which has focussed on the use of cocreational studies to enhance the use of the final prototype and achieve responsible innovation. The cocreation of initial ideas with the main project stakeholder (Swansea Council) involved the analysis of several modalities for interaction resulting in the choice of a binocular-based visual display. These initial design meetings took place just before the lockdown due to the Covid-19 pandemic. As the full extent of the lockdown became apparent, the design was adapted to become Covid friendly and touch free.

The co-creation element of the project involved four iterations of the content development with feedback taken from domain experts and end users. This led to a final physical design containing two installations; one display for adult pedestrians and one at a more convenient height for wheelchair users/children. Both of the proposed displays included an interactive aspect using elbow levers to trigger screen panning and a Bluetooth button controlled by an elbow push to select different aspects of the content. The final design resulted in an interactive visual experience where the user was able to choose a point of interest to locate to, pan the content screen and have their picture taken and shown within the display. Further iterations included the addition of audio tracks for different locations and the removal of trip hazards to help partially or non-sighted users to be able to use the installation. Within the final design blueprints an interactive public installation was presented that was as accessible as feasibly possible for all members of society and one which has been co-created by potential users to fit

the purpose of the local area in where it will be situated.

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Contents

Chapter 1

Introduction

This thesis focuses on the creation of an interactive public installation that aims to connect and engage the local residents with the development of Swansea's city centre. Swansea Council began work on this development plan in 2019 overseeing a £1.3 billion investment into 8 major projects and are a stakeholder within this project. The locations of these projects can be seen within Figure 1.1a. As part of this development Swansea council wanted to locate the interactive public installation within Phase One. Figure 1.1b shows a closer view of the Phase One development with the intended location of the interactive public installation pin pointed as "Mobile Booth", circled in red. This development phase will consist of a $3,500$ capacity digital indoor arena, coastal park, digital plaza, pedestrian bridge, car park, housing complex and retail, food and drink services with the developments projected outcome shown in Figure 1.2.

Figure 1.1: Figure 1.1 a) A highlighted map of the eight development areas related to the Swansea development project with the Phase One project shown in green [69]. b) A zoomed in map of the Phase One project with the location for our installation at circled in red. [68].

Figure 1.2: The birds eye view of the projected final outcome of the phase one development with the following areas from left to right 3,500 capacity arena, coastal park, pedestrian bridge, housing complex, car park with the installation located on the right of the car park [68].

The interactive display blueprint to be developed within this thesis aligns with the aim to create a new area of interest and interaction with the Swansea city centre development. In order, to achieve this it was essential to include the local community within each process of the development and provide them with a transparent insight into the progress of the site. Therefore, we created a blueprint for an installation that could provide interactive information about the development that would increase intrigue. It was important to Swansea Council that the installation was a type of interaction that had not been commonly seen throughout public areas and suggested that a digital headset interaction similar to the binoculars found within sea front locations would be a favoured design. However, at the beginning of the project the coronavirus pandemic caused the UK to enter into a lockdown from March 2020 creating a new environment of possible research. Therefore, the aims of the project were modified to reflect the need to create a Covid friendly installation.

1.1 Motivations

The motivation for this project is to create a Covid–19 friendly prototype installation which is as accessible as feasibly possible and has been designed through the methodology of human centred co-creation. This type of methodology has been proven to be a successful way of creating a useful interaction which aides the community because it takes advantage of the insight of local users. Therefore, providing a user friendly interaction that is more inclusive. This inclusive prototype will then be adapted to be deployed within the Swansea City Development.

1.1.1 Aims

This project aims to achieve three main outcomes. The first will be to create an installation that is as widely accessible to as many people as reasonably possible. In order to achieve this aim we will aim to incorporate users who are often marginalised in the cocreational process of the design. The second is to carry out intensive user-centred design activities to inform the public display system in both its physical and digital elements. In order to achieve this aim we will design storyboards (see Chapter 5) which will be iterated 5 times. The third aim is to create a working prototype of digital elements to act as a base for deployment. In order to achieve this we will provide a final design which can be used as a basis for the final deployment.

1.2 Overview

The objective of this project is to produce a Covid-19 compatible installation to be located within the Swansea city development site shown in Figure 1.1b. Therefore, an overview of the research of public displays has been carried out to provide a fundamental understanding of what has been done before and what the state-of-the art technology is to underpin the brainstorming of a wide variety of interactive modalities which can be adapted into touch free interactions. The project design work has been undertaken using the concept of responsible innovation and human centred interactions. In the work reported here a blueprint was developed for a final system that will be deployed at the development site. This blueprint will include a physical and visual prototype. The digital prototype will be an Android based application that enables the user to be teleported from the current view of the development site to a virtual representation of the site where they are able to pan and select different aspects of the design. For example, the user will be able to teleport to the arena, arena auditorium, pedestrian bridge, coastal park, housing complex and car park with the opportunity to incorporate their photograph within the site as well. Figure 1.3 shows a schematic of the final physical design which will be provided at two heights one for adult pedestrians and one for wheelchair users and children. The design includes two elbow levers which can be interacted with in order to pan the content of the visual prototype. There is also an interactive button to enable the users to select which area they wish to teleport to.

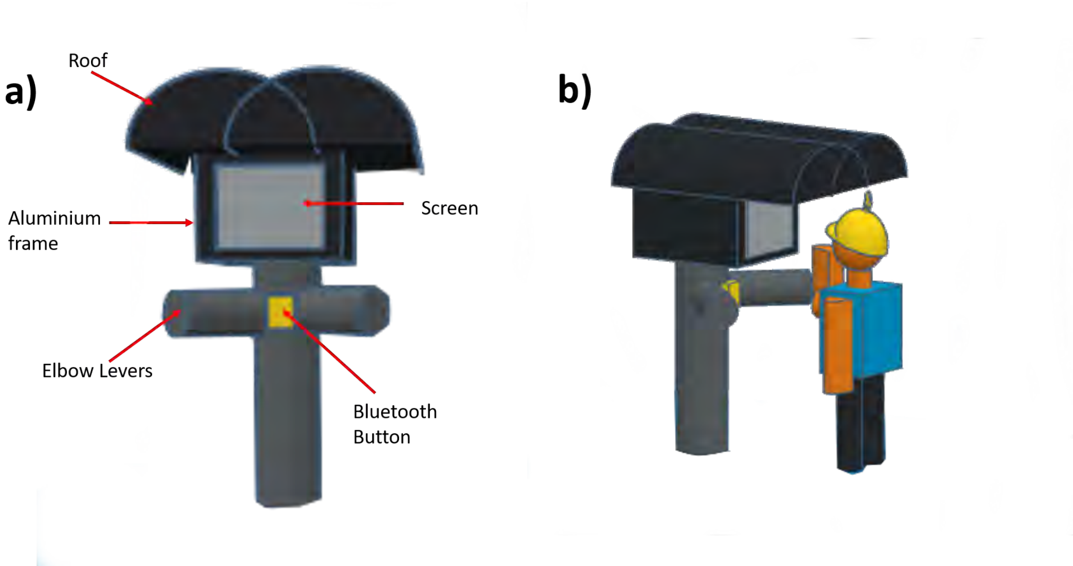

Figure 1.3: A schematic of the design for the final installation. Figure 1.3 a) shows a labelled prototype for the final blueprint. This design design will be completed at two heights, one for adult pedestrians at $1.4m$ and one for children/ wheelchair users at $1m$. b) shows a user interacting with the elbow levers to cause the installation to pan from east to west and vice versa.

Chapter 2

Background and Literature Review

This literature review relates to interactive installations which involve Augmented and Virtual Reality, users interacting with displays, software and modalities of interaction. Therefore, this chapter will cover all of these areas. For the purpose of this project interactive public displays are defined as installations located within public areas which enable the user to adapt the installation to provide information that aids the community in which the installation is placed within, with public areas including locations such as office spaces [13], train stations [54] and outdoor areas [35]. Therefore, all passive public displays such as, road signage providing traffic information are outside of the scope of this project; see for instance the sign in Figure 2.1b . An example of an interactive display which does fall within the scope of this thesis is a public art installation in Montreal, Canada which used Luminotherapie to provide an immersive experience for the community where the light within the prisms changed dependent on the location of the users next to them as seen in Figure 2.1a. To provide a basis for the remainder of the project a range of modality types for interactive public displays will be evaluated.

2.1 Public Visual Displays

Public visual displays or interfaces provide information through visual content to nearby users [28]. They are often manufactured using Light Emitting Diode (LED) screens, such as interactive poster boards which are large LED screens commonly found within shopping centres to aid navigation [53]. An example is the interaction shown in Figure 2.2 where the user is able to interact with different elements of the screen to find a variety of shops across the two story shopping centre. The advantage of LED screens is that they have sufficient resolution

a) b)

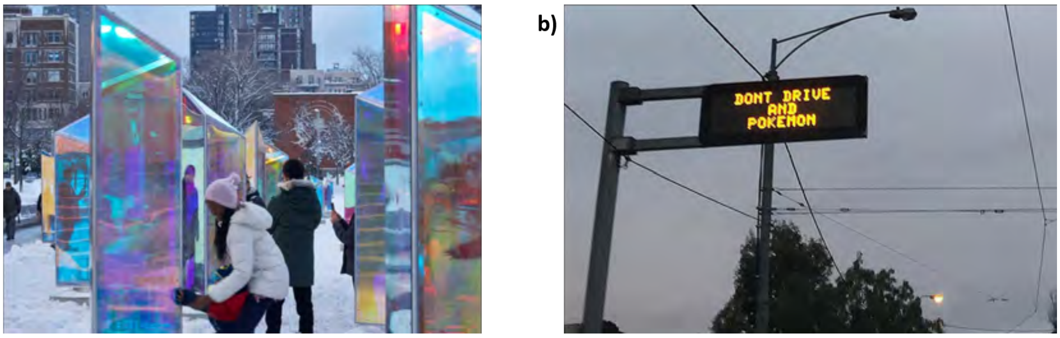

Figure 2.1: Figure 2.1 a) shows a user interacting with one of 50 pivoting prisms which change colour dependent on the position of the light source and the user, located in Montreal, Canada [16]. b) shows a passive signage sign that can change dependent on the traffic [8].

and colour range to appeal to the majority of the public and are ideal in busy areas such as train stations as they provide small pieces of information quickly [14]. However, these displays are often ignored as they have become normalised within public areas [1] and users often mistake them for televisions which shouldn't be touched [38]. This is known as interaction blindness and can be reduced by introducing physical objects such as remote controls into the interaction to aid the understanding of what the interaction entails for the user [50]. Some researchers believe that in order to aid the user to understand the content in the most depth, several spatially distributed displays should be used [35]. However, others believe that in order to achieve the prime volume of interaction from a user requires fewer interaction points so that they spend more time focussing on the one interaction [36]. Having considered these conflicting viewpoints, the decision made in this thesis was to create a novel kind of installation that was not simply screen based in order to reduce the possibilities of interaction blindness. The plan was to create an installation that users have rarely seen before and therefore find intriguing. Hence, the decision was to opt for a binocular based design which would not commonly be thought of as a digitally based interaction. This decision was also informed by discussions held with the Stake holder.

Furthermore, it has been reported that screen-based interactions can provide an easy promise of an interactive experience within urban spaces especially if accessible to a group of users compared to single user interaction [37]. This is because it enables a group to congregate around an installation and interact together [57]. For example, Scheible et al. deployed a large screen interaction within a restaurant in Finland which played interactive videos where users could vote for their favourite video using their mobile phones. They also provided an incentive

Figure 2.2: A user interacting with a wayfinder of the St Davids Shopping centre in Cardiff, Wales [51].

for users to interact by choosing a random voter to receive a free beer after each round [65]. In this project, it was not possible to provide free beverages for users who interacted with our installation. Instead, in this thesis, the design decision was to include a fun element to the interaction by providing the user with the opportunity to take a photograph of themselves and view it within the content which they could photograph themself on their phone and keep as a momento.

Displays which enable the user to feel in control of their interactions with the installation outcome without any additional support have been reported to receive a higher volume of interactions compared to installations which are easily misunderstood and therefore require in depth explanations before use [37]. In this regard, Houben et al. deployed an interactive physical data installation which enabled users to answer data related questions and provide their own insights about what the data could relate to [30]. The ability to make a personal contribution enabled the public to understand their own data and provided valuable insights for the stakeholder. In this project, the plan was to use this kind of approach as we wanted to observe the users interacting with our device. However, due to the coronavirus pandemic it was not possible to be near to the users and receive feedback from them directly. Therefore, it was decided that the installation needed to be simple but still provide the user with the sense of having learnt something new about the development site. The aim was to provide Swansea Council with feedback on how this affected users perspectives once the display had been installed.

Huang et al. reported that observational studies that record the interactions of users from the beginning to the end of the proposed journey can aid in evaluating the attention span of the user [31]. For example, Parra et al. studied a public interaction with two large screens within different areas of a busy train station in Brussels with the aim to increase awareness of 'Restart a heart day' [54]. They provided interactive content across a 12 hour period with an end goal of users signing up for CPR lessons using a QR code linking to the sign up website [54]. This was provided at the end of the content when the user placed a hand on their heart which led to the display triggering a video with information about Restart a heart day. They were able to pick up the gesture using skeletal sensors. The data that they collected showed that only 10% of the users who interacted with the interaction achieved the final goal. They ascribed the lack of completion to the users often leaving before the end of the content to catch a train. In this project, the design decision made was to try not to put pressure onto the users as it was felt that this would reduce the quality of the interaction that they completed. Therefore, the prototype was designed so that it was not affected by the length of time that the user might spend with the installation and it was not considered important when a user interacted with the installation for a short length of time.

Magical Mirrors have also been reported as another form of visual display which enable users to see themselves within a screen as if they were looking into a mirror. In this mirror, users can perform gestures to reveal different optical effects such as growing flowers. Michelis et al. deployed four magical mirrors into a department store window in Berlin, Germany [45]. They observed users completing a range of gesture-based interactions to produce a variety of graphic overlay. They found that by having several interaction points the users began to interact with the displays via the funnel effect. This is when a user goes through a number of interaction phases across a series of multiple interaction points. They may begin by walking past the first installation and viewing it in the corner of their eye. They reported that this can lead to subtle interactions such as a slight wave to see if the second interaction changes. The aim behind this approach was that by the third or fourth interaction point the user would stop and create direct contact with the installations [45]. Michelis et al. reported that the more phases the user completed was related to how effective the interaction had been in grasping the attention of the user. It has been found that this kind of design aids iterative cocreational design as it can highlight phases which cause confusion and therefore lead to loss of interest [47]. These new insights can then be used to adapt the installation and create a more effective deployment. The design approach in this thesis has sought to emulate this type of cocreational design with the hope of creating a funnel effect within our installation once the display has been installed.

Interactive public displays can be a way of supporting awareness and spreading information tailored to a local community [70]. For example, Taylor et al. deployed an interactive community board within a local shop that enabled users to update it with local news and information about the area. After over 10 years of observation and input from the community the Wray installation is still used and updated by locals. As these installations focus on providing detailed information based on a certain location they can provide information specific to the local community.

Cocreation has been reported to be a key tool used within the development of visual public displays as it helps to integrate the installation into the area especially when the content is orientated around a very specific location [43, 55]. Being able to cocreate with a community increases the buy in of the local people in taking time to come and see the interaction and spread the word about its uses [67]. The community will often have views about content and physical aspects which were not previously considered by the designer themself which provides an opportunity to iterate to a level at which the design is as inclusive as possible [63].

Similar to this, Frohlich et al. deployed a large interactive audiovisual display in Budikote, India [24]. The purpose of the deployment was to enable the local community to create stories that other members of the community could view and enjoy. It was shown that being able to deploy such a technology within areas which have had little technological exposure can provide invaluable insights for both further iterations within the community and new developments within the Western world [24]. The display that is being created in this thesis is heavily tailored to the development site within Swansea city centre and could be iterated to provide a new and interesting context within a community with different backgrounds of technology usage and culture.

Installations that can interact differently depending on the audience have been reported to be very effective at gaining user interest [15]. Within a museum in Naples a digital screen puppet interacted with customers differently depending on their age [37]. The purpose of this installation was to provide historical information about Naples to enhance the user's knowledge of the ancient city. In installations such as these it has been reported that it is important to ensure that the content is strengthening the user's knowledge instead of causing confusion and therefore causing the user to lose interest in the display [23]. In this thesis, the aim is to provide a display that hopes to enhance the users knowledge about the Swansea city development.

Visual displays are not limited to screen-based interactions. In fact there is evidence to suggest that physical objects that users can interact with can increase the likelihood of interaction substantially [12]. For example, Rogers et al. completed a study to evaluate the digital augmentation for learning outdoors. They used a wide range of digital displays including periscopes and discovered that by incorporating digital displays into teaching they were able to increase the children's interest in nature and expanded their minds [61]. In this thesis, it is hoped that a similar affect will be achieved by using our design to provide visual material to enhance the children's knowledge of development and different types of technology.

Proxemic interaction is an important interaction to try and create between users and public displays. Proxemic interaction focuses on the spatial awareness of users to devices, devices to devices and devices to users [3]. Cheung et al. used the proxemic zones created by Hall to create an interactive display on a university campus which was surrounded by constant foot traffic. The 3 zones relate to the distance a user is located from the interactive display with social (2m), personal (1.2m) and intimate (0.5m) [25]. The closer the user came to the installation the more engaged they were perceived to be and the content changed accordingly with a silhouette shadow of a user becoming bigger. They found that this type of interaction was enticing and attractive for passers by. The use of proxemic interaction to change content is something that we would hope to incorporate into the design within further work.

2.2 Augmented and Virtual Reality

As part of the digital design for the user display in this thesis, Virtual Reality (VR) and Augmented Reality (AR) were both considered as ways to enhance the user experience. Hence, a brief literature review of VR and AR in the context of user displays is included here. Virtual Reality (VR) provides an immersive experience where a participant is transported to a sensory experience of a virtual world [11]. It is important that a VR experience utilises all of the users senses to provide a well rounded experience which can aid users with disabilities who would not be able to have such an experience physically [5]. For example, if a user within a virtual world is walking across a passenger bridge not only would they need to see the visual bridge moving based on their movements but they would also hear a changing audio experience with audio including aspects such as other pedestrians and motor traffic [64]. This enables the creation of both visual and spatial memory [58]. In our work we were unable to use VR due to Covid-19 but aimed to provide a multi-sensory experience which is inclusive.

Augmented Virtual reality provides an experience in which $3D$ virtual objects, such as buildings can be integrated into a real $3D$ environment [2]. Lusk et al. created an AR picture assistant which could be used to assist the public in taking photographs at tourist attractions. The application works by taking a photograph of the attraction and recreated the main structures using AR with a marker as to where the user should stand to produce the best picture [41]. It is important that the AR is provided in a scale relevant to the real $3D$ environment [29]. For example, Cheil Worldwide et al. deployed an interactive kiosk in Seoul, South Korea to enable users to view $3D$ models of the Donuimun Gate where it once stood before being destroyed in the Japanese Colonial period as shown in Figure 2.3 [19]. The aim of their installation was to create an educational installation which accurately represented the bridge and therefore it was very important that it was accurate in scale and design [48]. As this thesis will be creating a futuristic design their are fewer issues with regards to accuracy as the buildings have not yet been built to scale.

Figure 2.3: A user interacting with an interactive kiosk in Seoul, South Korea. The kiosk enables the user to view the Donuimun Gate from the front of the gate, inside and a birds eye view [19].

2.3 Avatars

Avatars are visual personalised representations of people and can increase the attractiveness of public displays [59]. They have been integrated widely across several social media platforms enabling users to see themselves within different realities. Pogunkte et al. completed a user study to evaluate whether incorporating an avatar into a public display design increased the users likelihood to use it [59]. The high degrees of freedom for customisation enabled the users to create their own facial expressions which was very popular and increased their interest in the overall public display.

Using avatars to enhance the experience of users within Virtual Reality displays is becoming increasingly popular. Boberg et al. conducted focus groups to evaluate this and discovered that the users liked the use of camera mapping to create their avatars [7]. This is where the camera takes a mesh of the users face based on certain key points that the majority of users will have such as a nose. The avatars provided the users with their own identity within the virtual space and helped them to feel absorbed within the design. However, they found the selection of a large range of features to be too time consuming.

An alternative to a fully digital personal representation, AR overlays are digital features which can change the physical appearance of the user, such as adding sunglasses [33]. This kind of interaction can be more effective than avatars as it enables the user to imagine themselves in this new characteristic form within a virtual space with more clarity [33]. After testing this kind of interaction with make-up based AR in situ, Javornik et al. deployed a public display into two different locations: an opera house and a museum [32]. In both locations users were surprised and excited to view their physical transformations. However, they found that within the opera house users were more wary of the researchers observations. The plan in this thesis is to incorporate this kind of interaction into our design to provide an extra form of attractiveness to entice interactions but without having the time consuming process of creating a detailed avatar.

2.4 Other Modalities for interaction

Evaluating the use of sensor based interaction, such as gestures has become heavily prevalent due to the Covid-19 pandemic which could create a shift to sensory based interactions [57]. Jing et al. deployed a virtual touch screen that was controlled by hand movements [34]. They found that many users were not found by the sensor and they would therefore leave the display in disappointment. This is a common issue that many researchers experience due to the lack of accuracy in sensor trackers located within outdoor public displays [42].

Participants will often lose interest and not interact with an installation if there is a queue or long interaction time [56]. To evaluate this Kuikkaniemi et al. deployed an audio based installation which could adapt its content based on the number of users queuing for the display [37]. They found that the adaptation enabled more users than previously seen to use the installation but that adaptations were required in the case of a group of users surrounding the display together and therefore triggering the reduction of the content time even though there was no queue. It would also be helpful to adapt the audio volume for larger groups of users interacting together [60]. This is something we hope to incorporate into our design within the future.

Berge et al. completed a user study to evaluate whether users found it more efficient to interact with a public display using hand gestures or using their mobile devices [4]. They found that, without any training the users found the hand gesture interaction to be challenging and were unsure which gestures were needed for different sections of the screen. Whereas the mobile device interactions required no explanation. However, they found that if the gestures required were explained then the gestural interactions were more enjoyable for the users than the mobile interactions. In support of this, Loorak et al. found that users preferred sensory based interactions because they did not know how clean the displays were and therefore would prefer not to touch them [40]. This is a feeling that is likely to increase in prevalence substantially due to the Covid-19 pandemic.

Autostereograms are single-image stereograms that aim to produce a visual illusion of being 3*D* images [20]. Delamere et al. used autostereograms to reveal 3*D* content from 2*D* images within a user study where they evaluated the preference of users between touch and sensory based interaction with displays [17]. They found that direct touch input provided a faster and more accurate interaction for most of their participants. This is relevant because in this thesis, the hope is to integrate an autostereogram into the application as we have been provided with an autostereogram of the auditorium within the arena.

An interaction used less frequently within public displays is foot gesture based interaction but, with the ongoing Covid pandemic restrictions, this could become a prominent replacement to touch based interactions. For example, Han et al. deployed an interactive display based on kicking motions which enabled users to select menus and complete map navigation [26]. They found that a simple number of interactions could be understood by users but that some felt embarrassed to be creating such physical movements in public which would have led to a smaller number of users interacting with the display [10]. Several iterations of our design included foot based interaction with our design but after a user study completed with the Sight Life a charity for the blind we adapted our design to be elbow based to ensure that the installation was not causing a danger to any members of the public.

2.5 Summary

In summary, this literature review has investigated a variety of displays in public spaces and has been used to inform the design of this project. As LED displays have been used so widely throughout public spaces we chose to opt for a binocular based design instead to reduce the possibility of interaction blindness. In addition, we incorporated a photographic opportunity too the design with the addition of AR overlays as they were reported to be highly popular due their personal transformational ability and provided an extra incentive for users to interact with displays. In view of highly structured content leading to the boredom of users we adapted our design to be non-reliant on an end goal, enabling the user to view as much/little of the content as they wish. Since cocreation has been found to be an invaluable tool for community based public display designs this will be incorporated into the thesis methodology. Finally, considering that sensor based gestural interactions are often inaccurate when used within public displays the design decision made in this thesis was to incorporate lever based interactions into our design instead. In this context lever based interactions related to the use of poles which can be pushed from side to side and causing the screen to pan.

Chapter 3

Methodology

Throughout the process of design a methodology was used which focussed on a cocreational approach to prototyping represented in Figure 3.1. The method that we used was predominantly qualitative with a focus on user studies and interviews of stakeholders and local community members. At the beginning of the project a brainstorming approach was used which generated a vast scope of initial ideas with a range of modality options which we needed to reduce to a single modality for the final design. These initial ideas were then presented to the stakeholder (Swansea Council) who provided feedback such as insights into the types of content that they would want to be contained within the design, including the focus on the arena. They often also provided insight into the types of technologies they would find interesting to incorporate into the design. Each piece of feedback was evaluated based on whether it came in line with the aims of the project and the time frame available to complete the project. We presented the ideas using storyboards within structured user studies completed on Zoom which evolved to application prototypes across the length of the project (see Chapter 5). After these presentations were completed the feedback was reviewed and evaluated and the project aims and interaction design was modified as follows: the exterior installation design needed to be Covid friendly, the content needed to centred around the arena, an incorporation of a camera activity into the content was advised and the adaption of the height of the installation was required etc. The design presentation, feedback, review and modification process was iterated five times to reduce the number of design variables. This co-creation process was refined into the final blueprint for the final installation.

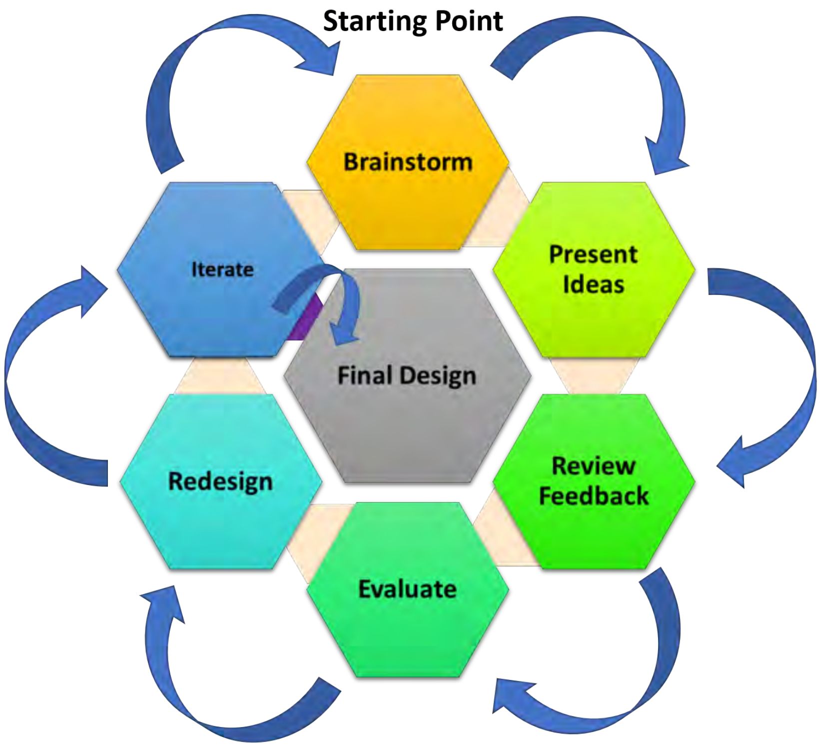

Figure 3.1: Diagram showing the methodology followed to prototype a cocreationally designed prototype. The process begins with brainstorming and travels clockwise for five iterations where a final design was confirmed.

3.1 Responsible Research and Innovation

Another aspect of methodology which we used throughout our iterations process were Responsible Research and Innovation (RRI) which hopes to create research outcomes that provide positive social impact by promoting creative opportunities that attract public interest [21]. In order to achieve this there are six key aspects which have underpinned this thesis; namely ethical review, educational value, gender and equality, open access, governance and public engagement [52]. Ethical reviews and ensuring public engagement were particular aspects of RRI which helped inform the final interaction design. Swansea Council were a key stakeholder engagement for this project and provided many valuable insights into the local community and the areas in which the development would be situated. They attended several user studies and discussions completed over Zoom where they were asked to provide consent for their feedback to be evaluated and represented within this project. They were shown a range of storyboards and asked for individual aspects of feedback such as whether the installation should have a speech probe to tell the user how to use the installation or a pictogram. The Council also provided a key connection to the Sight Life group who complete charity work within the local community with members of the community who are partially or non-sighted. Their involvement also enabled a transparent overview of the project to be provided for the local community groups and minutes were created for each meeting to ensure reflection at all times. The aim of this project revolves around public engagement and increasing the knowledge of the local community whilst creating an installation that is as accessible as feasibly possible. This enabled a vast amount of cocreation within the content and installation design which enabled the anticipation and reflection from many users who were all able to evaluate the design from their own perspectives.

3.2 Project Challenges

As the project began the coronavirus pandemic led the UK to enter into a nationwide lockdown. This meant that we had to adapt our methodology from face-to-face user studies to Zoom based interactions. Even though this was the case we were still able to complete three site visits to enable us to understand the scale of the development site and where each area will be located. Several different aspects of the development site changed over the period of the project. For example, originally a hotel was intended as part of the content but was later adapted as the hotel was moved to the second phase of development. The first visit was completed at the beginning of the project to take a tour around the site and understand the content we were trying to represent within our virtual content. Two further trips were completed closer to the end of the development, the first to evaluate the physical aspects of the device such as the height and the location of the handle bars. Secondly, drone footage was obtained of the site to enable the use of transitions between activities which created the feeling of being transported by the installation to a different area. Originally it had been hoped to provide this type of transition using 3*D* asset models but it was not possible to access them within the project time-frame and therefore the work was adapted to use drone footage.

Chapter 4

Cocreation of Initial Ideas

Swansea Council wanted to incorporate an interactive installation within the Phase One development site to educate the public about the site in an inclusive way. The original vision for this installation was a Virtual Reality (VR) Headset experience which would enable users to explore the virtual development of the site. This vision was based on discussions with Swansea City Council. The initial plan was that the installation would be similar to a pay-per-view binocular station found along many sea fronts in the UK. However, here the plan was for the interaction to be free to use and the users would be able to place their head into the installation and move the box using their hands to enable them to walk through the content.

However, due to the coronavirus outbreak, the UK was put into lockdown in March 2020. Therefore, it was necessary to rapidly consider alternative forms of interaction that were compatible with Covid rules; especially in terms of social distancing and avoiding possible transmission through surface touching. It was also necessary to consider the changes to Covid rules as infection numbers fluctuated. The alternative methods that were explored included speech, mobile and mirror based interactions as seen below.

4.1 Speech Interaction

Speech interaction and speech recognition were both considered in response to the Covid pandemic because they are both touch free modalities that have been incorporated widely throughout homes and public spaces with the public's understanding of the technology superseding mobile phones. The lack of touch requirements position speech interaction and recognition as valuable technologies within the Covid era. The plan in designing these into the interaction was to reduce the public's wariness of contracting the virus when using this kind of installation. The concern here was that, if people did not start to use the interaction quite soon after it was installed, they might never consider using it and then it could become redundant. It was therefore essential that all potential users should view both the interaction and the method to operate it as completely safe. In order to provide an inclusive interaction the audio would need to be provided in both Welsh and English.

It was decided that a set of public speakers located within the hoarding which is currently surrounding the development site could provide a seamless touch free interaction for the public as shown in Figure 4.1. The design plan was for the speakers to have motion sensors which would be activated by passers by. The plan for these sensors was that, once activated, the installation would then provide pre-recorded audio clips with information relating to different aspects of the site. For example, in Figure 4.1 as the participant walks past the car park a pre-recorded prompt says "There is going to be a car park here" and would then produce audio of moving cars. The user would then be able to stop at this interaction point and ask further questions. The use of this interaction would also then enable groups of users to easily interact with the speakers either together or separately in different locations. The design plan for the speech recognition aspect was that it could be integrated to enable users to ask questions about the site. It was also decided that the motion related prompts could be added to raise awareness with potential users that there was an installation present with questions such as, "Ask me what is going on here?". The plan was also that a range of pre-recorded answers that play due to triggers of certain words from the users questions could then be added. For example, if the user were to ask a question with relation to the arena, the pre-recorded information about the arena would then play. To understand the types of questions that users might commonly ask, the pre-Covid plan was to run several in situ user studies.

4.2 Mobile Interaction

Mobile interactions were also considered at the outset of the planning work as they could provide an interesting form of incorporating a technology that users encounter every day into a development area. This would enable the users to experience the site without having to touch anything. As the plan was to make a simple application that people could easily understand how to use it, this kind of technology would be ideal as 72% of adults in the UK have been reported to have a smartphone [9]. Therefore, they will already know how to use it.

The design plan was that the application would enable users to view the 3*D* Augmented

Figure 4.1: An example of a prototype for a speech based installation along a length of hoarding surrounding the development site. The prototype includes speakers located within the hoarding which are able to provide pre-recorded messages about different locations of the site. These pieces of information are triggered by the movement of a user walking past them.

Reality (AR) content within their own devices. To achieve this, the plan was that users would download the application and click on different areas to view the Augmented content on top of the current site to aid them in understanding the scale of the development. Prior to this thesis, a similar kind of application was produced by Google called Animal 3*D* where users were able to project AR content into their homes using different animal meshes, as shown in Figure 4.2 [27]. In the initial design phase, it was also considered possible that the application could be incorporated into social media platforms such as Instagram where users would be able to take a picture with the AR background of the development site when within the area. The advantage of this design approach was that the application would be based on each individuals phone. In this scenario, this would therefore mean that many different users would be able to experience the interaction at the same time without queuing issues. This approach would also have the added advantage that users would be able to follow the content at their own pace.

Figure 4.2: An example of the Google 3*D* application which enables the user to place 3*D* animals into their houses, such as Tigers [27].

4.3 Mirror Interaction

Magic Mirrors were also considered within the design phase to increase both the fun element and the interactive nature of the user experience with the aims of extending the users interaction time and to increase the word-of-mouth publicity. The mirrors are screen based interactions which enable users to see themself within a screen, perceived to be a mirror [33]. Our plan would be for a mirror to be provided for each location of the development including a variety of different AR overlays. To achieve this, each screen would need to be fitted with an Xbox Kinect which would enable the tracking of the users skeletal motion which would enable the incorporation of gesture based interaction. Figure 4.3 shows a prototype for three mirror installations to be located along the development of the current site. Figure 4.3a shows the user projected in front of the area, Figure 4.3b shows the user located in the coastal park where flowers would grow around the user as they interact with the screen via gestures. Finally, figure 4.3c shows a user with an AR overlay of a towel robe relaying to the hotel development which was part of the early concept design for the development later removed in finalised plans. The mirror designs would also be produced for the pedestrian bridge, car park and housing complex.

4.4 Design Review

In order to come to an agreement on the final modality type we presented our alternative designs to Swansea Council to review which would in their view be the most efficient at providing users with an exciting interaction that enables them to understand more about the development site.

On review of the speech-based installation it was deemed as a cost-effective method with

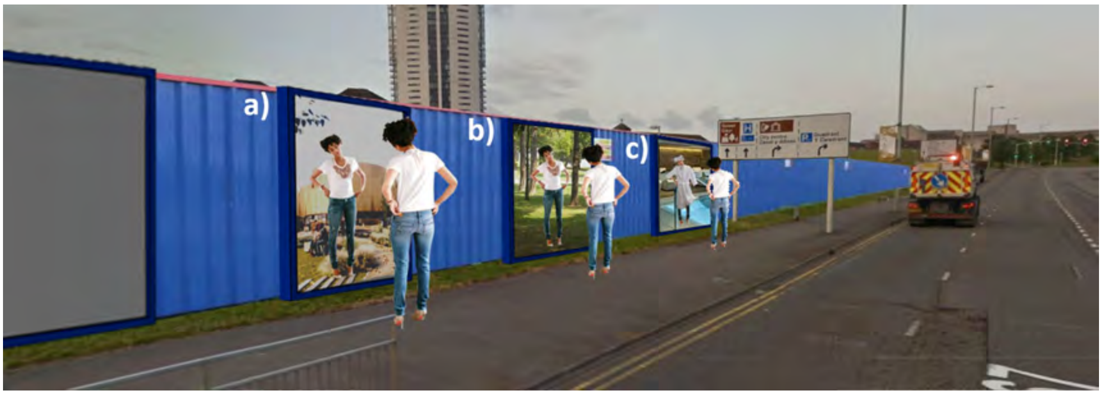

Figure 4.3: An example of three mirror based interactions relating to different locations of the development. Figure 4.3 a) The user is interacting with the mirror close to the Arena development which is shown as a reflection behind them. b) The user is interacting with the mirror close to the Coastal Park development which is shown as trees growing around their person. c) The user is interacting with the mirror close to the Hotel development which shows the user now sporting a towel robe within a hotel room.

the ability to cover a large area of interaction points. However, it was thought that it might not be likely to be able to create an exciting interaction and that it could exclude more elderly users who might not immediately understand how to interact with such a device. It was thought that this could put an important user community off using the device and create negative publicity for what ultimately needed to become a user-driven device. Speech recognition devices have also become much more commonplace within homes in recent years and the uptake across the UK population has been broad [44]. For example, devices such as Alexa and Google play are already widely used and therefore it was thought that using speech recognition within the new installation would not provide an additional fun element for anyone trying to access and use it.

In order for the mobile based interactions to be utilised by many users a vast amount of advertisements or incentives would need to be provided to try and entice users to take time to find the content using their phones. Taking this into account it is unlikely that even a small proportion of users would achieve the desired end goal of accessing the content because it would be deemed to time consuming. Also the interaction would not be open access putting users without smartphones at a disadvantage of being unable to access the content. Therefore, this type of interaction did not satisfy the accessibility goals we were aiming for.

It was agreed that the magical mirrors design would provide an interesting type of interaction for users but that the cost of several LED screens and cameras would put it far above the available budget. There were also worries about the possible weather damage and having to prevent them from being stolen, increasing costs again. As this type of installation is also provided via screens it would be likely that many users would not acknowledge their presence due to interaction blindness [50]. Therefore, this type of installation would not be able to provide the excitement about the development site that we were hoping for.

Therefore, the binocular design remained as the design which achieved all of the councils aims: to provide an interactive, interesting installation that was as accessible as reasonably possible. The binocular design is a new form of interaction that has rarely been seen within public spaces and therefore can produce a higher volume of intrigue than the other interaction types. The physical design of the binocular also enables us to produce a sturdy shell that should prevent weather and vandalism damage. However, due to the coronavirus pandemic the original design needed to be adapted to ensure that it was safe for users to interact with.

4.4.1 Covid-Adapted Binocular Design

When looking at the redesign of the binocular idea to incorporate a non-touch based height it was clear that a Virtual Reality headset as seen in Figure 4.4a could not be worn by any users for the foreseeable future. Therefore, an interaction which was less touch orientated was created using a virtual experience on a tablet as this was established as a safer option. The physical design plan was for the tablet to be situated within a sealed aluminium box with bullet proof glass covering the tablet screen and a roof to reduce solar glare and to maintain screen contrast at a consistent level. An addition to the design plan included foot/elbow levers. In the proposed design, when the levers are moved the magnetometer contained within the tablet then causes the content on the screen to pan dependent on the direction of the lever movement. For example, if the lever is moved to the right the content on the screen will also pan to the right. A Bluetooth button controlled via a foot/elbow button was also included to enable the user to click on buttons in the content. This completes the physical aspects of the interaction. Figure 4.4b shows the Covid-adapted binocular design, renamed to the Media Playing Mounting Unit (MPMU). The design plan also included the ability for the installation to operate at two different heights to ensure that adults, children and wheelchair users were all able to interact with the installation in the same way.

To further enhance the entire experience the design plan was for sound to also be incorporated into the device to ensure that the installation was not just visually based. Instead of a speech-based audio the plan was to incorporate a musically based audio. The plan was for these additional sounds to be replications of the sounds that will be heard once the development has been completed within each area. This kind of interaction will provide a well incorporated experience that utilises several different senses and could provide something that aids users who find changing areas very challenging such as users with Autism where sound sensitivity (especially to sudden unexpected noises) can cause that individual considerable distress to the point where not only would they not wish to use the installation but would probably not go near the area again out of choice. Instead, by choosing expected and predictable sounds the plan was that the installation could become autism friendly and attract more users to it.

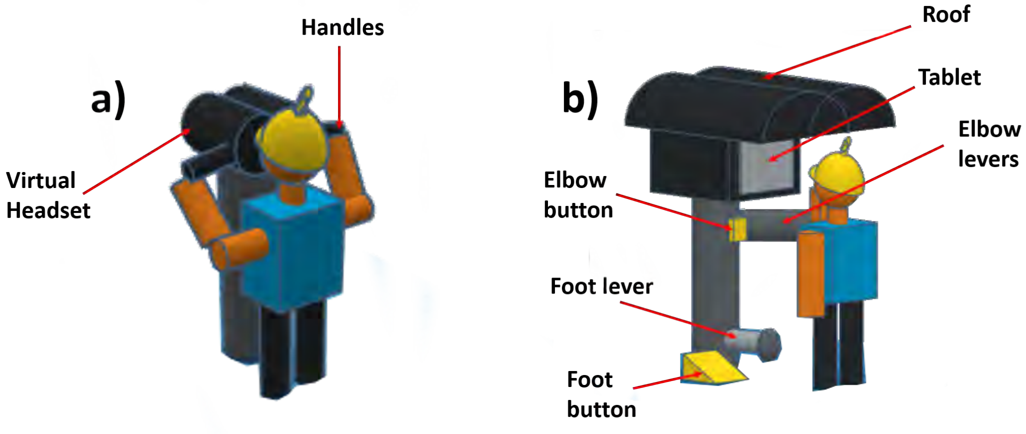

Figure 4.4: Figure 4.4 a) The original binocular design which was designed prior to the Covid-19 pandemic in February 2020. b) The alternative binocular design named the Media Playing Mounting Unit (MPMU) with the option for foot or elbow lever and button which was adapted due to the Covid outbreak in March 2020.

Chapter 5

Cocreation and Content development

Within this chapter the content development for the Media Playing Mounting Unit (MPMU) will be explored. The aim throughout the content development was to provide the user with a better understanding of what the new building development means for the Swansea City Centre area. Therefore, it was important to incorporate users within the designing process to ensure that the installation would be as fit for purpose and inclusive as possible. However, due to the coronavirus pandemic it was not possible to have face-to-face user studies and so video conferencing technology such as zoom had to be used as an alternative. This sometimes made it difficult for all the potential users to understand all the proposed concepts without a physical representation. However, it was possible to complete several studies with both domain experts and end users. In order to complete each user study, an ethical approval form was completed and permission was given by all individuals to use their feedback to enhance the design and write about within this report. These volunteers were always assured that no personal or sensitive information would be used and that all data collected complied with GDPR.

Four iterations of the content were evaluated throughout the development and were created using a range of digital and drawing based storyboards. The phases which we completed for each user study is outlined within Figure 5.1 which provides an overview of the phases of cocreation which were used as a basis for each study [71]. For each evaluation the participants were shown the most recent iteration of the storyboard and asked for feedback.

Figure 5.1: A schematic of the cocreation used within this thesis. Adapted from [71].

5.1 Initial Flow

The initial flow of the content was created as a drawn storyboard; examples of which are shown throughout this section. This storyboard was created as a step by step explanation of the planned interaction path to be presented to the domain experts in the following user study. The aim of the storyboard was to provide an initial view of the potential content and receive feedback from domain experts. The storyboard provides a step-by-step explanation of the initial content and how the user will interact with it.

Figure 5.2 begins with the user walking near the MPMU and towards the shopping centre. In this storyboard, the user then notices the MPMU and walks towards it to begin an interaction. Their first view of the installation consists of the forward facing view of the development site with Augmented Reality (AR) arrows overlaid above the arena, housing complex and car park. In the proposed design, selecting one of these AR arrows would teleport the user to that geographical position in the development. In this storyboard, the user then selects the car park as their first location to teleport to. A picture taking activity enables them to teleport their photograph into the 2*D* car park image as well. Figure 5.3 shows the user returning back to the main menu where they now select to be teleported to the housing complex. Their photograph is then displayed within the housing complex image. This process is also repeated for the teleportation of the users photograph into the arena image. This concludes the teleportation locations within the current screen that the user is viewing. In order to select more locations to teleport to, the user pushes the foot lever to the left. This results in the MPMU moving 30 degrees to the right.

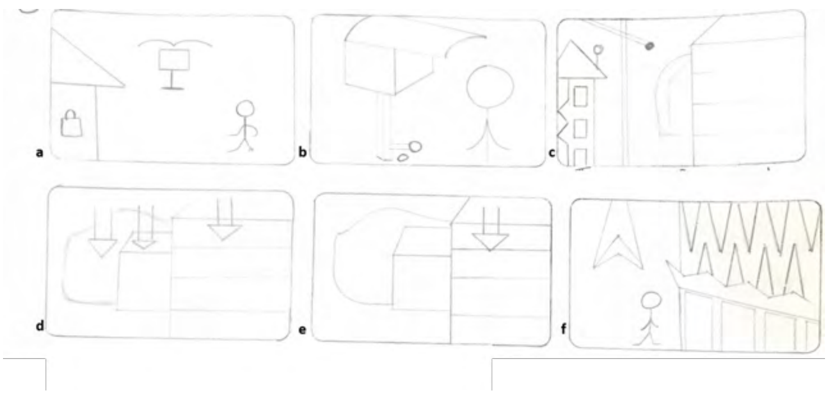

Figure 5.2: The first six steps of the first iterative design for the MPMU corresponding to figures *a* to *f*. Figure 5.1 a) A user walking past the interaction towards the shopping centre. b) The user walking up to the installation to begin the initial interaction. c) The users first screen view which is the live footage of the site. d) The forward view of the development site with AR overlay arrows which can be selected for teleportation. e) The car park being selected by the user. f) The car park activity where the users photo has been incorporated into the car park image.

Figure 5.4 then reveals the view of the development site looking east with an AR overlay arrow providing the ability to select the coastal park. In this storyboard, when the user selects this arrow, they are teleported to the 2*D* coastal park image. When they click on the button again they are returned to the main screen. The user then pushes the foot pedal to the right turning the MPMU 60 degrees to the left, revealing the development site looking west with an AR overlay arrow providing the ability to select the pedestrian bridge. The selection leads the user to the 2*D* pedestrian bridge image.

Finally, Figure 5.5 shows the user returning to the main screen and then walking away from the installation whilst another user observes the usage of the display and walks towards it to begin their own interaction.

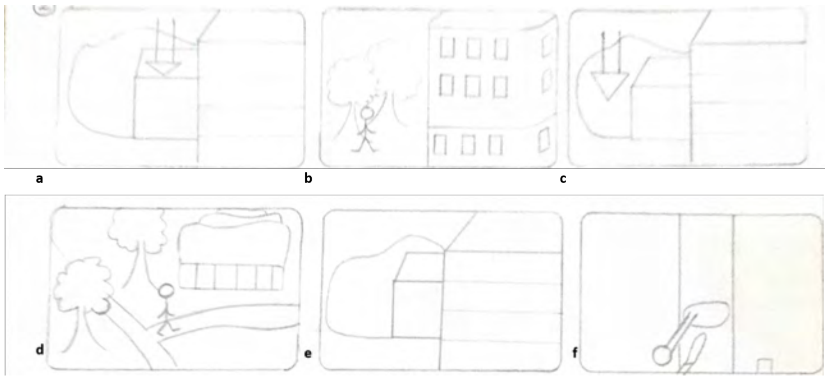

Figure 5.3: Steps 7 to 12 of the first iterative design and steps 13 to 18 of the second iterative design for the MPMU corresponding to figures a to f. Figure 5.2 a) The users return back to the main screen where they then select the housing complex. b) The housing complex activity where the users photo has been incorporated into the housing complex image. c) The users return back to the main screen where they then select the Arena. d) The arena activity where the users photo has been incorporated into the arena image. e) The users return back to the main screen. f) The user pushing the foot pedal to the left which triggers the live content view to be moved to the right.

Figure 5.4: Steps 13 to 18 of the first iterative design and steps 19 to 24 for the second iterative design of the MPMU corresponding to figures a to f. Figure 5.3 a) The right side live view of the development site where the user is selecting the coastal park. b) The coastal park activity where the users photo has been incorporated into the coastal park image. c) The users return back to the main screen. d) shows the user pushing the foot pedal to the right which triggers the live content view to be moved to the left. e) The left side live view of the development site where the use is selecting the pedestrian bridge. f) The pedestrian bridge activity where the users photo has been incorporated into the pedestrian bridge image.

5.2 Evaluation 1

A user study was carried out with 10 domain professionals including building managers and project management consultants via Zoom. The participants were selected to provide a broad

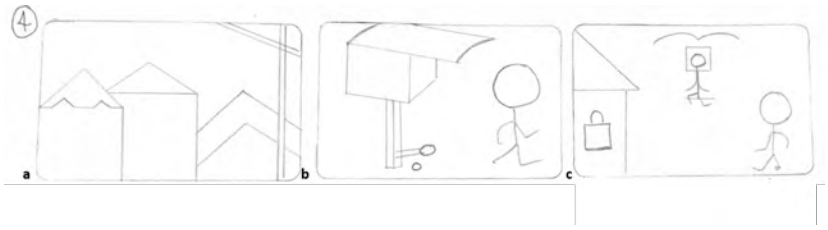

Figure 5.5: Steps 19 to 21 of the first iterative design for the MPMU corresponding to figures *a* to *c*. Figure 5.4 a) shows the users return back to the main screen. b) shows the user beginning to walk away from the installation as their interaction is complete. c) shows a different user seeing them use the installation and walks towards it to begin their own interaction.

representation of the professional and personal opinions of the building industry and beyond. The participants were asked to give verbal consent and were assured that no personal data would be used as a result of the study. An ethical review was also completed which was to ensure that the data we were collecting was not causing environmental risk, taking advantage of vulnerable people or creating or being completed with users with a conflict of interest. The study was recorded to enable the detailed and accurate evaluation of the feedback after the study. The recording was then deleted once the evaluation was complete and the conclusions had been written up. The storyboard which was used was as detailed throughout 5.1. At the start of the user group, this storyboard was shown to the users via Zoom by using PowerPoint slides and the Zoom screen share option.

When evaluating the content of Figure 5.2 the participants voiced their confusion as to how the user would understand that they needed to use the foot lever or button in order to be able to interact with the display. The participants felt that the introduction of the user's photograph into the content would be an interesting option for the display to increase user traction. However, the user group feedback showed that they were unsure how the user had evolved from the main screen to including their picture within the 2*D* images.

Furthermore, in the evaluation of Figure 5.3 the participants questioned how the user was able to locate the area they wish to select and then complete that selection. Finally, in the evaluation of Figure 5.5 it was discussed that the clarity of how the interaction ended for the user was to be desired.

In summary, for this iteration these were the revisions suggested:

- provide an explanation as to how the user knows how to use the interactive aspects of the display

- provide an explanation as to how the user had their picture taken.
- provide an explanation as to how the user selects the location which they wish to teleport to

5.3 Adaptation 1

Due to the evaluations of our initial designs, several changes needed to be made. As the participants were unsure as to how the users would know how to interact with the installation three different methods of explanation were introduced (see Figure 5.6). The first was a written explanation with the pictogram of a button, the second showed Augmented Reality (AR) arrows with written text such as "Click on this". This was similar to that of an advert often found within emails and so it was hoped that this would be a familiar format for users. Finally, a pre-recorded audio prompt was proposed to tell the user to "Step their way into the future".

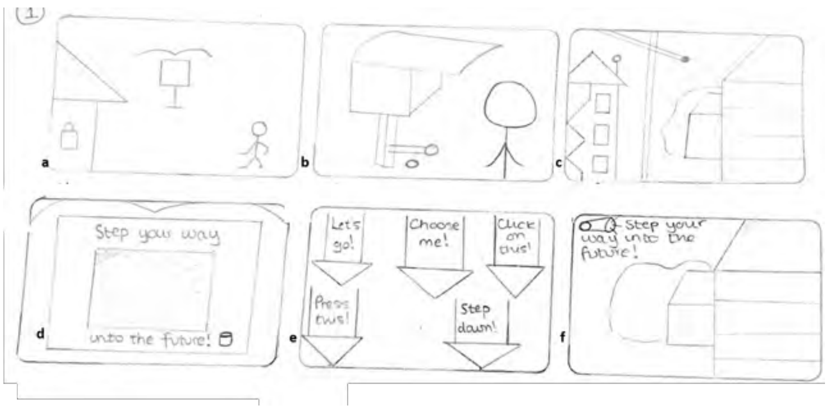

Figure 5.6: Figure showing the first six steps of the second iterative design the MPMU corresponding to figures a to f. Figure 5.5 a) A user walking past the interaction towards the shopping centre. b) The user walking up to the installation to begin the initial interaction. c) The users first screen view which is the live footage of the site. d) The text based explanation about how to interact with the design including a pictogram of the interactive button. e) The arrow based explanation about how to interact with the design including prompt based text. f) The audio based explanation about how to interact with the design.

In order to aid the participants in understanding the process by which they could select different areas of the development site to be teleported to, several steps were added to the storyboard that provided a pictographic representation this interaction is shown within Figure 5.7b. This shows that the user can push the foot lever to the left or right until the area which they wish to teleport to is located in the centre of the screen. The user could then use the foot button to select this location. The introduction of the viewpoint camera activity was shown within Figure 5.7e where the camera captures the users photograph at the beginning of the experience. The plan was for this photograph to then be shown in each different location of the development until the user re-enters the main screen.

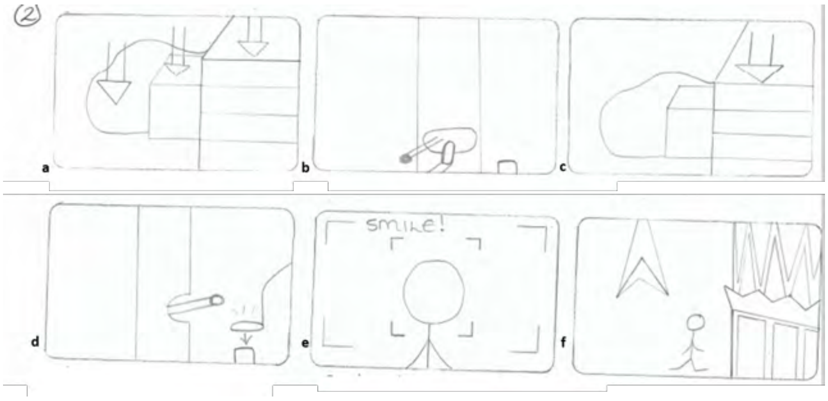

Figure 5.7: Steps 7 to 12 of the second iterative design for the MPMU corresponding to figures a to f. Figure 5.6 a) The main view of the installation with AR overlay arrows which can be selected for teleportation to the development locations their are hovering above. b) The user moving the pedal to the left which pushes the content of the screen east. c) As a result of the pedal movement the car park arrow is in the centre of the screen. d) The user pushing the foot button to which results in the teleportation to the car park. e) The user having their picture taken with the viewpoint camera. f) The previously taken photograph displayed within the car park image.

Steps $13-24$ remain identical to the steps shown within Figures 5.3 and 5.4 as no adaptations were suggested by the user group. The final steps of the second iterative design are shown within Figure 5.8. This Figure shows the new adaptation where the user would be able to click the foot button or push the foot lever to return to the main menu and show the final interaction. Finally, Figure 5.8 shows that as on user walks away another user begins their own interactive experience.

5.4 Evaluation 2

The second evaluation was completed with two user groups: domain experts and the Sight Life group. The domain experts provided opinions of the building industry and beyond. Whereas the Sight Life group provided opinions of the partially and none sighted community living within Swansea. Both user groups evaluated the storyboard content shown within 5.3. As for the first evaluation, the participants were asked for consent to take part in the user study were

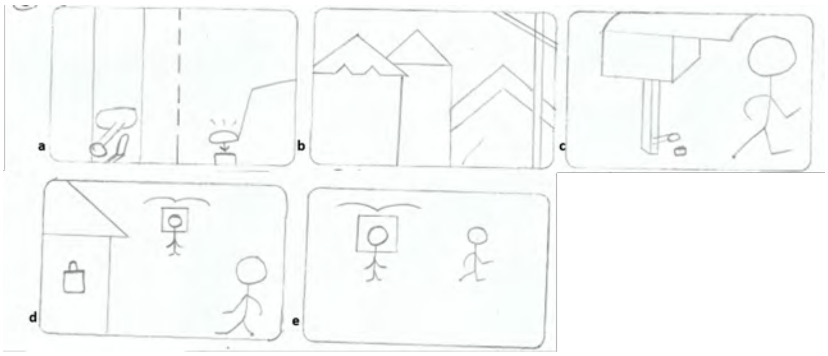

Figure 5.8: Steps 25 to 29 of the second iterative design of the MPMU corresponding to figures *a* to *e*. Figure 5.7 a) The user pushing the foot lever and the foot button. This is how the user returns to the main screen. b) The users return back to the main screen. c) The user beginning to walk away from the installation as their interaction is complete. d) A new user seeing the original user interacting with the installation and walks towards it to begin their own interaction. e) The new user interacting with the installation as the original user continues on with their day.

assured that no personal data would be used. The study was also recorded with permission to ensure no piece of feedback was lost.

5.4.1 Domain Experts

Within this user study 10 domain experts including building managers and project management consultants provided their insight via Zoom. At the start of the user group, the storyboard detailed within 5.3 was shown to the users via Zoom by using PowerPoint slides and the Zoom screen share option. We began by showing the users the first adaptations created to provide an explanation for the user as to how to interact with the display (see Figure 5.6d-f) and then asked for feedback, provided via general discussion. The participants raised an issue with the inclusivity of the phrase "Step your way into the future" as participants such as wheelchair users would not be able to do this. Participants suggested that a pictogram based explanation could be a more effective method. The pictogram would need to show the user how to interact with the foot lever to cause the screen to pan and button to teleport to different locations of the development site.

With regards to the accessibility of the display, the domain experts user group also raised a question as to how wheelchair users would be able to interact with the design using their feet was discussed. This discussion then lead into the materials that could be utilised in ordered to provide a safer interface against Coronavirus. It was noted that Copper only retains coronavirus in its contagious form for 4 hours compared to 72 on steel [22]. This adaptation at the time of writing this thesis will be incorporated into the final design.

The mitigation of users walking away from the design was also discussed. As we wanted to ensure that all users had the same initial interaction screen it was important to mitigate against users who walk away from the display mid interaction. The storyboard showed that the user needed to push the lever or press the button in order to return to the main menu but the domain expert user group raised a question as to what would happen if the participants were to walk away before completing this interaction. Therefore, it was suggested that a timer was added to each activity which would return the display to the main site after a length of no interaction.

Finally, participants from this user group also observed that the use of arrows to show the teleportation areas were clunky and a move to a more seamless experience would be preferable.

In summary, for this iteration these were the revisions suggested:

- ensure all text reflects accessibility and inclusion
- provide a mitigation for users walking away from the design
- provide a more seamless selection process

5.4.2 Sight Life Group

Sight Life are a charity located within Swansea and Cardiff city centres which provides support for those with partial or total sight loss. They aim to help their members to be independent, active and to have socially fulfilled lives [39]. The user study with Sight Life was completed with 13 members of the charity via the telephone conferencing network. The group requested that the storyboards shown in Figure 5.3 were distributed via email before the meeting to enable their partially sighted members to evaluate them. Within this user study, a verbal explanation was also provided of both physical aspects of the installation and the visual content. As the display was predominantly visual it was known that the users with complete sight loss would not be able to interact with the display. Therefore, within this study we focused on the physical aspects of the design.

Due to the locations of the foot lever and button the users suggested that it was unlikely that a walking cane or guide dog would be able to pick them up. Therefore, this represented a significant trip hazard for those walking independently. With regards to this, the ability to incorporate big colour contrasts in the content, surrounding pavements and pictograms were deemed very helpful by the users when attempting to manoeuvre their way around the site.

When asked about incorporating Braille into the information boards surrounding the interaction area the participants explained that this would be of no aid as they would not know where the Braille was located. It was suggested instead that an audio description of the content could be provided instead to aid those travelling alone who would not be able to view the content. However, the users also noted that they would be unlikely to be travelling without a guide who would be able to describe the content for them.

In summary, for this iteration these were the revisions suggested:

- adapt the foot lever to reduce the fall risk
- create colour contrasts between content and locations wherever possible
- provide audio explanations of the site

5.5 Adaptations 2

Following evaluation 2 described in section 5.4, further adaptations to the design were required. These were produced using a digital storyboard to provide a clearer overview as the what the content would look like. This approach enabled the addition of audio content for each area. The design adaptation also allowed the use of the location-based images which were taken whilst on a site visit during June 2020.

To provide an explanation as to how the user should interact, a pictogram was added to tell the user to use their elbow to interact with the installation (see Figure 5.9). To create a display that was as accessible as possible the physical design was also adapted from a foot to elbow operated lever. It was also requested that the application of a Copper film and a yellow painted button were included to make it safer with regards to Covid because Copper is anti-bacterial and anti-viral and the yellow colour would make it more visible for the partially sighted. Also following the feedback from Sight Life, to aid the blind community Astroturf will be lay around the installation to provide levelling and a contrast between the pavement and installation location. A further design adaptation was to place planters and benches surrounding the area to act as a warning for the obstructions presented by the MPMU. To further assist access, a walk around tour of the installation site for all members of the charity was offered to provide them with a verbal explanation and and the opportunity to ask questions about the site.

Figure 5.9 shows representations of the live view of the site as seen by the user. The images show that, when walking nearby the development site the MPMU can be clearly seen

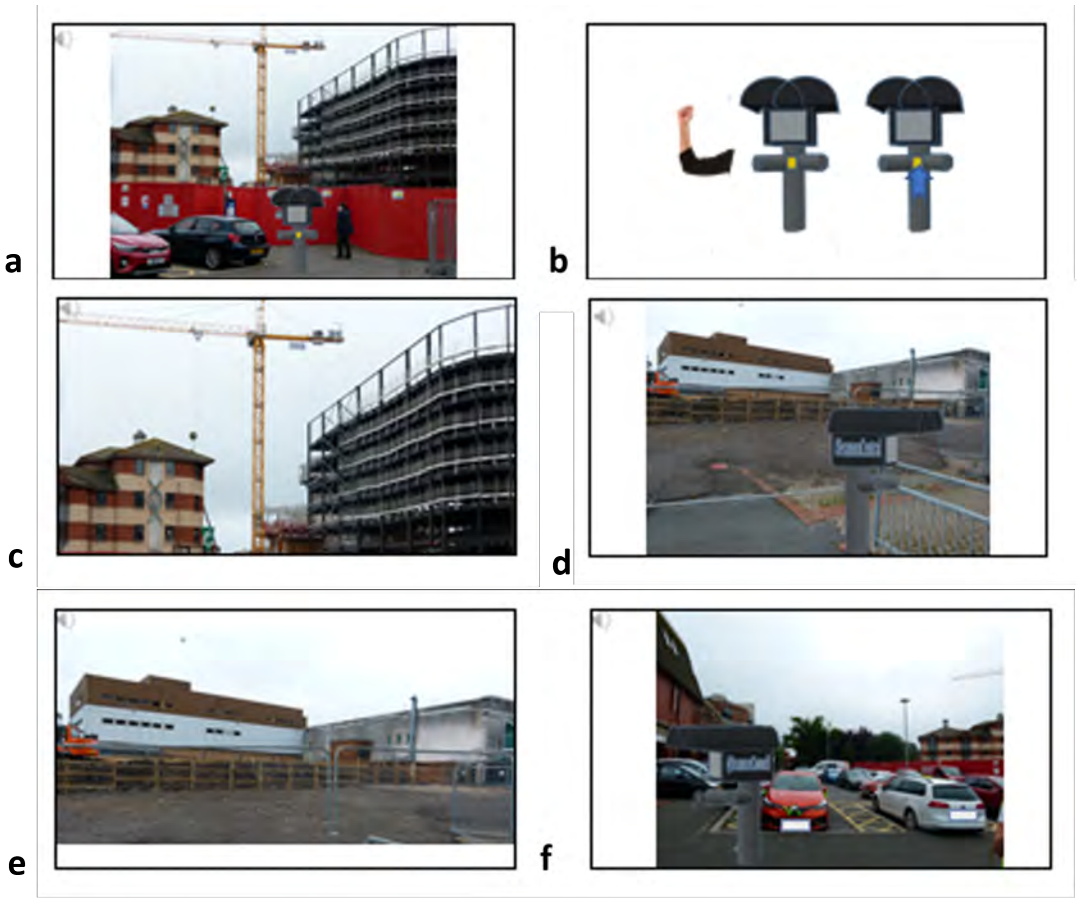

Figure 5.9: Figure showing steps 1 to 5 of the third iterative design of the MPMU corresponding to figures *a* to *f*. Figure 5.8 a) The view of the MPMU from a distance. b) The pictogram which provides an explanation for how the user needs to interact with the display in order to pan and select. c) The forward view of the display. d) The MPMU where the user has pushed the left elbow lever resulting in the MPMU facing east. e) The east view of the development site. f) The MPMu where the user has pushed the right elbow lever resulting in the MPMU facing west.

from some distance. When a user looks into the MPMU they can see the live view of the site and can use the elbow lever to pan the view 30 degrees to the left and right (see Figure 5.9). Figure 5.10b shows the new adaptation of the MPMU where the user is transported to an interactive screen where they are asked to "Click here to see what's coming". This would then show the user a birds eye view tour of the site via a pre-recorded video after which they are transported to an activity where they have their photo taken to produce their own personalised Bitmoji. A highlighting technique was used to represent to the users the different locations that they could teleport to based on the location closest to the centre of the screen. For example,

Figure 5.10e shows that the user pushed the lever to highlight the car park location which they then selected using the interactive button causing them to be transported to the car park. The use of highlighting also reduced the clunky appearance of the selection view in the response to feedback from the user groups.

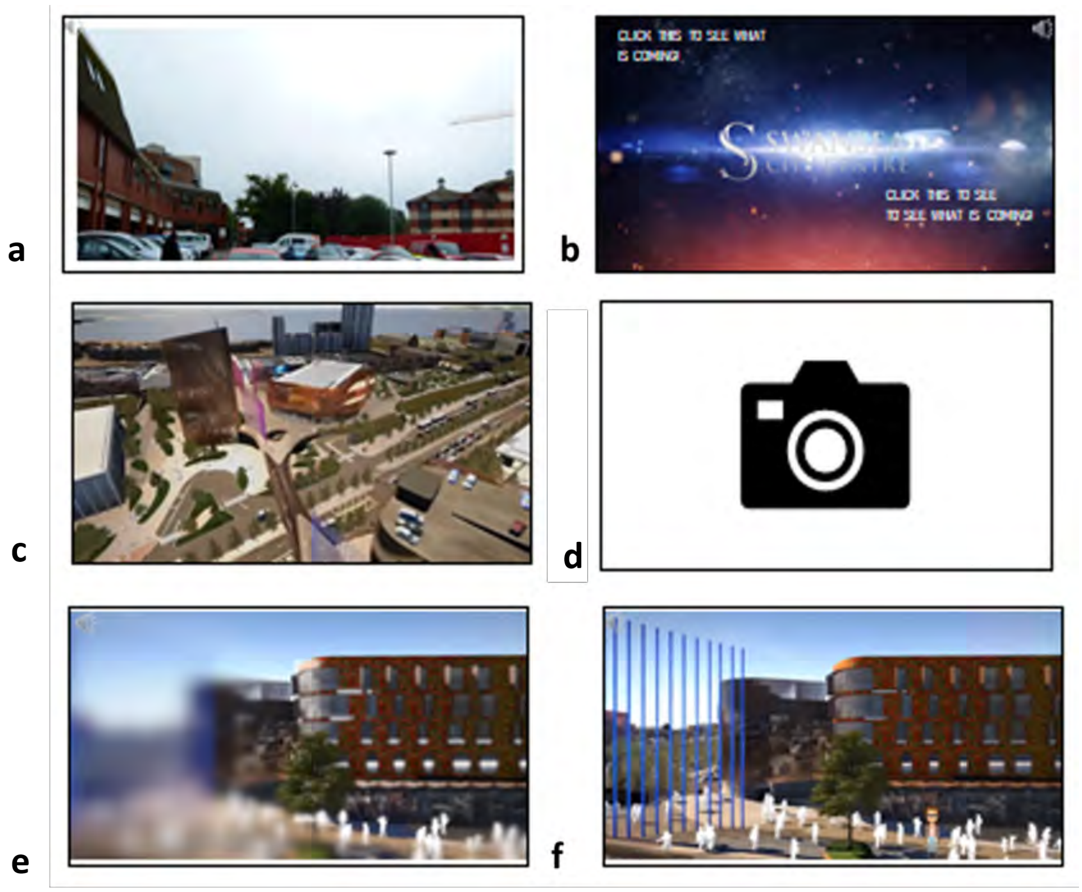

Figure 5.10: Steps 7 to 12 of the third iterative design of the MPMU corresponding to figures a to f. Figure 5.9 a) The west view of the development site. b) An interactive screen which asks entices the user into clicking onto the screen. c) A snapshot from a video showing a birds eye view overview of the site virtually. d) A camera icon representing the incorporation of a camera taking opportunity which produces a personal Bitmoji for each user. e) The car park highlighted as it is in the centre of the users screen. f) The users personalised Bitmoji within the car park activity.

To further enhance the sensory experience of the user, audio files were added which were specific to each location. For example, at the coastal park the user would be able to hear trees moving in the wind and birds chirping.

Finally, the design was adapted to have a timer that would be linked to each location so that if the user were to walk away without completing the return to main menu selection, the display would automatically do this for them. This would prevent other users from seeing a previous users personalised image and also ensure that all users would begin with the same content (see Figure 5.12).

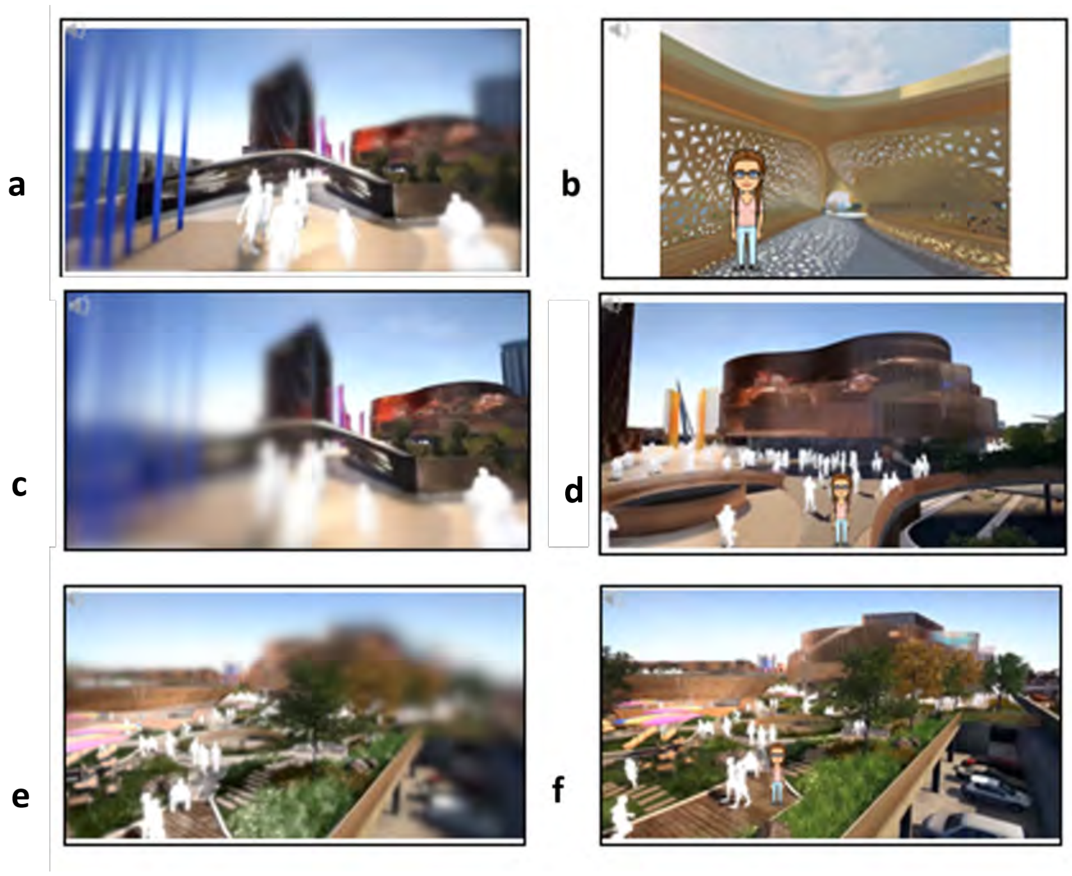

Figure 5.11: Steps 13 to 18 of the third iterative design of the MPMU corresponding to figures a to f. Figure 5.10 a) The users return to main screen where the user has moved the screen view to select the pedestrian bridge. b) The users personalised Bitmoji within the pedestrian bridge activity. c) The movement of the MPMU to highlight the arena selection. d) The users personalised Bitmoji within the arena activity. e) The movemenet of the MPMU to highlight the coastal park selection. f) The users personalised Bitmoji within the coastal park activity.

5.6 Evaluation 3

The third evaluation was completed with 10 domain experts. The participants were selected to provide a broad representation of the professional and personal opinions of the building

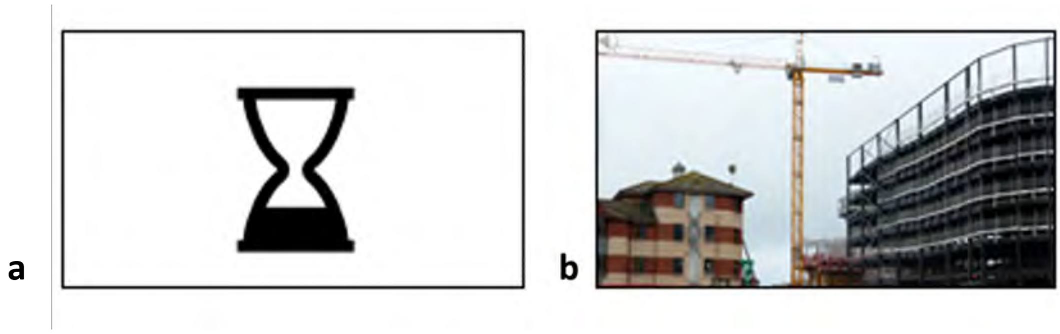

Figure 5.12: Figure showing steps 19 and 20 of the third iterative design of the MPMU corresponding to figures *a* and *b*. Figure 5.11 a) A timer icon to represent that if the user walks away from the display without returning the the main menu that it will time out. b) The timer has caused the display to return to the initial screen.

industry. The participants were again asked to provide verbal consent and were assured that no personal data was obtained. The purpose of this study was to evaluate the visual content to be used with the Android prototype. At the start of the user group, the storyboard detailed throughout 5.5 was shown to the users via Zoom and PowerPoint presentation on screen share.

After viewing the live images as the initial view (see Figure 5.9) the participants noticed that if the first view was to show the live content then the installation for children and wheelchair users would only be able to see the hoarding from the height that they are located at. This would directly counteract the accessibility which was a key initial aim for this project. This user group suggested that the virtual "birds eye" view shown in Figure 5.10c would be a more appropriate starting point.

The participants also found that the highlighting method was too confusing as they couldn't understand which area was being selected at which point. However, the participants really enjoyed the addition of a Bitmoji that would enable the person to be teleported into the picture as shown in Figure 5.10b. However, on further consideration, because the camera would only be able to take a photograph of the user's shoulders and above it was thought that possibly a filter based add-on similar to Snapchat could be more effective.

Finally, it was requested by this user group that the arena was centred as the main location as it was the main focus of the development. This user group also asked if the arena picture could be adapted to include Jimi Hendrix, an image that had been widely used across the council's publicity campaign for the development.

In summary for this iteration these were the revisions suggested:

- provide an initial starting screen that is the same for both installations
- consider other possibilities for camera incorporation to Bitmoji
- adapt the main focus of the content to be the arena

5.7 Final Design

The final design iteration was created using android studio with a main focus on the content design. This design was created based on the evaluations provided in 5.6. Due to the delay in receiving hardware caused by the Covid-19 pandemic, it was not possible to incorporate the camera-based aspects within this iteration of the design. Further to this, the Android Virtual Device which was used to create the following content was unable to incorporate camera based activities.

Within the evaluation 5.6 the accessibility of the initial screen was discussed. Therefore, the initial screen was adapted to a virtual 3*D* birds eye view with buttons for selecting each development location (see Figure 5.13a). This adaptation replaced the live camera footage which would have shown different opening screens for the adult pedestrian installation compared to the wheelchair and children's installation due to height differences. Buttons were introduced to provide the clear interactive development points compared to the highlighting previously seen. In order to teleport to each location the design was set so that the user would click on each located button where they could then click again to return to the main screen. If the user did not click off the different location based screens then they would be returned to the main menu after a certain length of time.

Finally, the image was adapted to centre around the arena as the main focus and adapted the image to contain Jimi Hendrix as shown in Figure 5.13b.

5.8 Final Evaluation

The final evaluation was carried out with 10 domain experts via Zoom. The participants were selected to provide a broad representation of the professional and personal opinions of the building industry. At the start of the user group, the storyboard illustrated throughout 5.7 was shown to the users via Zoom using an Android Virtual Device (AVD) and the Zoom screen share option. The participants were asked to provide verbal consent and were assured that no personal data would be utilised. The purpose of this study was to evaluate the final

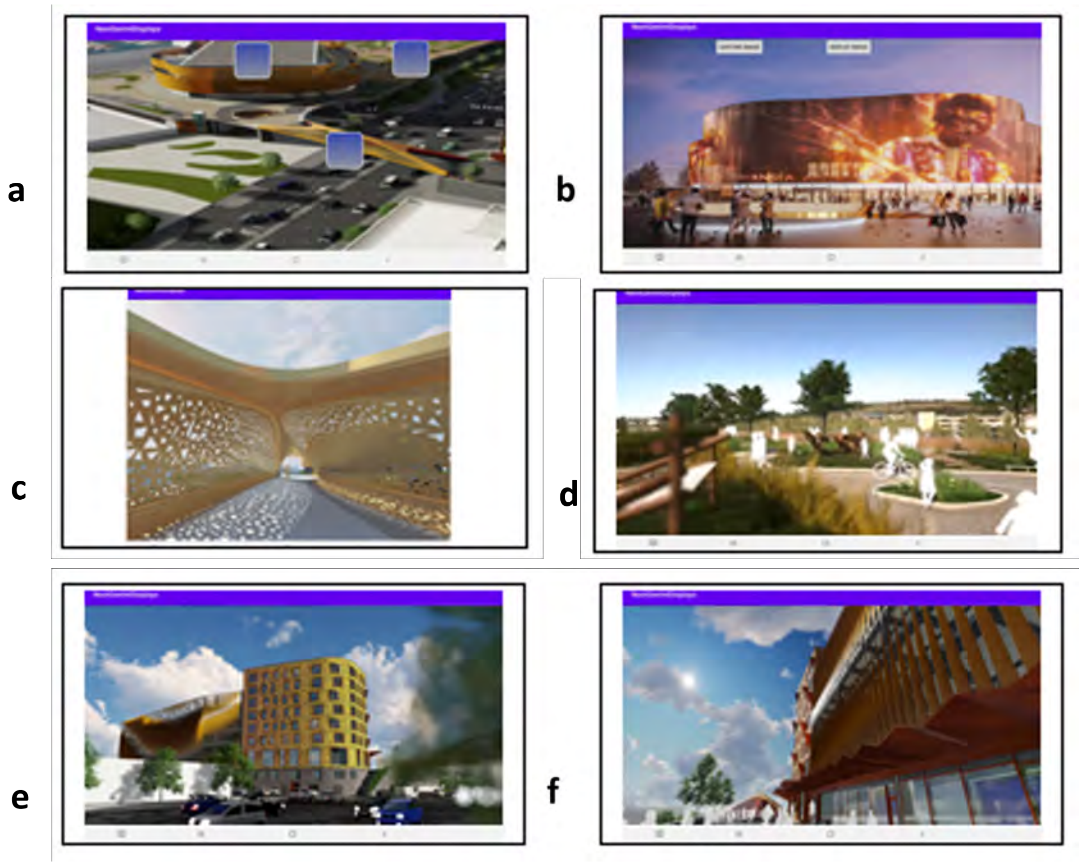

Figure 5.13: The final design iteration created on Android Studio. Figure 5.12 a) The initial screen which is an image of the birds eye view of the virtual development site. It contains buttons on each location that can be selected for teleportation. b) The arena activity has been selected with Jimi Hendrix located on the arena. The arena activity has a 15 second timer before returning to the selection screen. c) The pedestrian bridge activity has been selected causing the pedestrian bridge image to show. The pedestrian bridge activity has a 30 second timer before returning to the selection screen. d) The coastal park activity has been selected causing the coastal park image to show. The coastal park activity has a 60 second timer before returning to the selection screen . e) The housing complex activity has been selected causing the housing complex image to show. f) The car park activity has been selected causing the car park image to show.

content options of the design and to choose a timer length for returning to the main menu. The participants were happy with all of the location-based images and they stated that they looked forward to seeing the addition of the camera attribute. However, they said that the starting screen may be confusing for users who do not understand where the Bird's Eye view is located. Therefore, it was decided that a panoramic view taken on site from the location of the MPMU would be used to provide the initial starting screen (see Figure 5.14).

Finally, the users were shown three different timer settings and asked which they felt was the most effective for enabling the users to absorb the content without being cut off but also ensuring that if the user were to walk away the application would timeout to the main screen before the next user interacted. The users were presented with the arena location with a 15 second timer, the pedestrian bridge with 30 second timer and the coastal park with 60 second timer. With the 60 second timer being agreed upon as the most efficient choice for timing out in time to ensure all users began with the same starting screen and providing enough time for the participant using the display to absorb the content without being returned to the main screen prematurely.

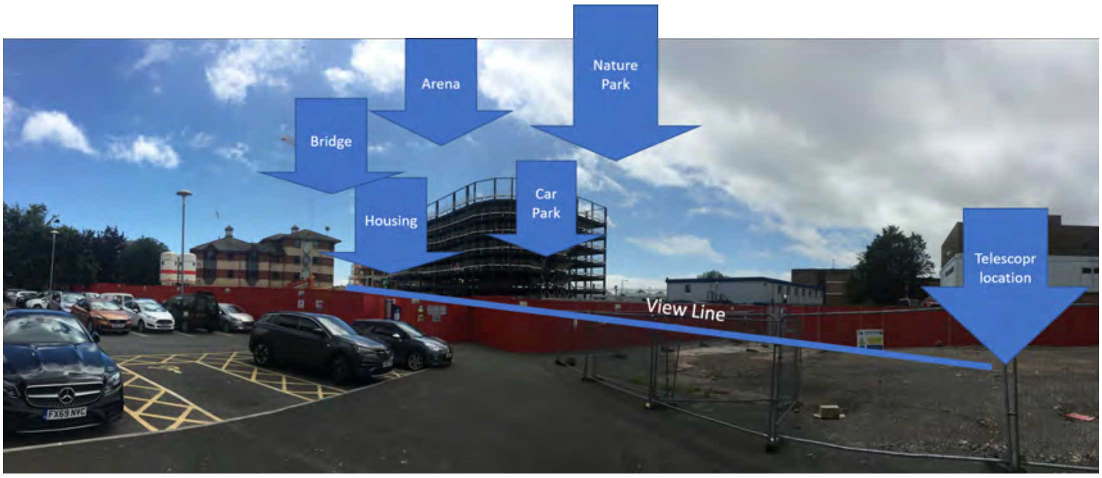

Figure 5.14: A panoramic view taken from the location of the MPMU installation in August 2020. The diagram includes arrows representing the locations of the different areas of the development site.

5.9 Summary

In summary, this chapter has focused on four iterations and the corresponding analysis and adaptations for both the physical and visual components of the MPMU design. These have been completed with both domain experts and end users. This approach was based on the cocreational methodology shown in Figure 5.1 and has enabled us to create a design that has been cocreated with the local community. This has led us to adapt our design aspects and evaluate how the installation could be perceived by the public. In completing this kind of approach we hope to have a successful installation that encourages word of mouth publicity due to it being created with the community in mind. The stages by which the final design was created are detailed within the next chapter.

Chapter 6

Design of the Prototype

This chapter discusses the aspects contributing to the final design of the physical and visual prototypes. These designs were created following the cocreation sessions as outlined within Chapter 5 and will be utilised as blueprints for the deployed installation within the Swansea city development site. The original deployment date was set for the end of September 2020 but this was delayed due to the pandemic.

6.1 Physical

The processes taken to produce the physical aspects of the prototype will be detailed in this section. The aim was to create a vandal proof installation that was as accessible as feasibly possible to all parts of society whilst also echoing the design of binoculars. This section will also evaluate the interactive and non-interactive elements of the design. The following decisions were all made due to the cocreation studies evaluated within Chapter 5.

6.1.1 Interactive Elements

The interactive elements of the physical design are designed as those that, when used, cause a change in the content. These aspects include the interactive levers and Bluetooth button.

To incorporate interactive levers into the design, two options were explored: a single foot lever and two elbow levers. The single foot lever would ensure that no users should touch the installation with their hands. This was a possible design choice which was considered as a touch-free response to the Covid pandemic. It also provided a simple interaction point which could be used for the panning of content. However, when speaking with Sight Life their feedback brought to light that the presence of a foot lever would be a significant trip hazard for the visually impaired. Therefore, elbow levers were deemed as the safer option. The design plan was to use two levers, one for each elbow to try and reduce the possibility of the public using their hands to interact (see Figure 6.1). This was also deemed necessary due to the requirement to create a Covid-adapted installation. Figure 6.1 shows a diagram of the panning interaction completed by a user. Figure 6.1a shows a user pushing the elbow lever left resulting in the screen panning to the left and Figure 6.1b shows a user pushing the elbow lever to the right resulting in the screen panning to the right.

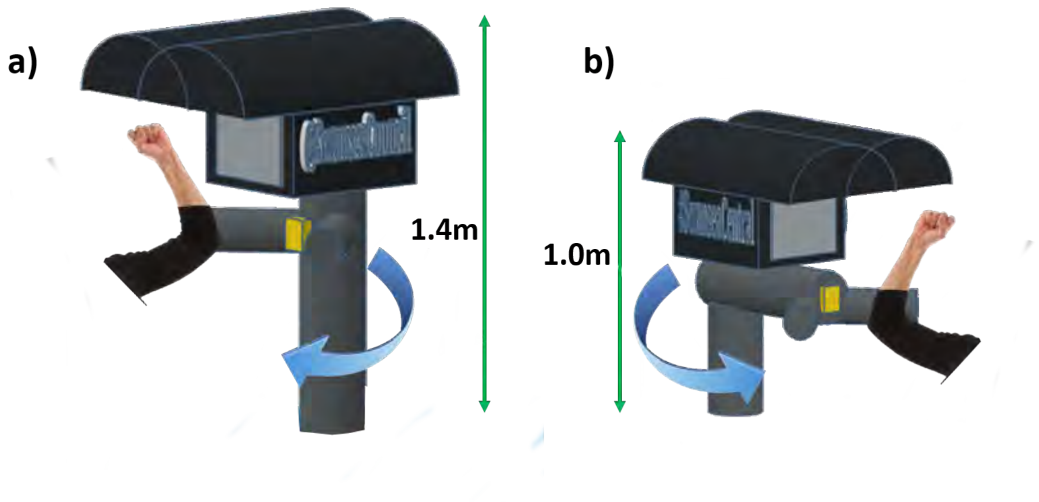

Figure 6.1: An example diagram of two installations located next to each other: one for adult pedestrians at the height of 1.4m and one for wheelchair users/children at 1m. Figure 6.1 a) A participant using their elbow to push the left elbow lever on the adult pedestrians installation. This causes the display to turn left. This causes the display to turn left b) A participant using their elbow to push the elbow lever to the right on the wheelchair users/ children's installation. This causes the display to turn right.

The Bluetooth button enables the user to select different items on the tablet similar to a computer mouse but via Bluetooth signalling. Figure 6.2 shows a diagram of the button interaction. As the user pushes down on the covering a metal rod then pushes the Bluetooth button sending a signal to the tablet that a button has been clicked resulting in an activity change.

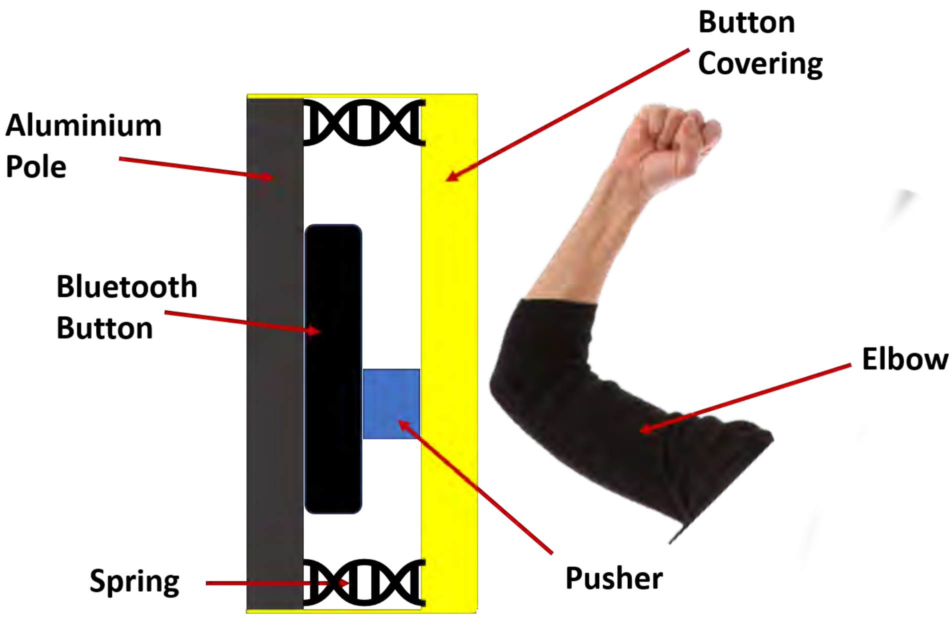

Figure 6.2: The mechanism of the interactive button, where the participant pushes their elbow onto the button covering causing the Bluetooth button to be pressed.

6.1.2 Non-interactive Elements

The non-interactive elements of the physical design are those that the user does not interact with. These aspects include the interactions height, the housing design and the hardware choices.

The initial height of the installation was set at 1.5m for the adult installation and 1.2m for the wheelchair users/children's installation. These heights were chosen based on the average height of a male dominated office. However, the average height of females is roughly 12cm less than their male counterparts [62]. Therefore, to ensure the installation was equally accessible the design heights were altered to 1.4m for the adult installation and 1m for the wheelchair users/children's installation.

The design of the tablet housing was initially similar to that of a binocular but was adapted in order to house a 10.1" tablet instead of the VR headset which was roughly 7" in width. The box was therefore adapted to a cuboid shape with a roof to ensure enough space for the tablet. However, the roof was designed to replicate the binocular shape using two curved metal sheets to reduce solar glare (see Figure 6.1). In addition, there were two options for the metal encasing: steel and aluminium. Whilst steel is a widely used construction metal that would provide protection from vandalism it is also known to shield magnetometer readings [49]. As we are using magnetometer readings to pan the content on the tablet it would not be able to use steel as a housing. Therefore, at the time of writing this thesis aluminium which has no magnetic shielding capabilities was chosen for the outer casing.

Finally, a decision had to be made between an Apple and Android based tablet. Apple iPads are a very popular design, and are easy to use. However, due to the open access nature and ease of customisation provided by Android, an Android tablet was deemed a more suitable option.

6.2 Digital

This section will explore the process taken to produce the Android Application prototype. The content and flow of the application were heavily based on feedback given within the previous chapter. The aim was to create an android application that could be used as a prototype to then be adapted and installed within the Swansea city centre development. This section will evaluate three key aspects panning, selection of the point if interest and the addition of photographs and filters. The following decisions were all made due to the cocreation studies evaluated within Chapter 5.

6.2.1 Panning

The movement of the tablet was a key aspect for creating an interactive experience for the user. The housing of the tablet will enable a 30 degree movement in both the left and right direction. Therefore, the physical design needed to incorporate a way for the tablet to move in either direction based on the users interaction. One option considered was to user clickable arrows which enable the user to turn the tablet left and right when they click the corresponding arrows. However, in this design, when using arrows the user would only see a selected area of the screen as the arrows would obstruct a large proportion of the screen. Therefore, the user would have a limited experience with poor transitioning. In contrast to this, a design which used sensors to pan the view from left to right should enable a continuous experience of the image whilst also being more interactive. As the project aim was to create a highly interactive experience the sensor based panning was considered the best option to continue with.

In order to complete a sensor based panning experience the next decision was whether to use the tablet's inbuilt sensors or to use external sensors. However, having considered the previous research in the literature review, external sensors had often been reported to be inaccurate and to cause frustration for users who cannot get the sensors to pick up the orientation in the magnetic field. Therefore, the decision made was to use the tablet's in built magnetometer sensor which senses the changes in the magnetic field surrounding the tablet. As the tablet would be orientated horizontally in the proposed design, the decision was to use the sensor based on the rotation around the z axis of the tablet which should enable the screen to pan horizontally when the user pushes the elbow levers (see Figure 6.3).

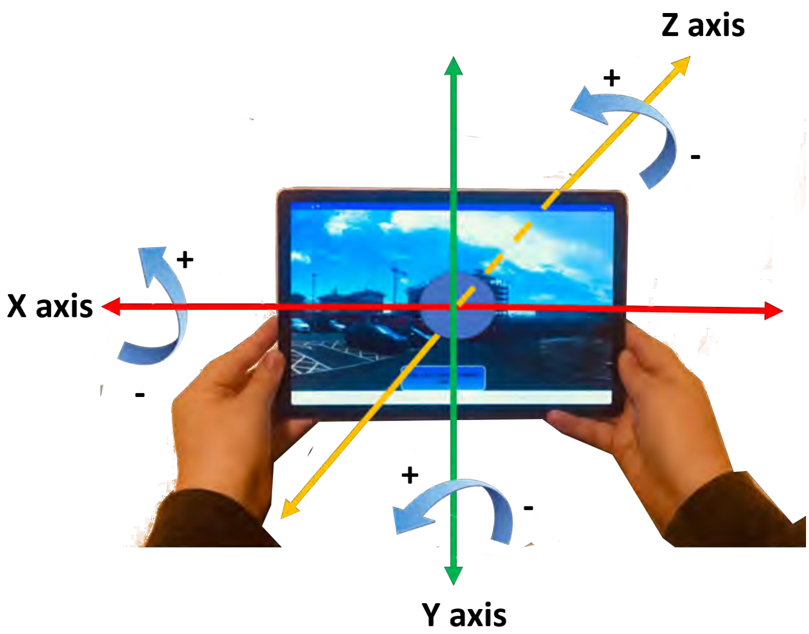

Figure 6.3: The tablet prototype with the x, y and z axis for the magnetometer labelled. When the tablets rotation around the z axis changes the content on the screen begins to pan.

6.2.2 Point of interest selection

The next issue to consider was to enable the user to be able to transfer from one location to another. Two options were explored for this design decision; clickable buttons and the highlighting of different transportation locations. The highlighting shown on the screen changed with the panning of the screen to the area which was closest to the centre of the screen. The highlighting was deemed too confusing and caused frustration when an area selected crossed over with a different location which could lead a user to a location they had not selected. For example, the housing complex is next to the car park development and therefore could cause confusion when highlighted. In contrast, buttons were considered to provide a clear interaction path where the user could evaluate the text on each button in detail and choose the location they wish to transport to accordingly. Therefore, the button based interactions were deemed the most efficient form of selection. In order to create the feeling of being teleported a drone-based transition was added for each point of interest. To create the effect of the user being teleported from one area to another the plan was to use the 3D assets of the future development area but we were unable to obtain access to these models. Therefore, we completed a site visit to obtain drone footage of the different development areas. This enabled the design to provide the user with the teleportation from the real to the virtual view of the site. For example, Figure 6.4 shows a snapshot of the drone footage taken from above the arena. The footage speed was increased and fading effects were added to replicate teleportation.

Figure 6.4: A snapshot from the drone footage taken above the arena. The footage from which this snapshot is taken begins from the location of the installation and travels across the top of the development site before completing a 360 degree tour of the arena.

6.2.3 Addition of Photographs and Filters

When contemplating the type of personalised experience to incorporate into the design two options were considered: avatars and Augmented Reality (AR) based face filters. Avatars are often created via stages of personalised selection including the selection of skin colour, hairstyle and eye colour (see Figure 6.5a). However, the selection process can be long-winded and one which can come across as being exclusive. For example, Facebook's personalised avatars have 14 physical features which are often tailored to white customers [66]. The lack of equality in avatars has also been reported to be increased by the facial recognition attributes which have been found to have a lower performance rate for the detection of non-white users [46]. As our aim was to create a fully inclusive interaction for all users it was not possible to justify the use of Bitmoji's within our design. Instead the decision was made to use AR based filters which could be applied to the users face live using a library developed by Google called ARCore [18] (see Figure 6.5b). In this case, filters are applied to the users face based on a face mesh consisting of hundreds of vertices that focus on three regions of the users face: their left forehead, right forehead and nose tip. Figure 6.6 shows the face mesh used to locate the different aspects of a users face and overlay an AR filter accordingly.

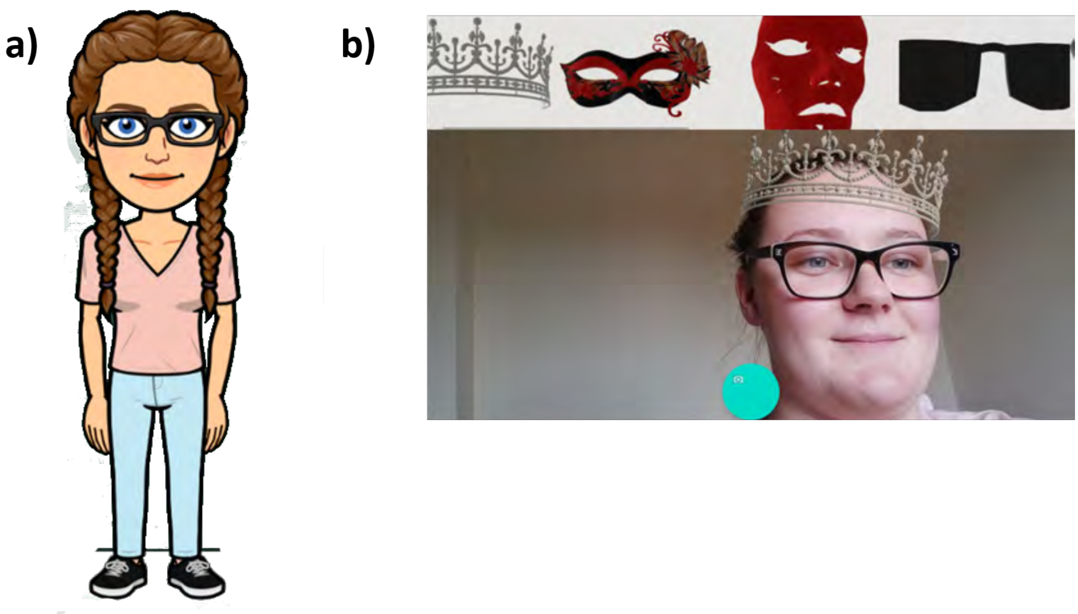

Figure 6.5: The following Figures are examples of photography based interactions that the user could have with our design. Figure 6.5 a) An example of a bitmoji character created using Snapchat's Bitmoji kit [6]. b) An example of a user interacting with a filter based activity and choosing a crown overlay from a range of filters including a masquerade, sunglasses and pirate hat etc.

The aim was to enable the user to take their photograph with an AR overlay but it was not possible to achieve this due to time constraints. However, we were able to incorporate a picture taking opportunity as a part of the arena activity within the design to provide an extra level of

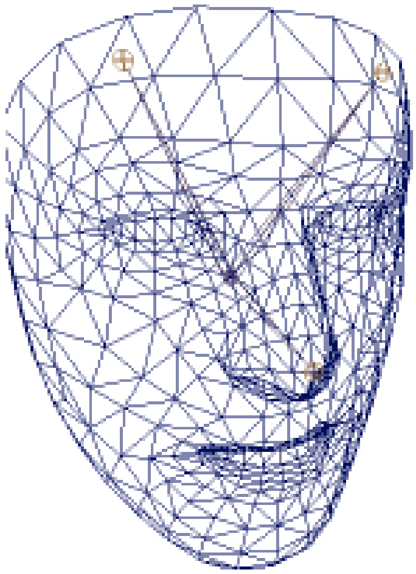

Figure 6.6: The face mesh utilised by ARCore to overlay AR filters onto users faces and used as a basis for the filters used within this project [18].

interactivity as shown in Figure 6.7. The decision was to provide the picture taking opportunity as a part of the arena activity to enable the user to choose whether or not they wish to have their picture taken. Incorporating the image in this way also prevented the need to save the images, removing the ethical issues contained around storing users personal data. The hope here was to be able to remove the background of the image to provide a more seamless interaction but due to the delay in which the hardware devices were received it was not possible.

6.3 Summary

In summary, this chapter has evaluated the physical and visual designs of the final prototype. In order to complete our aim to create an installation that was as accessible as feasibly possible for all members of society we adapted our design based on user feedback to have elbow levers instead of a foot lever for interactivity. A photographic opportunity was also incorporated into the design to enable each user to have their own personalised experience with the display which is something that has been shown to increase the users enjoyment of display interactions. The designs were created based on the design adaptations completed within Chapter 5 which were

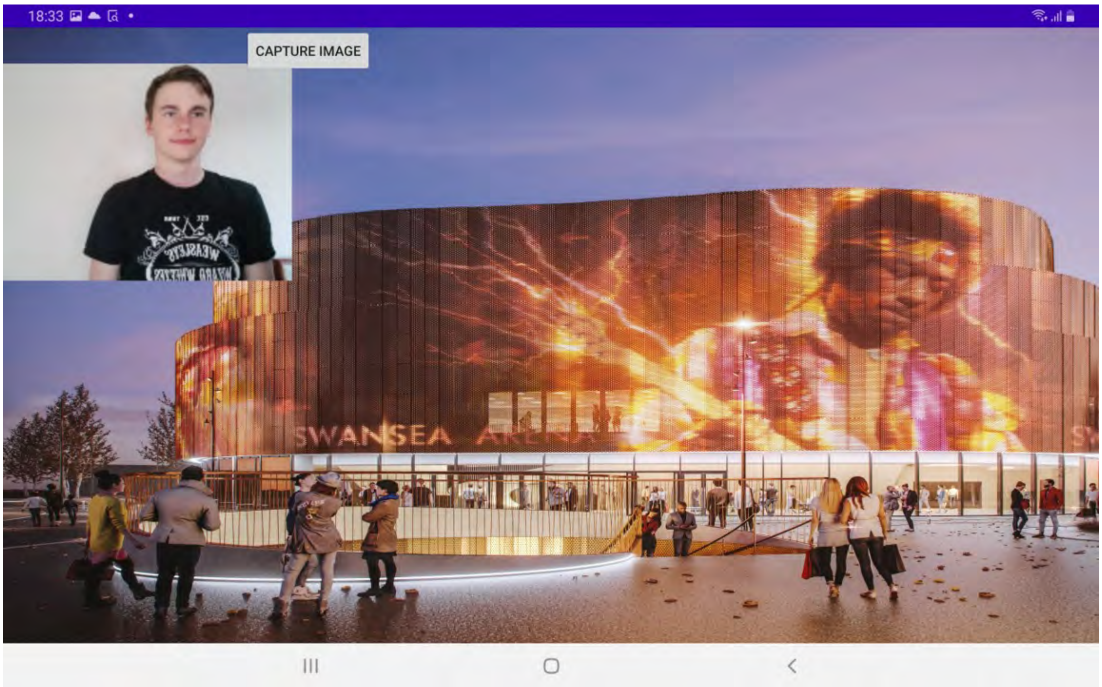

Figure 6.7: An example of a users photograph contained within the Arena Activity. The photograph was taken using a viewpoint camera.

predominantly led by feedback provided by domain experts and end users. The following Chapter will provide the final blueprint for the prototype to be adapted and deployed within the city centre.

Chapter 7

Final Prototype

Within this chapter the final blueprint for the visual design is outlined including the range of interactions that can be completed. The final physical design of the two installations is also outlined representing the differences between the adult and wheelchair users/ children's design. The final visual design will then be evaluated by domain experts and end users to provide an insight into the final adaptations that are required for the prototype before it can be adapted for full deployment.

7.1 Final Visual Design

The final prototype was created on Android Studio and installed onto a Samsung tablet. In this design iteration, each time a new screen was seen in Android Studio it meant that a new activity had begun and will be referred to as such within this chapter. The prototype begins with a panoramic image of the current site and the text "Take a Picture" provided in both Welsh and English. By turning the tablet left and right the user is able to pan the image causing the centring of the panoramic view to track along with the users movement to give them a sense of being in control of the process (see Figure 7.1a). Figure 7.2 shows a user completing the panning interaction. On clicking the button the user is transported to a new activity where they can choose to apply a range of Augmented Reality (AR) face filters including a crown, masquerade, face mask, sunglasses, moustache, pirate hat, Viking helmet or a beard. The user can also choose to select no filter. As an example, Figure 7.1b,c shows two users interacting with the AR filters with one choosing the sunglasses and the other the beard.

Once the user has completed their interaction with the filter activity they click on the green

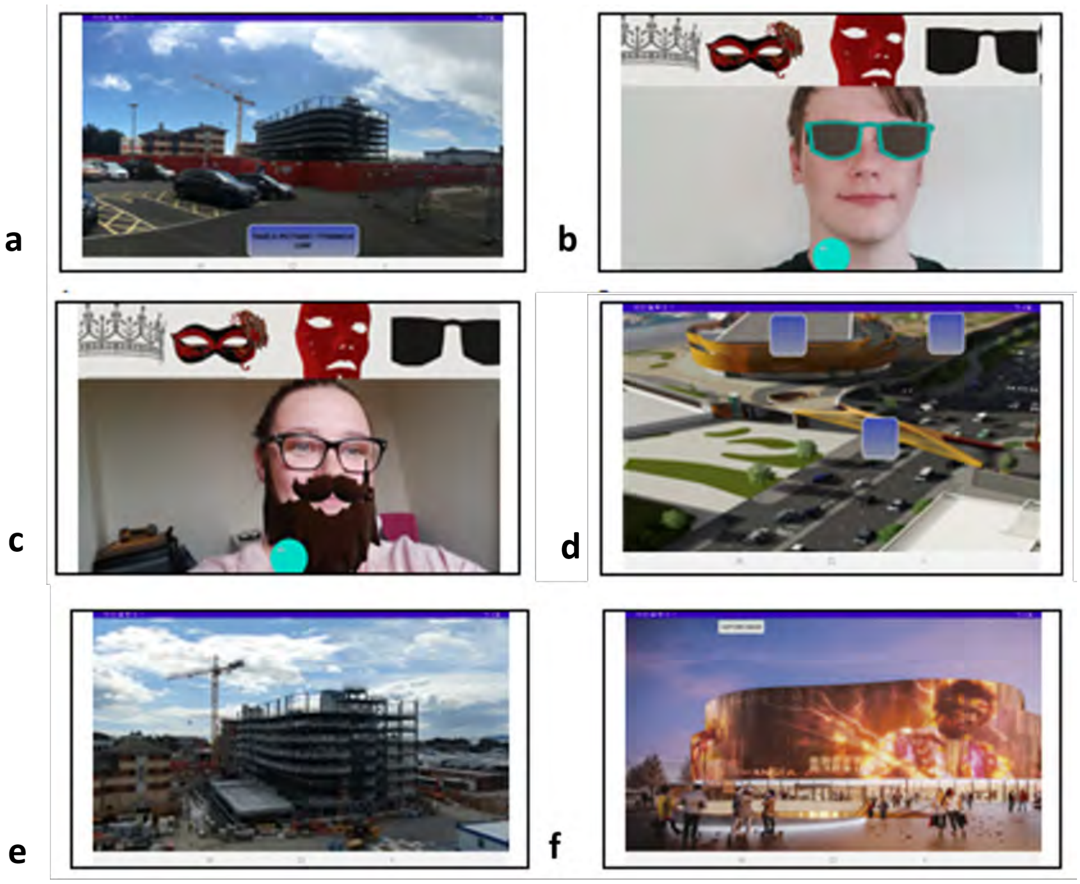

Figure 7.1: The first 6 activities of the final prototype where steps 1 to 6 correspond to figures *a* to *f*. Figure 7.1 a) The initial starting screen of the MPMU which was a panoramic image taken from the location of the MPMPU. b) A user interacting with the filter activity and selecting the sunglasses. c) A user interacting with the filter activity and selecting the beard. d) The selection activity which has a button located on each area that the user is able to teleport to. e) A snapshot from drone footage taken from the location of the MPMU to the arena. f) The arena activity where the user is able to choose to take their photograph.

button which transfers the user from the filter activity to the selection activity shown in Figure 7.1d. Within this activity the user is able to select the location they would like to be teleported to by panning the screen and selecting the button located on the area they wish to teleport to. The arena placed in the centre of the "home" panoramic view as it was centred as it was the main focus of the development site. On clicking the arena image a drone transition begins which shows the user footage from the installation location to the arena (see Figure 7.3e). Within the arena activity the user can choose to take a selfie or continue to the next activity. If the button labelled "Capture Image" is selected the user is taken to a viewpoint camera activity

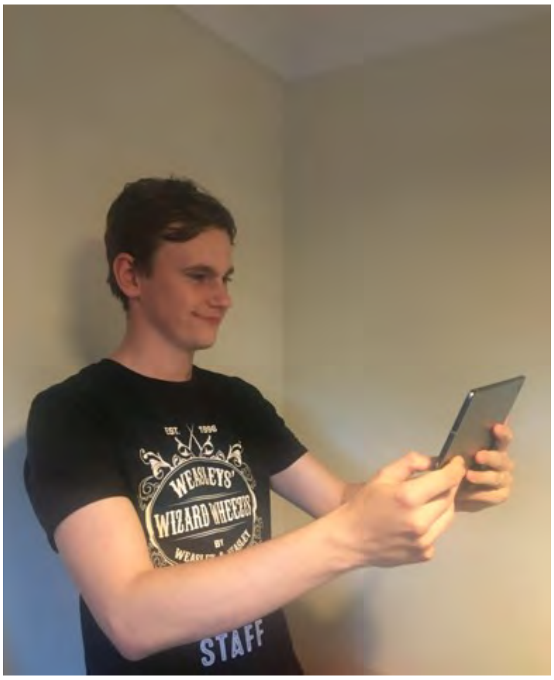

Figure 7.2: A user interacting with the final prototype and causing rotational change along the z axis of the tablet to achieve panning of the content on screen.

(see Figure 7.3.a). The user can then choose to either retake their image or proceed to the arena activity where the photograph is displayed (see Figure 7.3.b). The arena activity contains both a 60 second timer to return the user to the main activity and an audio clip of generic pop music to provide a multi-sensory experience.

When exiting the arena activity the user views a drone transition that shows a 360 degree view of the arena (see Figure 7.3c). The drone footage transitions into Figure 7.3d which is an autostereogram of the arena's auditorium which can then be viewed. An autostereogram is a $2D$ image which appears as $3D$ content. They enable the user to pan the auditorium 360 degrees. When the user has finished this activity they click the blue button to return back to the main menu (see Figure 7.3e). The user can then select to teleport to the pedestrian bridge and view a transition via drone to the pedestrian bridge (see Figure 7.3f). In Figure 7.4a the user can choose to have their photograph taken again. To enhance their experience further users were also able to listen to an audio track including walking pedestrians and passing traffic to crate a more immersive experience.

The final three destinations include drone footage transitions to the car park with an audio track including moving traffic (see Figure 7.4d), the housing complex with audio including

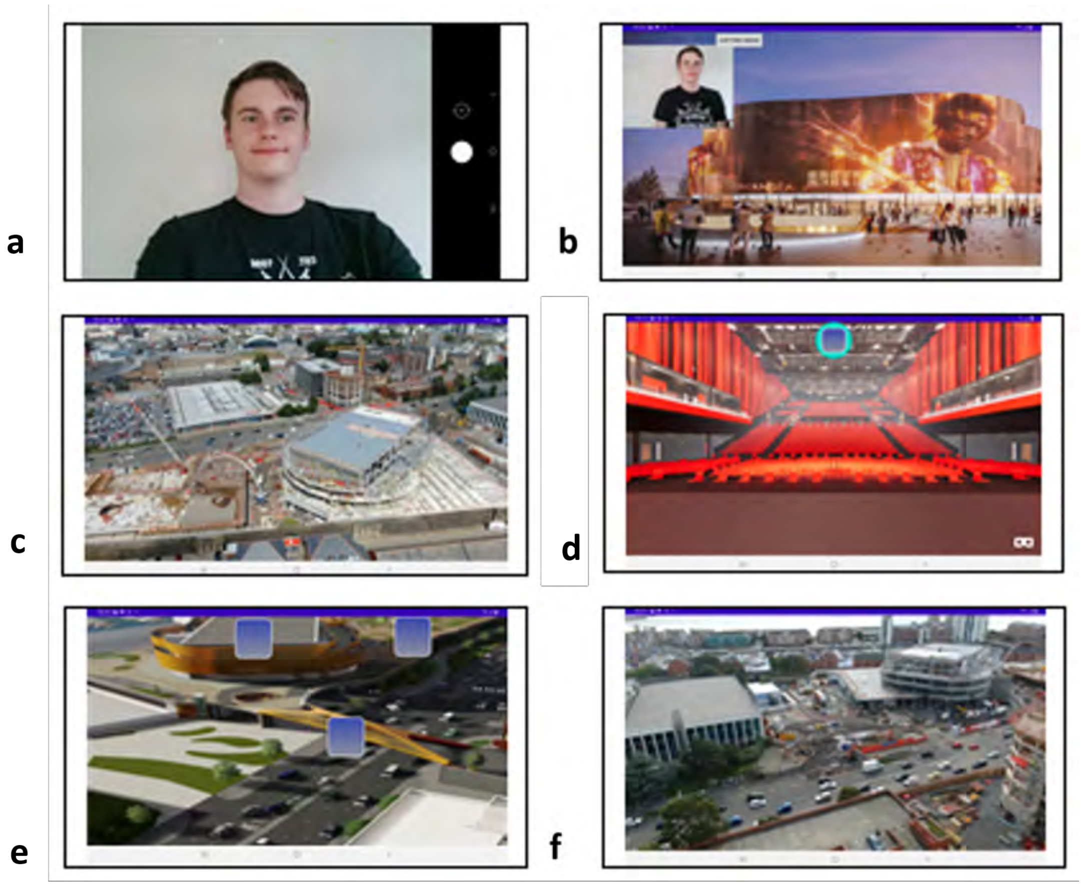

Figure 7.3: Activities 13 to 18 of the final prototype corresponding to figures a to f. Figure 7.3 a) The user has taken their photographs and can choose whether to retake the image or accept it. b) The users image has been displayed within the arena activity. c) A snapshot taken from drone footage of the 360 degree birds eye view of the arena. d) An autostereogram of the auditorium within the arena which the user can interact with to experience a 360 degree experience. e) The selection menu where the user can choose which area of the development they wish to be teleported to. f) A snapshot from drone footage transporting the user from the installation site to the pedestrian bridge location.

family chatter (see Figure 7.5a) and the coastal park with audio including trees moving in the wind and chirping birds (see Figure 7.5d). All these audio tracks were included in the design based on feedback from the domain experts and Sight Life user group (see Chapter 5). Between each selection the user can click to return to the selection menu. However, if the user has no interaction for 60 seconds the display will return to the initial screen as shown in Figure 7.5e.

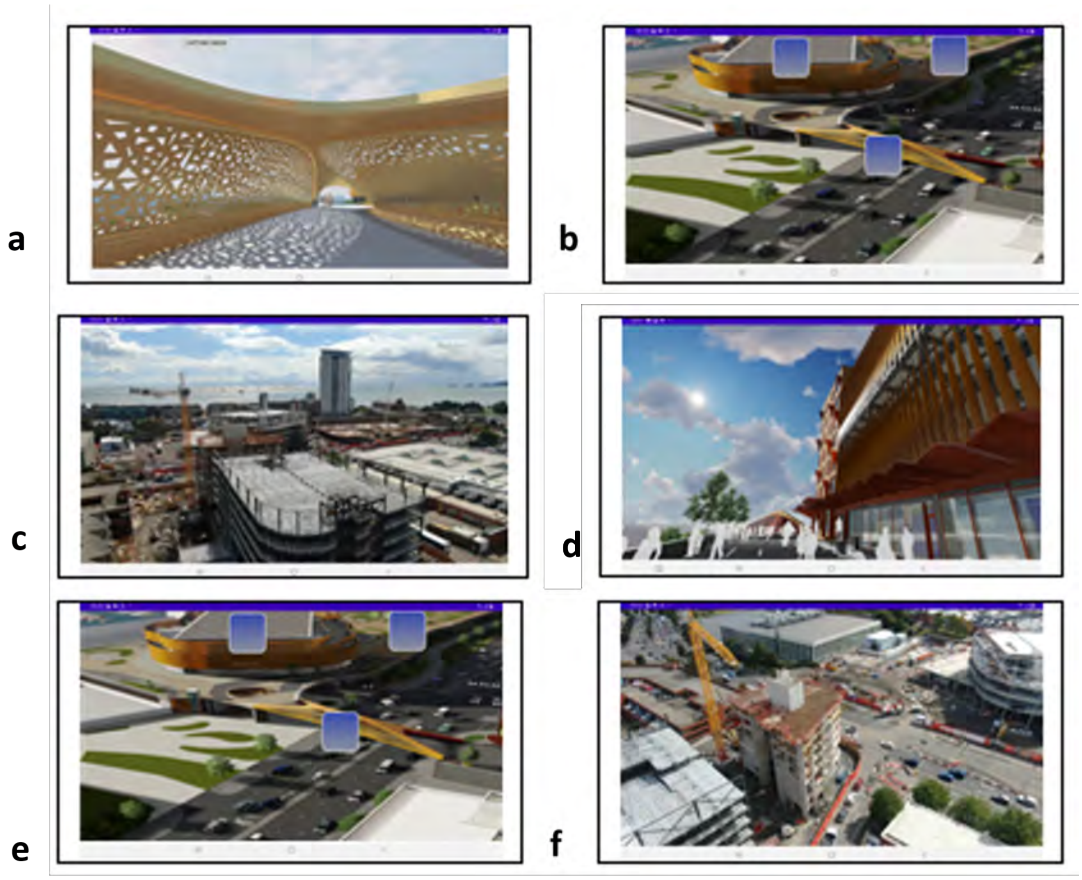

Figure 7.4: Activities 19 to 24 of the final prototype corresponding to figures a to f. Figure 7.4 a) The pedestrian bridge activity where the user can choose to have their photograph taken again. b) The selection menu where the user can choose which area of the development they wish to be teleported to. c) A snapshot from drone footage taken from the installation site to the car park. d) The car park activity. e) The selection menu where the user can choose which area of the development they wish to be teleported to. f) A snapshot from drone footage taken from the installation site to the housing complex

7.2 Final Physical Design

The final physical design includes two MPMU installations, one for adults and one for wheelchair users and children. These installations are identical other than a difference in the vertical height of the tablet and levers to make these more convenient for users to interact with. Figure 7.6a shows a final representation of the taller installation set at the height of 1.4m. The installation includes an extended roof to prevent solar glare on the tablet screen which is also contained within a matte black painted box, also designed in order to reduce solar glare. This a

b

c

d

e

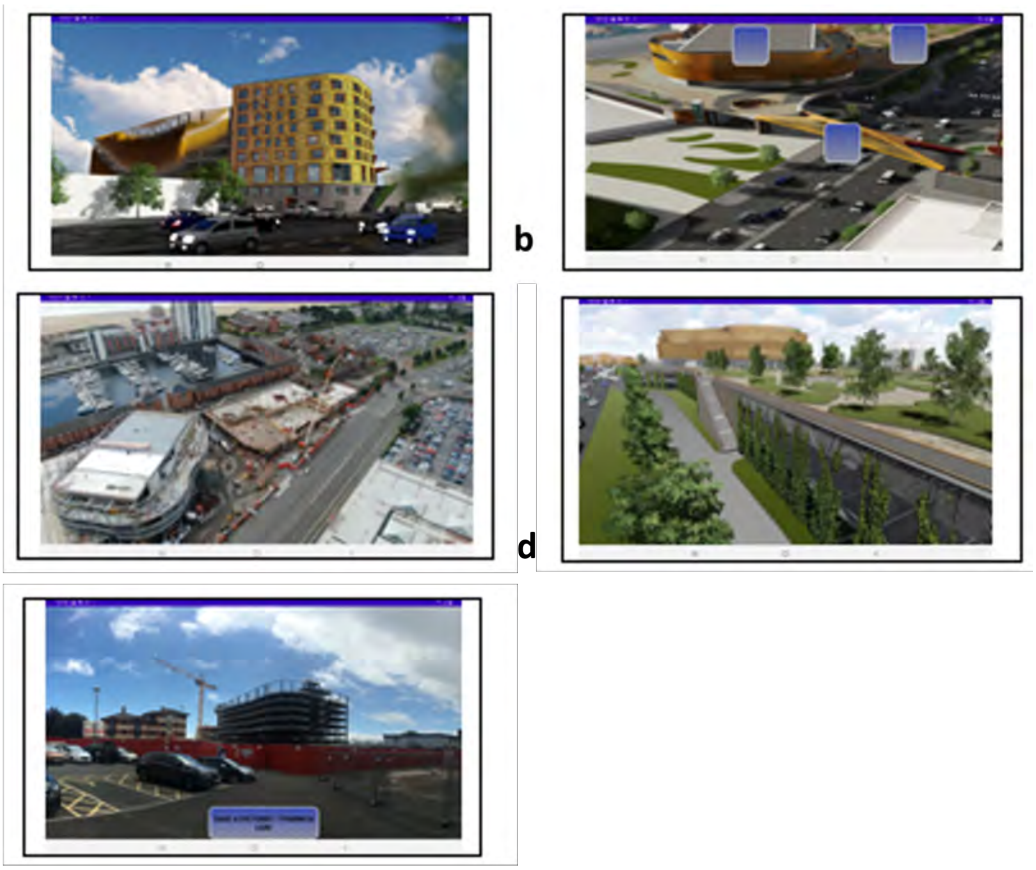

Figure 7.5: Activities 25 to 29 of the final prototype corresponding to figures *a* to *e*. Figure 7.5 a) The housing complex activity. b) The selection menu where the user can choose which area of the development they wish to be teleported to. c) A snapshot taken from the drone footage from the installation to the coastal park. d) The coastal park activity. e) The user has walked away from the installation causing a time out or viewed all of the development locations taking them back to the initial screen.

was to reduce problems caused by the tablet constantly auto-correcting its contrast and back lighting settings in response to external light conditions because the installations are located outdoors. There are two elbow levers to control the panning aspect of the display. The left elbow lever pans the content to the west of the development site and the right elbow lever pans the content to the east side of the development site. The interactive aspect of the design is completed with an elbow button covered in a copper film and painted yellow to act as an anti-viral surface and to enhance visibility, respectively. Finally, the metal used to create the box surrounding the tablet was chosen as aluminium to ensure no issues occurred with the tablets magnetometer sensors which could otherwise cause the tablet to spontaneously change its image at a right angle or even 180 degrees which would rapidly impair the users experience.

A CCTV camera was also requested to be installed within the area to ensure that the chosen installation was less likely to be vandalised and to enable observation of users from a distance due to the current social distancing climate. It was essential that users felt comfortable when using the chosen installation and therefore having researchers within close proximity could have caused undue stress and prevented users from interacting.

Figure 7.6b shows the wheelchair user and children's installation. There are two differences between this design and the adult pedestrians installation. The first is the vertical height of the display set at $1m$ and the second is the area provided to enable wheelchair users to wheel under the display. To achieve this the length of the box which is holding the tablet was extended and the holding pole placed at the back of the box instead of centre. The elbow levers were also extended to ensure that wheelchair users would be able to reach them from their chair. Apart from these modifications to enhance user access, the installation was identical to the taller version.

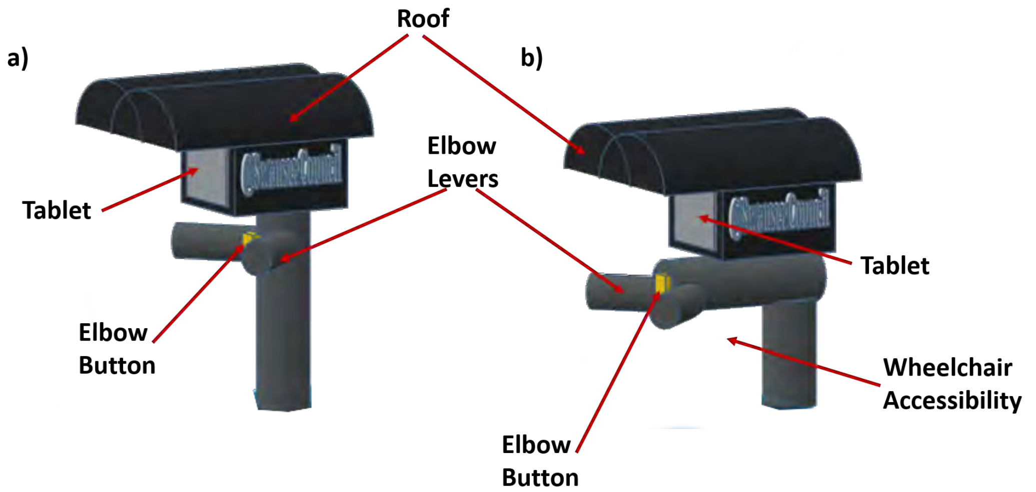

Figure 7.6: The final physical design prototype for the MPMU. Figure 7.6 a) shows the final design for adults b) shows the final design for children and wheelchair users.

7.3 Final Evaluation

The final evaluation was completed with a range of domain experts and end users. Sadly due to time constraints it was not possible to show all of the previous cocreation groups the final design. The domain experts provided a broad representation of the professional and personal opinions of the building industry and the end users provided the personal opinions of the public. These two user groups completed one-on-one interviews where the content of the application as detailed within 7.1 was connected to the Zoom call using a Samsung tablet via the Zoom screen share option. This enabled the users to take control of the screen and use the application themselves. The participants were all are asked to provide verbal consent to have their feedback reviewed within this project and were assured that no personal data would be utilised.

7.3.1 Domain Experts

Two domain experts were interviewed and asked to voice their train of thought whilst using the prototype. As the domain experts work within the development site, and therefore knew it well, so we did not ask about their knowledge of the site before or after using the prototype.

For the beginning screen both users were confused by the text shown within the main activity (see Figure 7.1a) and questioned whether they would be taking a picture of the development site or of themselves when clicking the "Take Picture" button. Therefore, we adapted the text to "Take a Selfie/Cymerwch Hunlun". The participants also felt that pop-up prompts throughout the content would help users who are not used to technology to understand what interactions they should do to interact with each different activity. Text based prompts were therefore added to each activity to ensure no matter how basic the users knowledge in technology was they would still be able to interact with the device. Finally, the participants expressed their enjoyment in viewing the different AR filters and how they adapted to their movements in real time.

7.3.2 End Users

Seven end-users were interviewed with regards to the content shown in 7.1. The end users interviewed had no prior knowledge of the project and we were therefore able to evaluate how their perception of the site had changed based on the interactions they had with the prototype. The interviews were structured to ask the user about the knowledge they had about the Swansea development site, to then use a prototype and then ask if the understanding had changed and if so how.

Thus the user groups prior knowledge was very limited with the majority of the group having no knowledge of the development site at all, with only one user having a basic knowledge of the funding grant. We therefore continued the interviews by sharing the prototype with the users and asking them to speak their train of thought as they used it. Each participant thoroughly enjoyed being able to select an AR filter, with the crown-based filter showing as a dominant favourite. The incorporation of drone footage was also a popular attribute with user's saying it had helped them to understand the scale of the development being undertaken which would have been hard to view without this footage. It could be argued that due the new local lockdown rules uploaded such content online for users to access could be used as promotional tool to get user excited about be finally able to use the interaction themselves.

The final observations from the prototype usage related to the autostereogram of the auditorium. All of the users really enjoyed being able to view the auditorium in a 360 degree view with one user even asking if a microphone could be included so that it appeared as if they were singing in the auditorium. However, after viewing this image the remainder of the development site images were somewhat of a disappointment as they were only contained in 2*D*. The initial plan was to be able to provide an autostereogram for each area within the site but were only able to obtain the assets for the auditorium within the time frame of this project.

When asked about how their perception of the development had changed all of the users said that they had not realised the scale of the project before and were particularly excited to see an arena being developed. One user added that they often find it challenging to navigate their way around new areas but would feel confident doing so after utilising this prototype. Some final comments from the users included that they liked the fact that the content provided information but was also an enjoyable interaction and that it would be really useful to occupy their children with whilst they are orientating themselves in the new area. We aimed to complete more in depth user studies on site with a larger range of groups including children groups but due to the Coronavirus pandemic this was not possible.

7.4 Summary

In summary, the final prototype met our initial aims by delivering an interactive display with elbow levers compared to foot levers to prevent any users from being harmed by the display.

We also design two separate installations to enable adults, wheelchair users and children to interact with the display without requiring additional aid. This enabled an interactive that we had created an interactive experience that was as accessible as feasibly possible to all members of society and wouldn't cause harm. Finally, this design was moulded on the basis of the feedback given by a range of users and stakeholders which enabled us to create an prototype that has been cocreated within the local community to fit the needs of the local community.

Chapter 8

Conclusions and Future Work

To conclude, within this thesis a detailed blueprint for an interactive display has been developed using a co-creation methodology for deployment within the Swansea city centre development. The final deployment is shown within Figure 8.1 including two installations one for adult pedestrians and one for wheelchair/children users with surrounding astroturf to provide a clear colour contrast for partially sighted users. The cocreational process has involved both stake holders and end users. The main stakeholder (Swansea City Council) have been involved from the inception of the project and were involved in the initial discussions about project ideas as described in Chapter 4 and onwards providing feedback through user groups and discussions throughout the project. Feedback on subsequent project designs was also sought from user groups. In total, feedback was sought from 5 user studies with stakeholders and end users who heavily influenced the final design of the prototype to fulfil the aim to carry out intensive user-centred design activities to inform the physical and digital elements. Due to the Covid-19 pandemic, all of these user groups had to take place online via Zoom and through presenting ideas, concepts and designs through images and audio descriptions. This was not ideal but, despite the limitations that this caused, the feedback received from these user groups was extensive and supportive, and it led to a range of modifications including geographical position, physical attributes, interactive aspects and content which undoubtedly improved the final prototype. Overall, this co-creational approach worked extremely well even in the adversity of not being able to meet in person and it is an approach which should be used more widely, especially for community-based projects such as this one.

The two underlying themes for the design of the installation were that it should be as fun and engaging as possible and also that it should be as widely accessible as reasonably

Figure 8.1: showing the final deployment shown within Swansea City Centre.

possible. To introduce the fun element, the content was designed to include “selfie” images of the user which they could then annotate themselves to create their own character to travel around the virtual site and also to use drone footage to provide all users with a new view of this part of Swansea. Both of these concepts were also very inclusive because all users would be able to access exactly the same content. Users can be seen evaluating this aspect of the content in Figure 8.2.To further extend the inclusivity theme, two prototype installations were developed: one taller version for adult pedestrians and another one at a more convenient height for children/ wheelchair users. Based on feedback from a sight impairment user group, the installation design was modified to remove trip hazards for partially or non-sighted users by incorporating elbow levers and buttons compared to foot levers located within a blind spot for canes and guide dogs. Figure 8.3 shows a participant using these elbow levers to pan the content. Audio tracks were also included to help identify different parts of the site in line with the aim of making the design as accessible as feasibly possible for all members of society.

Our final aim was to create a working prototype of digital elements that could act as a base for deployment. However, the issues resulting from the Covid-19 pandemic prevented the

Figure 8.2: A couple panning the content to select a range of AR filters on their faces.

organisation of on-site user studies and so these had to be organised online instead. Whilst useful insights were obtained from this user group feedback, it was not possible to get direct feedback on how users might perceive the design and operation of the installation differently when on site. However, despite all the problems and delays that the Covid-19 pandemic caused, it was still possible to achieve the overall project aim and the blueprint design from this project will be developed and deployed into the Swansea development site in October 2020.

8.1 Future Work

Future work in the area of interactive installations has considerable scope. For the physical design, there is the potential to develop a single installation under a larger roof but with a larger screen to operate at multiple heights. If this could be fully audio operated, this would avoid the need for levers etc. However, this would require significant work on the security side to prevent misuse. Failing this, Bluetooth control through smartphones could be used but again this would need the security issues sorting out perhaps by allowing to register to use the

Figure 8.3: A user moving the elbow levers to pan the content of the screen.

facility.

In terms of the digital content, there is clearly significant scope to incorporate a wider range of content. So whilst the current content is focussed on the future to show the new development, there is also the possibility of being able to also see the history of the area via an AR overlay incorporation into the live view of the current location. We would also like to incorporate the ability to send the user's picture within the arena activity back to the user's via technology such as Bluetooth or screenshare.

Finally, building on the co-creation approach of this thesis, the future plan would also be to carry out more user studies with a wider range of users. For example, a family group to obtain a perspective of the design from a child's point of view and also other societal groups to make sure that the installation is accessible to as many people as possible.

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