
An Evaluation of the User Interface for Presenting Virtual Tours On line

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Declaration of Authorship

I, MURRAY JOHN QUARTLY, declare that this thesis, 'AN EVALUATION OF THE USER INTERFACE FOR PRESENTING VIRTUAL TOURS ONLINE' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for the Master of Human Interface Technology at this University.
- No other part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.



Signed

Date: 31st August 2015

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Abstract

The intention of this research is to evaluate and determine what the best user interface is for presenting virtual tours online through a mobile device. The mobile application will provide the ability to stand on location and look back in time through a series of virtual tours taken on different times at that same location.

The content material for this thesis is the Red Zone virtual website tours taken by the researcher over the last three years. The primary motivation for capturing this material is to create a historical record which will be available for future generations, not just in New Zealand but also overseas via online content. The application will be designed to display virtual tours and /or supporting material. Through a series of iterations my research investigated the operational performance, the preferred design and layout of the user interface, and what product should be available online. This also means the user will gain an understanding and appreciation of the content material. This may also help the public to grieve and move forward from past losses and dramatic changes.

Four different interfaces were developed; (1) Thumbnail menu, (2) List Menu, (3) Frame slider, and (4) swipe menu, and a user study conducted to compare between these conditions. The main results from the user study showed that there was no operational difference in timing between the four different conditions. However, it was clear that participants preferred certain features to be included; most notably the launching of virtual tours from hotspots on a map. Other findings were the need to have an environment which included other information to make it more interesting and engaging. The use of additional information also helped create a sense of being on location when displayed alongside a virtual tour. Audio files were acknowledged as being a preferred inclusion as they added a little more “richness” to the environment.

In summary, people were interested in interacting with the virtual tours with supporting content. All of these online features are helping to create an immersive environment that is engaging, interesting and promotes understanding.

To be of value to any user it is very important to include other features and a variety of content material with the virtual tours. The way the virtual tours are presented online and the content material that may or may not be included will impact on the perception that people have of the application. These findings are presented to provide positive and pragmatic information that is of assistance to people who intend to develop and use virtual tours online.

Introduction

1.1 Thesis Research Goal

The main goal of this thesis is to research and evaluate the best way to effectively present online virtual tours. The research will explore different user interface options for presenting immersive virtual tours on a desktop and / or mobile device. Virtual tours are immersive 360-degree panorama images created from using a variety of different imaging and software technologies. Although it is relatively easy to create virtual tour imagery, there is still research needed on the best way to present the content to the end users. The research will evaluate different user interfaces with the intended outcome being guidelines for developing online virtual tours application for mobile devices.

The research is motivated by a desire to record the aftermath of the 2011 Christchurch earthquake, a magnitude 6.2 earthquake centered beneath the CBD at 12.51 pm on 22 February 2011, which severely damaged the city's central business district (CBD). After the earthquake, the Red Zone was the portion of Christchurch's CBD where access was denied to businesses and the public because of health and safety reasons. Extensive damage to the buildings in the Red Zone meant that most of them were now unsafe and would need demolishing. This was primarily due to liquefaction of the ground underneath the buildings which caused uneven subsidence of the building foundations. Land damage assessment was carried by Tonkin and Taylor environmental engineering consultants [34]. Following this, the corners of some buildings have settled further into the ground putting considerable strain on the existing structures. Given that further earthquakes could occur in the future, the buildings were now considered to be extremely unsafe. Access was firmly denied to all businesses in the Red Zone, regardless of whether confidential files, expensive furniture, or precious computer systems were still present in these buildings.

The photos below show earthquake damage to some of the central city buildings. Figure 1.1 shows the Crowne Plaza being demolished. A view through the main entrance shows the Forsyth Barr building on the other side of Victoria Square. Figure 1.2 shows the BNZ building in Cathedral Square being partly demolished. The bottom half of this building was retained that has never reopened to date. Figure 1.3 shows the Trinity Church on the corner of Manchester and Worcester Street. This building suffered significant damage with a large gaping hole and rubble on the ground, but is being repaired.



Figure 1.1



Figure 1.2



Figure 1.3

Figure 1.1: Crowne Plaza 28 March 2012. Being demolished.

Figure 1.2: The BNZ building 24 March 2012. The top half is being demolished.

Figure 1.3: Trinity Church 5 March 2012. On the corner of Worcester and Manchester Streets.

The access barrier to the Red Zone created a visual vacuum. The public and businesses were unable to view the subsequent deconstruction of the Red Zone due to health and safety reasons. Access approved by the Canterbury Earthquake Recovery Authority (CERA) to the company Focus360 created an opportunity to historically record and collate the changes taking place using virtual tours. Capturing images inside the Red Zone provided the opportunity for the public to see how the CBD changed over time following the series of devastating earthquakes.

One way to capture the changes in the Red Zone is through the use of immersive virtual tours, a recent trend in digital photography. Virtual tours are immersive panoramas that capture up to 360 by 180 degree views from a given location (See Figure 1.4). Smart phones capable of this are Android phones with a three megapixel camera or better, and an iPhone 4 or better. A completely spherical image can be created from this 360 by 180 degree, two-dimensional, still image. By using an interactive button array or moving the cursor on the virtual tour image, the user is able to pan and zoom about the picture. Some cameras and smart phones now have panoramic capture functions that make it easy to stitch images together. For greater pixel depth, image exporting and editing capability there is also desktop software for creating very high-resolution immersive imagery, such as Kolor [35]. A virtual tour may also include other multimedia elements such as sound, text, hotspots, maps etc.



Figure 1.4: A 360 by 180 degree panorama of the Manchester Street and Hereford Street intersection, Christchurch, New Zealand photographed on 1 June 2014.

Panoramic images [36] are usually considered to be any images with an aspect ratio greater than 2:1. This means that they are twice as long as they are high. The panoramas used to create completely spherical virtual tours must be 360 by 180 degrees. Panoramic images can also be exported and represented as planar images. Planar images are less than 360 by 180 degrees and do not have the same functionality options of a completely spherical virtual tour, but they only provide limited movements online.

The process to produce virtual tours is through three steps. The first step is to take the imagery using the proper equipment. The second step is to stitch the raw photos together to form the 360 by 180 degrees panoramic image using one of two popular methods:

- *Rectilinear*: Images are stitched together in a cylindrical format with a 360° horizontal panning but limited vertical panning, usually up to 50 degree maximum.
- *Spherical*: Images are stitched together to a format which is 360 by 180 degrees.

The final step is to import the 360 by 180 degrees image into the virtual tour software. Files are then exported and uploaded onto a web server. An executable HTML file is used as the URL to run the virtual tour normally placed within an iframe. The process can be carried out manually or fully automated.

The intended focus of the research is to evaluate the effectiveness of several user interfaces for virtual tours. This is an important topic because although panorama content capture is relatively straightforward, there is still research that needs to be done on the best way of presenting the captured content back to the user. This is especially true for mobile devices that have a wide range of different form factors and interface possibilities. In this thesis the research will focus on different user interfaces for presenting mobile virtual tour experiences. The research will include comparisons of image frames for housing the virtual tours, web page layout options, and supporting content media. The decision to code and build four different user interfaces was based on experience with the software photo stitching and time constraints. The four consoles provided a wide coverage of presentation software technologies available although not covering all the plugins available e.g. video inserts.

The thesis research was carried out through a user-centered interaction design process that included the following: (1) determining user needs, (2) designing interfaces to meet the users' needs, (3) developing prototype interfaces, and (4) testing the prototypes with end users. This process helped to understand how efficient each interface presentation method was compared to one another, what interface preferences users preferred for their virtual tour experience, and what type of content they would most like to see during their virtual tour.

1.2 Company Partner

This thesis is being developed in collaboration with Focus360 Ltd., a company which has developed over 140 virtual website tours of Christchurch's CBD, the Red Zone, and other locations. In the beginning, the company was primarily interested in documenting the dramatic changes that occurred in the CBD and greater Christchurch as a result of the series of devastating earthquakes occurring in Canterbury from 4 September 2010 through to the end of 2012. These virtual tours can be viewed by using a website's menu system. Figure 1.5 shows a sample website with a Virtual Tour embedded onto a web page [37].

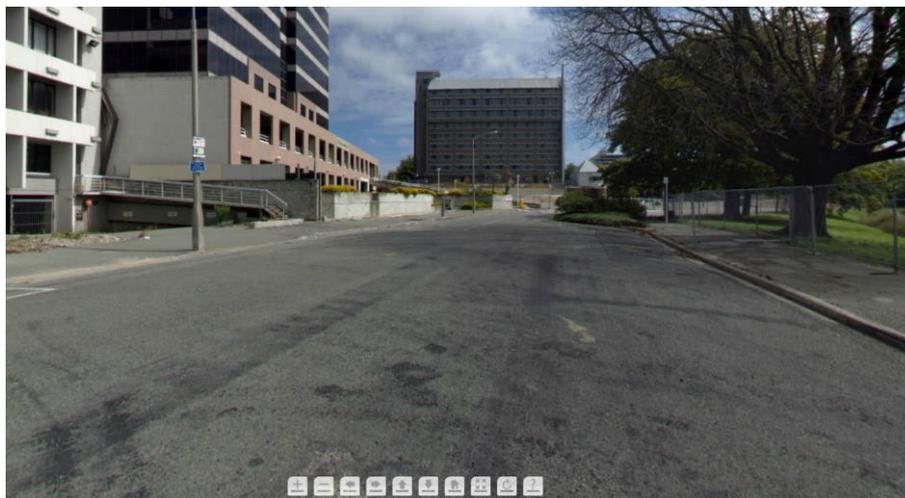


Figure 1.5: The image is a virtual tour console with a button array. The buttons add functionality (e.g. opening full screen). The thumbnails can be clicked to open other virtual tours in the same window.

As the initial project developed, there was considerable interest from both the public and business sectors to be able to view the changes occurring at the CBD as portrayed by the established virtual tours. Consequently, the virtual tour collection was provided under a Deed of Gift to the University of Canterbury's Quake Studies CEISMIC [38] (see Figure 1.6).

The virtual tour collection can also be found on a touch screen TV in the Canterbury Museum. The virtual tours are now displayed on the University’s website as well as a touch screen TV in the Canterbury Museum’s Quake City’s exhibition (See Figure 1.7). Approximately 100 virtual tours were supplied to the University of Canterbury and the Canterbury Museum.



Figure 1.6: The virtual tours link on the University of Canterbury’s CEISMIC website



Figure 1.7: The touch screen TV currently on display in the Canterbury Museum’s Quake City’s exhibitionChristchurch, New Zealand. The virtual tours run from the “Home” screen and can be accessed using the image menu.

Based on this interest, Focus360 developed a mobile platform to share the virtual tours and supporting content material online. The virtual tours are managed through a separate web interface, which runs in parallel to the virtual tour online content. For mobile devices, it is possible to create a generic marketing platform whereby virtual tours can be viewed on the mobile device and managed through a menu system. The virtual tours are written in HTML5, so they are mobile responsive and can be viewed on many different platforms. Figure 1.8 shows an early version of the virtual tour that was developed by Focus360 for a mobile device.



Figure 1.8: Lamb and Haywards’[39] virtual tours produced in June 2014 by Focus360 Virtual Realities Ltd. Viewed on an Android Samsung Galaxy Mini III cell phone.

1.3 Overview

The research project was structured into an iterative process. This means a prototype was developed through an initial rapid iteration. This initial prototype was then qualitatively investigated and the outcomes were used to produce a higher fidelity prototype. Then through a further three iterations a working prototype was developed. With this high fidelity prototype an in-depth user study was carried out using both qualitative and quantitative methods. The outcomes of the user study were then used to design the final mobile device application.

The research reviewed historical perspectives and previous related work that influenced the user interface for viewing virtual tours made from panoramic photos. A description and explanation of the equipment, photographic process, photo stitching software and project content is presented to provide an overview of how to create virtual tours. The research carried out a needs analysis and a concept design process that worked through three iteration cycles to create a high fidelity prototype. A user study was conducted where the features of the high fidelity prototype were analysed quantitatively and qualitatively to establish what is required. The findings of the research were used to create a mobile device application which had the most preferred design and layout.

The final product is intended to be a culmination and inclusion of all the research findings. The goal is to produce a product that is an online mobile device based on the findings that will present the virtual tours of the Red Zone in an engaging and meaningful design and layout.

2 Historical Perspectives and Related Work

This chapter will provide an overview of previous research on virtual tour interfaces, and commercial products available for presenting virtual tours/panoramas on mobile devices. Even though the use of virtual tours is well-documented, there has been less research on comparing user interfaces for interacting with panorama imagery. This chapter investigates the design of user interfaces for virtual tours.

2.1 Historical Perspective

The word panorama is derived from the Greek words, “pan”, which means everything and “horama”, which means to see [36]. Therefore, panorama means the ability to see all around. In the beginning, panoramic images were created in a number of ways. During the 18th and 19th centuries, panoramas were round paintings. In 1787, an Irishman by the name of Robert Barker [40] put together a patent for the plans to create a cylindrical building that would be erected around a large panoramic painting. This was a new and specialised technology that no one would have experienced before [41].

It wasn't until halfway through the 19th century when the first photographic panoramas were taken and produced. In 1843, Joseph Puchberger from Austria patented the first panorama camera, which began over a 150 years of development in panorama photography [97]. Following the development of these panoramas a camera with a new gearing system was developed in 1844 by a German named Friedrich von Martens. He designed a gearing system which slowly moved the camera thereby properly exposing the black and white prints. After 1888 plastic photographic film which could be rolled up into a canister was developed. This provided the foundation to take many images and easily create panoramic images. From this point forward panoramic photography became a technically easy and exciting new industry able to reach any keen photographer [97].

Computers became more accessible in the 1990's and system hardware became faster with increased memory space. Around this time, digital photography and digital panoramic cameras first arrived on the market. Several applications became publically available and included the following: surveillance cameras, line scanners, and simple panoramic stitching software. The origin of the term “virtual tour” dates back to 1994 and referred to a 3-D walk through Dudley Castle as it appeared in England during 1550 [42].

By 2004, computers became powerful enough to process images and new companies like Kolor [57] were formed (see figure 1.1). A number of other companies joined the marketplace as virtual tours were becoming more popular. For example, SpheroVision [43] produced a virtual tour stitching software and display console. Initially, virtual tours were entirely computer-based and remained that way for a number of years. However, from the time that smartphones became available virtual tours have also been included on mobile platforms.

These products ran smoothly on all types of computers that had a Flash player installed. However, when the mobile market exploded Flash would not display and as a consequence would not run on all mobile platforms. During the middle of 2013, virtual tours became exportable in HTML5. This upgrade to existing software made it possible to export all virtual tours so that they could run smoothly across all mobile platforms. Companies during this period expanded their plug-in libraries, incorporated geo-locationing, and vastly increased the ability to customise the virtual tours for any application.



Figure 2.1: Geo-tagged points where virtual tours were taken by Kolor in 2015.

2.2 Related Work

The research objectives of this thesis are to evaluate the best user interface to present virtual tours online. A key outcome of this research is to design a mobile application with the best user interface to display these virtual tours online. Thus the research builds on related work in (1) user interface design and evaluation, (2) virtual tour applications, (3) mobile user interfaces, and (4) mobile virtual tour applications. In this chapter we review each of these areas in turn.

2.3 User Interface Design and Evaluation

Despite the global usage of virtual tours, Bastanlar [53] points out that there are very few user studies done to evaluate the issues around the user interface and user experience. His paper is one of the few examples comparing different control and navigation methods for virtual tour applications. In this case he compared different methods for navigating through a virtual tour of a museum, for rotating the user viewpoint. A user evaluation was conducted with 15 users and data was collected about their mouse and keyboard input, eye gaze patterns, and subjective preferences. They found that users mostly used clicking on a map for navigation and used dragging with the mouse on the screen to rotate their viewpoint. The subjective preferences matched this, for example user's feeling that clicking on the map was the most effective way to navigate followed by the selecting on screen arrows. The paper is an excellent example of how to conduct an evaluation of virtual tour interface options, and provides good information about user preferences with virtual tour interfaces.

Villanueva et. al. [98] provided a second example of a user evaluation with a web-based virtual tour. In this case they use three techniques for analyzing user behaviour; (1) Think-Aloud protocol, (2) Heuristic Evaluation, and (3) Emergent Themes Analysis. Using these methods they were able to identify some common interaction issues that need to be addressed in designing virtual tours, including: the user expectations of real world conventions not being met, limited use of the provided navigational aids, user difficulty in navigating and panning within the virtual tour and a limited field of view, among others.

Tsai-Yen Li et. al [46] also explores navigation in virtual tours, and states that the optimal sequence to traverse virtual tours requires topological consideration. A map is preferred as it provides users with the ability to complete the tour in the shortest amount of time for the greatest benefit. Engagement increased as

a consequence of the architecture and navigation system used, and an interactive map provides significant information to the user. The implication from this research is that a virtual tour interface should have an interactive map to aid with navigation, agreeing with the research of Bastanlar [53].

Kraljic [54] finds that interactivity is essential for engaging users in a virtual tour. Their research found that features such as decision points where the user makes a choice, and an interactive map for navigating to different viewpoints are both very good techniques for engaging with the user within the virtual tour. However, Ladeira [56] believes content preference plays an important role and should be directly aligned with the theme of the virtual tour. Interactivity can be improved by using properly written content that matches the theme of the virtual tour and not including material irrelevant to the theme. So the design of any mobile application requires a method for including the content relevant to the virtual tour.

An interactive digital character is another way of improving the virtual tour experience. This is typically an image that can appear in the window of a virtual tour and provide the user with a more informed virtual experience by guiding their way around the tour and providing text or audio information. De Almeida and Yokoi [49] created an interactive character which they used as a tour guide and they found that a character with a conversational dialogue provided much better interaction with the virtual tour by the user. Kaplan [51] similarly used a portable digital assistant that customized the virtual experience for the user and improved interaction with the digital tour thereby improving the user's experience.

In addition to user interaction, visual quality is very important for a good virtual tour experience. Research indicates that the viewing platform's capabilities e.g. a PC, and the imagery both are important aspects to provide a satisfactory if not excellent user experience. Tsai-Yen [46] emphasises the need to have good technology to deliver good imagery to the desktop PC. For example, Jing et. al. [47] demonstrated an online travel service that uses virtual tours to help travelers decide their tourist destinations. In this application the imagery was of very high quality and taken from well-known tourists' sites.

From these papers we can learn several key points can be identified. These points are summarised below and are:

- Maps were mainly used for navigation and clicking and dragging were used for changing the view.
- The expectations for real world conventions need to be met with, for example the ease of navigation.
- Interactivity provides user engagement. For example a map can provide significant benefit for the user by allowing them to complete the virtual tour in the optimal amount of time.
- Customisation of a virtual tour with an interactive digital character which provides concise information relevant to the experience assisted with further engaging the user.
- High quality imagery of places which the users can identify with assists with users making informed choices, for example tourist destinations.
- Less clicking and more viewing, Karat [99].

The literature provided particularly useful information with regards to any proposed design. It is worth noting that several researchers stated the benefits of a map.

Table 2.1 below provides a longer summary of academic research conducted related to viewing and interacting with panoramic images. This table provides a set of research-validated summaries that is useful to consider when developing a mobile responsive application with virtual panorama functionality.

Paper	Interactions with Interface Summary
CityViewAR: A Mobile Outdoor AR Application for City Visualisation. [1]	Provided an enhanced user experience. Panorama pictures were popular and participants who use these tended to use the application longer.
A Survey of Interaction Techniques for interactive Environments [27]	This report considered how to select and manipulate an assistant control. The interaction with the user interface required a series of guidelines with the human computer interaction was able to display information about the real world and utterly believable way. These include guidelines such as minimising navigation steps, text which conveys information and help embedded throughout the application.
Interactive Application Development Policy Object 3- D Virtual Tour History Pacitan District Based Multimedia [32]	The findings indicated that any 3-D virtual tour based application needed to have an interface that was simple, easy to operate, attractive, clear and useful.
Automatic Zooming Interface for Tangible Augmented Reality Applications [20]	Automatic zooming helped users to perform faster with better usability. This did not compromise the naturalness or intuitiveness of the conventional Tangible AR interface.
AntarcticAR: An Outdoor AR Experience of a Virtual Tour to Antarctica [28]	The interface was designed to be responsive to the user's input, provide immersive visualisation and be accessible to other forms of media e.g. video.
Freeze View Touch and Finger Gesture based Interaction Methods for Hand-held Reality Interfaces [3]	Freeze view touch method seems beneficial compared to the traditional touch input. To develop a more intuitive method for a hand-held mobile with a freeze view touch interaction. More work is required on the gesture based interaction method.
Gesture control interface for immersive panoramic displays [30]	The design should include a small set of natural and easy to learn gestures. Movement should be comfortable and intuitive for the participants.
An evaluation of immersive viewing on spatial knowledge acquisition on spherical panoramic environments [26].	Participants had to navigate through a spherical panorama and would generally be unsatisfied with discontinuous nature of travel and the spherical panorama environment due to the being unable to locate salient landmarks from each transition.
Handling Occluders and Transitions from Panoramic Images: a Perceptual Study [31].	Synchronised and blended transitions are the preferred method of presenting panoramas for the user at the interface.
Less clicking, more watching [99].	The results from a study on interactive design and evaluation of entertaining web experiences.

Table 2.1: Academic work summary

This research indicates that choosing the correct functionality and design are very important considerations for developing virtual tour applications [53] [46]. The literature also provides evidence about

the requirements and structure for the researches iterations and subsequent user study, and a clear road map that influences the design of the mobile application. In the next section we review some mobile applications that include virtual tour element and show how these design guidelines can be applied.

2.4 Virtual Tour Applications

Aside from research on user interfaces for virtual tours, there have been a number of virtual tour applications that have been developed that we can learn from. Two of the most popular are Google's Street View [66] and Microsoft's Streetside View [68].

Google Street View [66] displays images of streets and the exterior view of the surroundings. The technology allows the viewer to move from one point to another and zoom and pan at any particular location [31]. Users can rotate their viewpoint by clicking and dragging on the panorama image, and can move to different positions by clicking on hotspots embedded in the picture. They can also use a map view to drag and drop a viewpoint icon to set the position of the panorama. This provides the viewer an easy way to navigate around any locality and helps to find a particular address. Google's intention in the long term is to provide a comprehensive coverage of any particular locality, anywhere in the world. This technology can be found in both Google Maps and Google Earth. It was launched on the Internet on 25th May, 2007. Figure 2.4 shows an example Google Street View image taken in Christchurch well before the first earthquakes.

Google Street view allows interaction by having the ability to customise the view. This technology allows you to choose the features that you want to see on the map, decide what happens when something is clicked and what gestures you can use with the map.

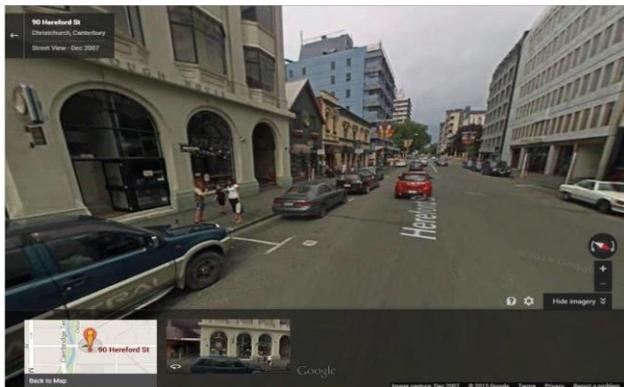


Figure 2.2: Google Street View: 90 Hereford Street, CBD, and Christchurch, New Zealand. The image above shows a typical Google Street View and is of Hereford Street taking during 2007.

Microsoft's Streetside View [68] used with Bing Maps also allows people to see virtual panorama imagery from map locations. The user interface is similar to Google Street View and relies on virtual tours taken and located on a single viewpoint to transit to the next viewpoint. This is a useful feature as it makes it very easy for the user to locate where they want go by seeing the actual location before arriving. The experience uses information and pop ups to assist the user with the experience. These pop ups would be a useful inclusion to include in the Red Zone mobile application to provide information on demolished buildings. Figure 2.5 is my Microsoft's Street Side View. This is a sample taken which shows some of the functionality including pop-up names of streets.

Street Side View is an eye level interaction which is a virtual walk through and enables the user to pan up and down. The view moves through the street by viewing a series of seamless overlapping photographs. With the ability to click on a street name (and if it is available) the user is rotated into the next street. The Microsoft Interactive Visual Media Group's [96] research found that this was a way dramatically improving visualisation and navigation [99].

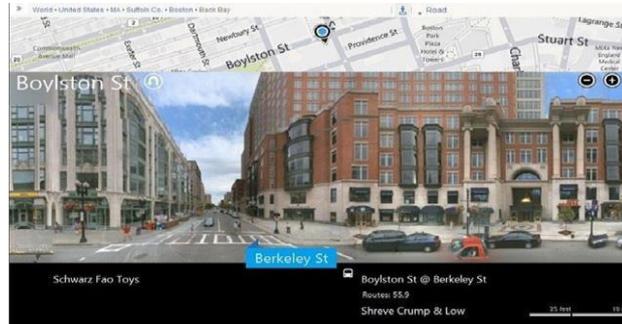


Figure 2.3: Microsoft's Street Side View

A number of other industries and researchers are using virtual tour technology for a wide range of different purposes. For example, Martinez-Grana et al [49] are using them in the geosciences to feature stops in national parks and establishing a geological heritage itinerary using smart phones and tablets. Users interact with their mobile application by viewing a map and itinerary. These features have stops that can be opened and provide the user with geological heritage information.

Bellan and Scheurman [48] see real benefits by using virtual tours in field trips within education, enabling students to reach into the past in a more meaningful way. They emphasise that the virtual field trip does not replace the actual field trip, and state that a richer and deeper depth of learning will occur by viewing virtual tours as well as using all the senses while on an actual field trip. They believe that the field trip is enhanced by the virtual experience as it can provide for example prior knowledge and therefore assist to answer any initial questions.

Jing F et. al. [47] have developed virtual tour applications for Tourism. They propose that virtual tours can be used in an online travel service if the virtual tours are taken of well-known locations easily recognisable by the tourist. The intended interaction was for users to manipulate the virtual tours online to explore the chosen locality.

Effective conceptual frameworks are required to evaluate virtual tours tourism. Yong-Hye [55] argues that tourism marketing because has become fragmented and specialised with the development of new styles of travel. It is stated that because of the importance of "experience oriented tourism" virtual tours are a beneficial way to show potential tourists without this interactive, clear and accurate imagery. Yong Hye states that the virtual tour is becoming an effective tool to display and market tourist destinations. Tourist markets can get a preview of what they may experience and remove any issues or doubts they may have of the possible experiences when and if they visit any locations.

Virtual tours are also being used on a website for the parents of children undergoing surgery as a day stay patient [44]. User study results indicated that the children who viewed an online website before the day stay had significantly less distress and greater knowledge based on a surgical virtual tour. So there are real benefits from preoperative preparation with a virtual tour for children and the parents of day stay surgery, such as promoting discussion about health.

There are also positive clinical outcomes in terms of procedures that assist with the management and lessening of post-operative pain and increasing children’s knowledge to assist with reducing emotional distress.

Museums are using virtual tours to help guide people through exhibitions and present information tailored to their interests. In a paper by de Almeida and Yokoi [50] they describe the use of virtual tours with museums where, for example, each room of XVI Portuguese ship is used and visited in a pre-defined sequence. Bastanar [53] is quite clear that virtual tours constructed from 360 degree panoramic images are being used extensively all over the world.

The High Street Stories website [73] has a large number of click-able images that link through to a particular aspect of the history of the High Street precinct. It is simply a repository of stories describing the precinct’s unique history. The Canterbury earthquakes destroyed the Victorian and Edwardian environment leaving no choice but to demolish most of these buildings. High Street Stories also contains content material about the people that lived and worked in this particular location in the city. The relevance to this research [27] is that virtual tours can assist by providing a richer glimpse into the past in a very unique and interactive way. High Street stories can be enhanced by including virtual tours. As a consequence the research can learn how different stories can be effectively presented online with supporting material. The image in Figure 2.8 of High Street Stories content [74] is clickable and a link through to a particular story. The reader just needs to scroll down to see the other story images.

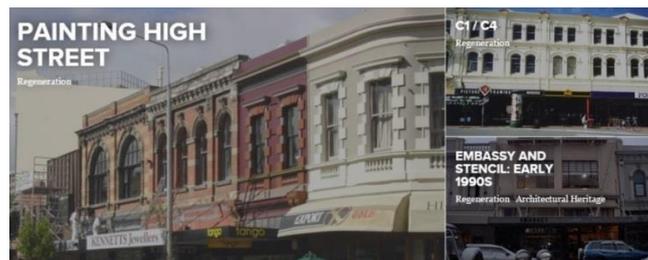


Figure 2.4: High Street Stories interactive elements linking to a particular story.

Virtual tours can be extremely popular in the real estate industry. Applications, such as floor plans, which show hotspots that link to a virtual tour of the property, and have arrows that can be clicked on are excellent online marketing tools. Virtual tours tend to cost more than still photography to produce, so they are not used that often. However, for commercial buildings and top-end real estate, they are the perfect tool for accurately showing overseas clients what is being sold.

A specific application that Real Estate has used virtual tours for is to spectacularly display their show homes online. A series of virtual tours linked by hotspots can create a virtual walk through. This is a very effective way of showing a customer around a new home. Other customisations possible with the virtual tours and real estate are the inclusion of hotspots linking to other files. For example in Figure 2.9 a show home added two small house icons to the sky in the exterior view virtual tour of the house. When clicked these icons opened PDF files. One file was pricing information and the other file was a plan and technical specifications on the show home. The image of Figure 2.9 shows a loading bar, thumbnail icons of each interior room, a yellow circular hotspot, the two PDF links floating in the sky and a tab left middle for a Google map.



Figure 2.5: Virtual Tours with Norton Show Homes. [75]

Virtual walk throughs are a specialised application suitable for any business wishing to show its online customers about its location. With the specialised software that is available today, customisation of a walkthrough can be much more realistic than in the past. Kolor have taken this process a step further by producing a 360° virtual video. This product stitches together video streams taken from a cluster of small cameras set in a cube. So, when synched together, the video streams overlap and can be stitched together to form a 360° video walk through. When clicked, the images in Figure 2.10 open a 360 degree virtual video.

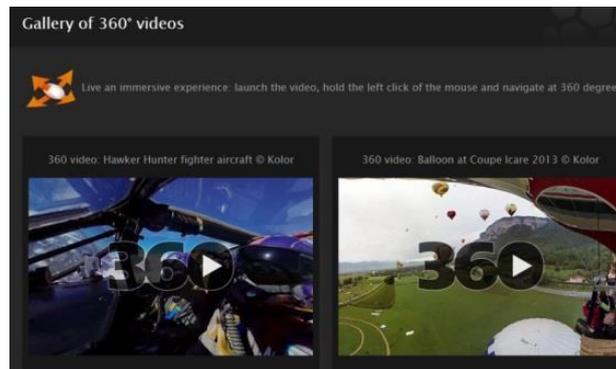


Figure 2.6: Kolor’s 360 Virtual Video Tours

Virtual tours are also available off-line because some companies produce off-line software to play virtual tours on a computer or a mobile device. They are simple and easy to operate, whereby the virtual tour digital file is dragged and dropped onto the player. The only restriction is the ability to create these files, which still requires specialised software; however, they are useful if the mobile device being used does not currently have Wi-Fi network access. Kolor’s Panotour Viewer [76] is a free application where offline virtual tour files can viewed on a computer. It is possible to open virtual tours from PowerPoint [77] by creating a direct offline link to the virtual tour’s html file which is sitting in a folder on the desktop.

2.5 Mobile Virtual Tour Applications

There are a number of virtual tour applications that have been developed for mobile devices that show how users can view and interact with virtual tour content in a mobile setting. For example, CityViewAR [1] is a mobile augmented reality (AR) application that allows people to see how Christchurch was before the earthquakes and building demolitions. Using an Android [63] or iOS [64] mobile phone, people can walk around the city, view life-sized virtual models of the buildings before demolition, and read about the history of each of the different locations. The application uses GPS and compass sensors in the mobile phone to enable virtual information to be overlaid on live video of the real world.



Figure 2.7: CityViewAR interface looking towards where the Zetland Hotel once stood.

The CityViewAR user interface has several ways of viewing information; (1) a list view, showing a list of buildings, (2) a map view, showing points of interest on a map, (3) an AR view showing virtual information superimposed over a live video view, and (4) a panorama view showing immersive panorama imagery.



Figure 2.8 (a) CityViewAR menu



Figure 2.9 (b) Aerial location view

Figures 2.8 (a) and (b). CityViewAR's menu system and an AR aerial view

The panorama view is launched by selecting panorama icons on the map view. Once launched users can rotate the panorama by either using swipe gestures on the screen, or by moving the mobile device itself. They can also pinch to zoom the panorama image, and select an icon on the screen to return to the map view.

A user study was conducted in which participants were asked to write down their preferences about what feature of the application they liked the most in regards to the three views of panorama, map and AR. Participants were divided into two groups, one which has access to the AR view and one which didn't. In both groups, a significant proportion liked the panorama view and the people who viewed the panorama pictures used the application longer. For example in the AR group this was just over 21% and for the non-AR group it was just over 62%.

Common problems that users experienced with the application were also discussed and included glare on the screen and unintentional button operation by inadvertently touching the screen. In some cell phones a magnet was placed near the phone compass within the body of the cell phone, thereby decreasing accuracy of the geo positioning.

Another example of a virtual tour on a mobile device is the AntarcticAR application [28]. The user interaction with Antarctica AR is via the mobile interface where users get to touch and choose the application making decisions on how they will explore the locations. It is a user centered journey where the engagement with the mobile interface teaches the user about the Antarctica.

A virtual tour on a mobile device needs to accommodate the different locations possible in an outdoor environment. AntarcticAR [28] uses a mission start, mission in progress and mission end as methods to accomplish this level of organisation. The research for the Red Zone will need to organise the virtual tours into locations and then organise the locations into a time line which is a comparative level of organisational requirement to make it useable online.

Virtual tours can also be included in mobile Augmented Reality (AR) browser software applications, such as Junaio [59] to improve its functionality. Junaio [72] is an augmented reality browser capable of producing effective, visual augmented reality projects. It uses channels to establish the type of AR it produces. Junaio supports virtual tours with its location-based channel.

The virtual tours, which are viewed through the camera of the mobile device, are geo-located to locations within a locality and augmented reality virtual “balloons” can be touched to open a virtual tour of the location, thus creating a virtual walking tour of the location (e.g. Google Maps). When the virtual “balloons” are touched a dialogue box with a thumbnail image pops open. The text within this dialogue box can be hyperlinked to open any URL. In the situation in Figure 2.7 the geo-localized balloons open the Junaio dialogue box that uses anchor text to open the virtual tours in a new window Junaio supports virtual tours with its user interface. The photo of Figure 2.7 is taken through a Samsung galaxy tablet shows augmented reality balloons with their information tags appearing in the live camera view.



Figure 2.9: Augmented reality balloons in Junaio on a Samsung tablet Galaxy S.

The user interface experience is always appealing as it brings the geo-located venue into full view and provides direct visual information of what the user can expect to see. This is a distinct advantage when trying to locate, for example, a business.

Another way of experiencing virtual tours on a mobile device is through using a mobile version of a website. For example, Time Lens [69] is a website that is also available as an iPad or iPhone mobile application. It displays a number of 360 panoramas plus other information on line. It is another way to use panoramas [8] on line. The panoramas display how the older suburbs with buildings that need extensive repairs and maintenance can be bought by wealthier people and then renovated. As a result the property values improve and this makes profits for investors. The reason for using panoramas with this application is to provide the viewer the experience of being on location without actually being there. The inclusion of actual stories from the homeless people who have been evicted from their homes as a result of this process has been included to add richness to experience. Figure 2.6 shows the Time Lens landing page. The description details the documenting of the rapid gentrification of urban neighbourhood and Philadelphia. Time Lens takes past panoramas and presents them as virtual tours through any iOS mobile device. Users can interact with the past virtual tour while being there in the present.

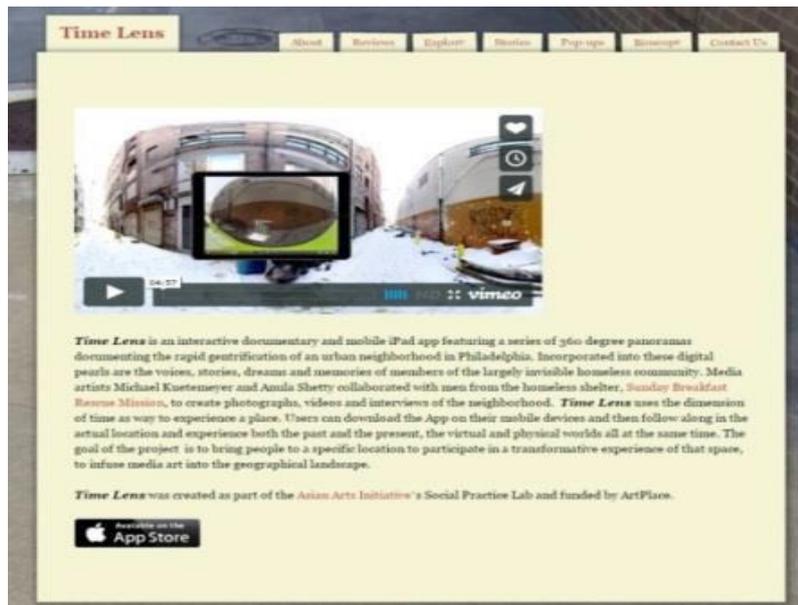


Figure 2.10: Time Lens

From these examples, we can see that there is some important common design features required for an effective user interface. These will need to be taken into consideration when the Red Zone products are fully developed. These include:

- Include compelling content.
- Build the application around the content.
- Ensure there is a map view for navigation.
- Allow people to use both touch and device motion to interaction with the panorama.
- High quality imagery.
- Interactive character and or an online mechanism to display information.
- A real world experience.
- Simple navigation.

2.6 Summary

In this chapter we have summarized related work from research and commercial sources in virtual tours, in desktop and mobile experiences. We found that overall there has been little evaluation of different types of user interfaces for virtual tours. The research that has been conducted has shown that users prefer using maps to navigation between virtual tours and mouse interaction on the screen for changing viewpoint orientation. For mobile devices it is common to rotate the device to change view into panoramas. In those applications that combine AR views with panorama views, the panorama has been one of the user's favourite features. The research has also shown that user performance measures and subjective surveys are an effective way to evaluate virtual tours.

Compared to this earlier work, one of the unique elements of our research is that a more rigorous user study evaluating the individual elements of a web based virtual tour interface can be conducted. This means user feedback can be collected from different interface layout options of the virtual tour interface.

In the next chapter a more detailed description on how virtual tours can be created is provided, and then in Chapters 4 and 5 show how the lessons learned from researching related work can be used to create virtual tour prototypes for user testing.

Chapter 3: Creating Virtual Tours

Virtual tours cannot be made without taking still images. The beginning of creating any virtual tours starts with a photo taking exercise on location. It is therefore important to understand the photography processes behind creating the virtual tours. The availability of the hardware and software for the initial still photography makes this research possible. Therefore, a background in understanding the image collection process is important to understanding the development of the Red Zone mobile application.

When still images for the virtual tours are taken, it is important to ensure that the exposure of the different images is consistent. If the image exposures are inconsistent then areas of shade and of brightness will appear in the stitched image. In order to avoid this problem, the camera operates in manual mode so that all images are equally exposed. This means that the photographer operating the camera must be proficient in taking photos and have an understanding of the following: f-stop, aperture, shutter speed, and focus. Without correctly balancing these variables, the resulting images are likely to be overexposed, underexposed, and/or lack the depth of field needed to use the zoom capability of the virtual tour.

To create high-quality imagery, it is useful to be experienced with photographic composition. There are some general guidelines for proper photographic composition which should be reviewed to ensure the quality of the imagery, particularly if it is required for any commercial application.

These general guidelines can be summarised simply by stating that a photographer should take a photograph of the subject material from an interesting perspective and ensure that there is no unwanted material in the final photo. The most important guideline is the KISS principle which means: *“Keep It Simple Stupid.”* Simplicity is the key to creating a superb image

3.1 Equipment

The equipment used to produce a virtual tour includes a high quality SLR camera, a wide-angle lens, a panoramic rotating head, a stable tripod, and a leveler. The camera must be able to capture a complete 360° by 180° image. In order to perform this crucial step, the camera must rotate in all directions so that it can capture a complete sphere from the point at which it is positioned. The requirement of photo stitching means that all the photos must overlap by at least 30%. If this minimum criterion is achieved, then a seamless virtual tour is likely to be produced.

The virtual tour imagery taken of the CBD Red Zone was captured using the following:

- Nikon D 7000 SLR camera
- Nodal Ninja panoramic rotating head
- Manfrotto tripod
- Nikon 10.5 mm fisheye lens
- Spirit leveler

The equipment above is the minimum requirement to produce high-quality virtual tour images. The Nikon camera provides the technical capability and programmability to efficiently take a series of virtual tours. The Nikon 10.5 mm fisheye lens provides the ability to overlap images by at least 30%, and it is a high quality lens that produces excellent imagery. The Nodal Ninja panoramic rotating head provides the user with the ability to accurately locate the camera lens in different positions, to ensure a complete spherical image, and

ensure that the lens rotates over the nodal point. The Manfrotto tripod was selected because of its ability to provide a stable platform for the camera and the panoramic head. The spirit level leveler was used to ensure that there was no deviation from the central axis running through the nodal point. This avoids parallax errors in the final stitched image.

There are other more sophisticated, programmable motor drives that can automate the process, but those are more often used when movement is involved in taking the photos for virtual tours. More sophisticated, programmable motor drives are, however, a requirement should the photographer wish to take gigapixel images.

3.2 Photographic Process

Virtual tours are created from stitching photographic still images together. The process requires specialised equipment and software to produce the final product. It is not absolutely essential, but some knowledge of HTML5 is helpful for presenting virtual tours online. Should the designer want to customise any website with virtual tours then knowledge of PHP, XML, and CSS3 coding is useful. However, some of the available modern software for creating virtual tours contains comprehensive plug-in libraries for optional customisation of the web product that will be viewed.

The equipment required is a very steady tripod with a panoramic rotating head mounted on a tripod. The panoramic head can be manually moved by the photographer or an automated motor drive could be operated through a remote control. When virtual tour imagery is taken, the rotating head is moved a set number of degrees both angled up and down in order to cover the inside of the sphere. These control points are identical places in both images and align the overlapping regions. After collecting sufficiently overlapping images of the inner surface of an entire sphere, a complete spherical image can then be stitched together.

To ensure that adequate image overlap is obtained, a wide-angle lens is used to ensure that a high quality virtual tour is produced. The camera required to take these images needs to be of high quality and needs to be at least 16 megapixels. The camera also needs the ability to be operated through a cable if the photographer wishes to take high resolution gigapixel images. Given that a single virtual tour may include over 100 images needing to be stitched together, a camera operated through a cable allows for more efficient collection.

Collecting the imagery required for gigapixel virtual tours by manually moving the panoramic head becomes practically impossible. There are several problems encountered when trying to collect virtual tour imagery by manually moving the camera. First, moving the camera into at least 100 positions accurately is next to impossible. Second, manually operated panoramic heads are not calibrated to this level of accuracy. Thus, a programmable motor drive that is capable of rotating the camera into the number of positions required accurately is vital to the project. For gigapixel virtual tours, Figure 3.1 shows one possible set up of the equipment that will produce a completely spherical image.

The final stage in the development of the virtual tours is to import the 360° by 180° images into the software that allows the user to build a virtual tour console.

An important aspect of taking the imagery for any virtual tour is determining whether parallax errors are being created. Parallax is the apparent change in the position of an object relative to the where the observer is positioned as they move position. This means should parallax errors arise it will cause photo stitching problems to occur, such as straight or curved lines being broken by the breaking and shifting of the lines. To avoid the creation of parallax errors, all cameras need to be calibrated to the nodal

point. The nodal point is where the light passes through the iris and is the center of the lens. When the camera is rotating through a central axis any objects in the distance do not shift their perceived location, which is due to the parallax errors.



Figure 3.1: A programmable motor drive from Roundshot [79] mounted on a motor driven rotating head.

The equipment shown in Figure 3.1 can move the camera up and down and make a complete horizontal circle. It is most efficient for taking gigapixel imagery to create high resolution virtual tours.

Once the photos are stitched together to form a 360° by 180° panoramic still image (see figure 3.2 for an example), the next stage is to import the still image into the virtual tour software. It is worth noting that Adobe Photoshop has the ability to stitch photos together, and they can then be used to create the virtual tours.



Figure 3.2: A 360 by 180 degree panoramic still image of Murder Mystery.

This image in Figure 3.2 was taken at Ferrymeade in January 2014 just before the evening's live show.

3.3 Photo Stitching Software

To create a 360° by 180° image on the desktop simply requires the use of Adobe Photoshop. If photo stitching is to be carried out using Adobe Photoshop [80], then camera images need to be imported in the RAW format. In Adobe Photoshop CS6 and above, Camera Raw is no longer a plug-in, but is now embedded in the software package. Camera Raw is an essential first step for editing photos for stitching purposes. It allows the user to adjust the white balance and exposure evenly over a large number of photos. There are a number of other toolbar features, such as clarity, vibrance, and colour balance that the user can also use to most effectively adjust a large number of images.

If further editing is required due to stitching errors caused by parallax errors then Photoshop's toolbar array would be able to fix most issues or problems with an image. The actual processing of an image in Adobe Photoshop is beyond the scope of this research. From experience all high-quality 360° by 180° images require double-checking in Adobe Photoshop to identify any incorrect stitching areas, and any compositional problems e.g. light flare before the photo stitching process to a virtual tour is initiated.

Photoshop retains the ability to easily remove colour aberrations caused by different wavelength frequencies present in the white light, which results in the recognition of slightly different focal points. It is also useful for removing vignettes, which is caused by the shading that can occur when differently exposed images are stitched together. It is also possible to correct the stitching errors caused by the camera lenses not being directly over the nodal point.

A number of other platforms that can process 360° by 180° panoramic images into virtual tours are available. The more popular platforms are Easypano [81], 3Dvista [82], Kolor [83], and PTGui [84]. To better understand how these platforms operate, I will briefly review the user interfaces for each of these products.

PTGui's User Interface in Figure 3.3 shows the window for uploading image files from a camera and the panorama editor. PTGui does not specialise in making virtual tours from stitched images. It has a large amount of tools available to manipulate the panoramic imagery. It can export files as formats that can then be easily imported into other virtual tour software packages. It is capable of producing its own stitched images from file sizes as large as gigabytes. These images require no compression and need to be supplied in RAW format from the camera. PTGui uses its own stitching processes and can be extremely useful for producing panoramic imagery that needs to be printed on large paper (e.g. 3 m in length and 2 m in height).

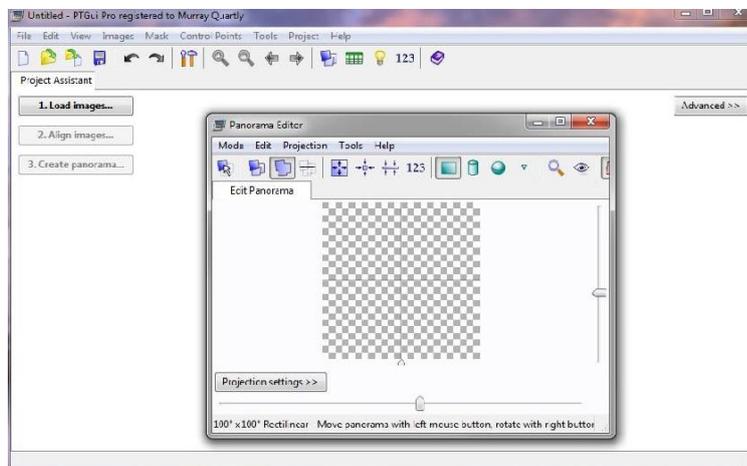


Figure 3.5: PTgui's interface

3-D Vista produces a tidy product which creates high quality, professional imagery. The interface is well-organised and places the 360 by 180degree still images in a group on the left-hand menu, which allows the user to see them all at once. This function is a real advantage when creating a full virtual tour console using a collection of 360 by 180 degree still images. One excellent feature of 3-D Vista’s virtual tour software is the HDR (high dynamic range) process. This process allows a room to change exposure as the virtual tour moves from a dark area in the room to a bright window.

All of the above platforms now allow the exporting of the virtual tours as HTML5. It is important to ensure that the virtual tours are iOS and Android compatible. Given the move to wearable technologies and mobile devices, exporting the virtual tours as HTML5 makes them viewable across all platforms. The virtual tours currently produced by Focus360 Virtual Realities Ltd. use HTML5 and so are compatible with all mobile platforms, and are mobile responsive.

To visually illustrate how a virtual tour appears online, the following diagram represents a standard virtual console with a thumbnail array already made by Focus360 Virtual Realities Ltd.

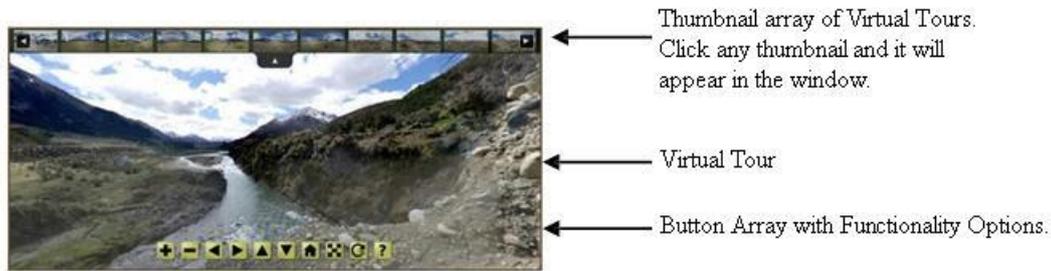


Figure 3.3: Sample Virtual Tour: St James Cycle Trail, Nov 2012

Figure 3.4 is the McArthur Bridge location approximately half way around the cycle trail looking north towards Saddle Spur. The workflow for the entire photo stitching software is similar. The first step is to go on location and take the photos. It is recommended to retain quality images in the RAW format. The next step is to use photo stitching software to assemble the images into 360 by 180 degree still images. At this point in the process, it is important to check the stitching quality by viewing the images in Adobe Photoshop. Any observed stitching errors can be corrected using the Adobe Photoshop editing tools. Finally, the panoramic still images are uploaded to the virtual tour software; the user customizes the virtual tour accordingly and exports it as a HTML5 file format that is suitable for publication on the web.

The existing technologies have slowly been built on existing frameworks by improving the technical capabilities and expanding the range of features the user can incorporate within the virtual tours. The latest software upgrades make it possible to now export virtual tours written in HTML5. This makes it possible to run virtual tours in both the iOS and Android mobile device platforms. The development became available on the commercial market approximately 18 months ago. Prior to this, it was only available as an Adobe Flash product.

A number of additional features were included in the new, commercially available products for purchase. For example, 3-D Vista [82] added a new feature, LIVE HDR, which changes the exposure of a room or a view. HDR (high dynamic range) alters the exposure to suit the brightness of the view. To compare photo-stitching software a comprehensive table of companies and products can be found on Wikipedia, Comparison of Photo Stitching Software [85].

Chapter 4: Design

4.1 Potential User Groups

Deciding the target user groups was an important first step in the Interaction Design process. Based on the people Focus360 had sold virtual tours to in the recent past, a list was drawn up. This list included the following:

- The George. The George was approached as it is a customer of Focus360 and they were the only hotel open after the earthquakes in the CBD. Even though they supported the research they felt that there was no need to be involved. They have a policy to not include external businesses or organisations with having a presence on their website.
- The Commodore Airport Hotel is a major supporter and will be involved in any final product. They are always looking for external ways to market the hotel now that they have left the Millennium group.
- Infinity Wanaka. A good supporter as they are looking for innovative ways to promote their company.
- The Canterbury Museum. The needs of the museum are that they are wishing to continue to promote the Quake Cities Exhibition. A firm supporter of the research.
- University of Canterbury's Quake Studies office. The Quake Studies Office has always been enthusiastic to have the tours included in the digital archive. These tours create a rich resource for the future.

4.2 Interaction Design Process

An Interaction Design process was chosen to research and evaluate the optimal user interface for displaying virtual tours online. This involved iteratively cycling through three main phases of (1) Discover, (2) Design and (3) Evaluate (see figure 4.1). This methodology is one of reflection on qualitative and quantitative feedback received after users groups interact with the prototypes produced during the iteration process. The iteration process moved from a rapid prototype to a low fidelity prototype and then through to a high fidelity prototype finally ending with a formal user study. In this chapter we discuss the Discover phases and User Needs Assessment. In Chapter 5 we present the Design work we completed and the prototypes developed, and finally in Chapter 7 we describe the Usability Evaluation conducted.

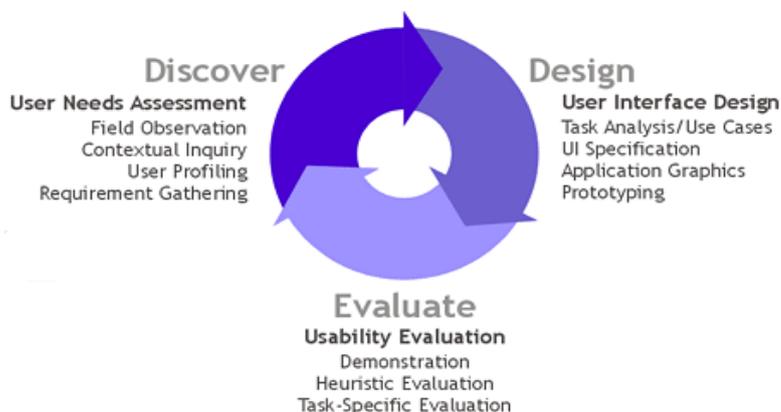


Figure 4.1 The Interaction Design process followed.

Data from this Interaction Design process will inform how the final user study is structured. The desired outcome is to determine the requirements of the user study and then the design of the mobile application. It is important to provide a variety of different presentation methodologies in the user study to ensure sufficiency and validity so that the final design is the preferred design. The quantitative and qualitative outcomes of the user study will provide the understandings for the preferred design and functionality of the final mobile application. Based on these results from the user study, the final design will be presented.

During the Interaction Design process user feedback was collected to allow the design to move from a low fidelity prototype through to a high fidelity prototype, finally ending with a formal user study. Each of the iterations improved in fidelity and required a mock-up that had a greater degree of functionality. The prototyping and design changes occur at the conclusion of each of the iterations.

Initially, the Pop app was used to build a low fidelity interface by photographing pieces of paper with a cell phone and creating hyperlinks between the images. Verbal feedback from this iteration was used to create the design of the second iteration. With the second iteration a Joomla website was built so that participants could view and interact with the virtual tours on their mobile device. Written and verbal feedback was provided by supplying the prototype URL via email and then questioning participants directly or asking them to email their comments. Finally, an Axure high fidelity prototype was developed, as the third iteration, and supplied to user groups that had been identified e.g. the Canterbury Museum. The prototype was loaded to a server and an online prototype was provided as an email link or shown directly to the participants. Email responses and written feedback provided the evidence that determined the structure of the user study.

Using this iterative design process has meant that the final design would provide a rich educational experience as well as a visually interactive and engaging activity. The data collected from the environment, iterations and participants are all based around this interaction design process. It is therefore possible to evaluate and then view the best functionality and design that promotes interaction with the virtual tours through any mobile application.

The final user study was the most comprehensive iteration where qualitative and quantitative data was collected, by allowing participants to directly interface with a PC monitor in a user-centered experience. The interactions are recorded on paper designed to record responses as the participant worked through a series of exercises using a native application built for the task.

All feedback was recorded, reflected upon and conclusions drawn from the data. For the final mobile application design all quantitative data was analysed using SPSS statistical software whereas the qualitative data was analysed thematically using key word or key phrase searches. The interaction design process was carried out in each of the four iterations. This ensured that final mobile design was the most preferred application.

The final stage for design, being a user study, would take all the evidence from the iterations to produce a native application and carry out a quantitative and qualitative user study. Results would be statistically analysed and the final research outcomes are used to design the mobile application. Qualitative and quantitative data from the user study was used to determine the design and layout of the final product. One important outcome from the first three iterations was that there was a need to be different presentation formats available for the participants. There are a number of ways to present virtual tours online and the anecdotal feedback obtained from discussions with the user groups did not point to anything specific because accept that there is a wide variety of available options. However, it was clear from the user feedback that the user study should offer in the user survey specific presentation formats so that their answers could be properly quantified.

4.3 Needs analysis

For the needs analysis, a number of interviews were conducted with a variety of people from the target user groups e.g. Museum staff, hotel management, etc.

For the needs analysis the Commodore Hotel provided 2 staff members, being a senior manager and the IT specialist. The Canterbury Museum provided 7 staff across a range of job titles from the Curator of Modern Social History to the Exhibitions Manager. The Quake Studies office provided all the staff in the office available on the day totaling 4 people. There 6 people asked from friends and family.

In general they were all asked what features they would like to see with a Red Zone mobile product that displays virtual tours online. Each group was asked the same questions and these were:

- Should a map be included?
- Should full screen be included?
- Does it need to be a rich source of information?
- Can you see how the existing buildings looked before the earthquakes?
- How will it be available electronically?
- How can people contribute and use the resource?
- How should all the virtual tours be presented online?

The main lessons learned from the from the user feedback are as follows: That the design needs to represent the flow of virtual tour information within a mobile application. A possible flow of information within the design for the interactive viewing console, the mobile device and the content is illustrated in Figure 4.3.

These findings were used to inform how the prototype would be designed. It also meant that that the development of this prototype would require the ability to hyperlink different screens. The functionality of the initial concept discussed is represented in figure 4.3.

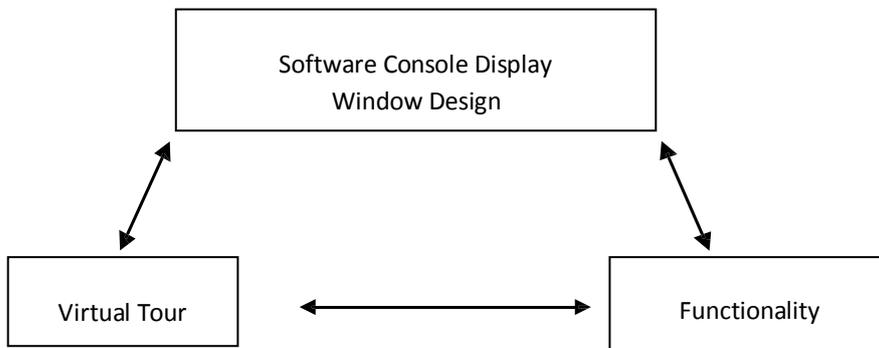


Figure 4.2: Initial concept diagram of the design, content and functionality.

The people that were asked in the needs analysis had at least seen some virtual tours online. All of them liked the virtual tours and saw it as a very good way to display visual imagery effectively. Not directly quoting him but the Assistant Manager at the Commodore Airport Hotel said he really likes the virtual tours to display the facilities as he receives positive feedback about their quality and usefulness to showcase special areas. The Museum staff saw them as a fantastic way to preserve modern social history. Friends and family all said they are useful to remember what buildings were there as they had forgotten.

The needs analysis provided the platform to decide how to establish the process for the first iteration being rapid prototyping. There needed to be hyperlinking capabilities to establish a flow and it needed to be a quick and interactive to engage users. To ensure quick prototyping with minimal time required it was decided the Pop app would be a suitable platform.

Chapter 5: Design Iterations

5.1 Rapid Prototyping

The initial interface concept was developed using the POP [87] rapid prototyping tool. The purpose of the first iteration was to assess the user preferences for the design of the type of software that is being developed. The POP application can use a smart phone's camera to take pictures of interface sketches (see Figure 5.1). These can then be linked together and viewed on a mobile phone, so it provides an opportunity to rapidly produce a prototype using handwritten bits of paper. The functionality of these links is able to show flow from one feature to another. By photographing the paper the app is able to create hyperlinks and produce an electronically available demonstration.



Figure 5.1: POP application home page from June 2014

5.2 POP Application Rapid Prototyping

The purpose of the first iteration was to assess the user preferences for the design of the first prototype. The first iteration was merely a rapidly produced prototype, but it provided the initial flowchart software design, which was shown to members of the user study groups for the purpose of getting their input. Figure 5.2 show the initial sketches of the virtual tour interface, highlighting the links between interface screens that are quickly created from handwritten notes and incorporated into prototype. This initial design was based on the touch screen interface previously used to show virtual tours in the Museum's Quake City exhibition.

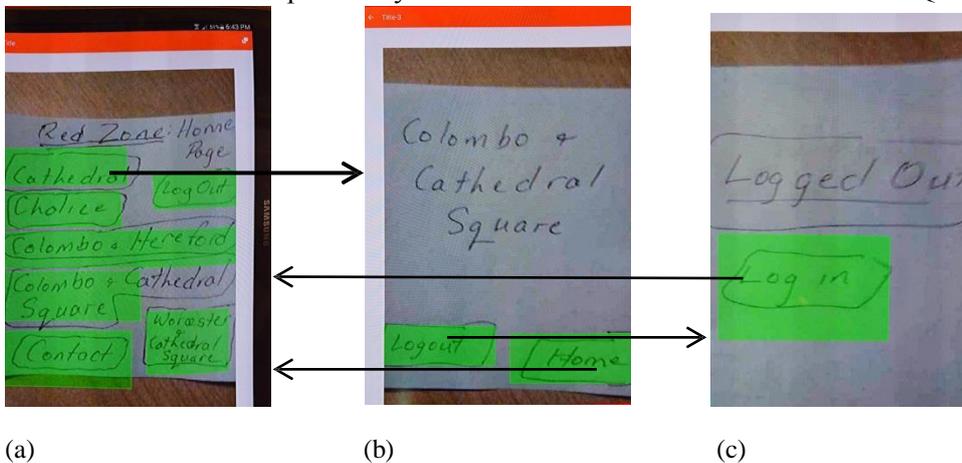


Figure 5.2: a, b, c, POP app figures show the hyperlinks in Green.

Screen 5.2 (a) show the titles for the Red Zone CBD locations where the virtual tours were taken e.g. Colombo and Cathedral Square. Screen 5.2 (b) is intended to represent the virtual tours taken at that particular location. The final screen 5.2 (c) is included to highlight the requirement of functionality requirements.

The above figures show the hyperlinks between interface screens highlighted in green. For example, by tapping on the Colombo and Cathedral Square highlighted words in Figure: 5.2a, the POP application links to the next screen that is shown in Figure 5.2b. There is a home button available which takes the user back to Figure a. This figure represents only one sample as additional locations were added to the actual working demonstration. It must be noted that the green highlighting does not appear in the working demonstration.

To construct and evaluate these concept designs, the user groups were consulted again and shown the flowchart and sketch prototype produced using the POP application. By showing this to the interested potential users, it was found that the sketch prototype was an extremely effective way to show how the application could be constructed. This rapid prototyping provided on-the-spot opportunities to adjust the design. The user groups being: staff from the Canterbury Museum, the Commodore Airport Hotel in Christchurch, the Canterbury Earthquake recovery Authority (CERA) and Quake Studies plus friends and family, were supplied with the URL link, and asked to provide feedback on how they viewed the demonstration on a mobile phone. This was approximately the same amount of people with similar if not the same backgrounds as the needs analysis who gave feedback. In brief the staff at the Commodore Airport Hotel were in the hospitality industry, while the staff at the Canterbury Museum served the general public and tourism industry. There were other people that were shown the POP application, including my friends and family. Based on the opinions of this diverse range of people, a good impression of the initial prototype became apparent, while additional items to add to the application were also revealed.

The feedback obtained from the staff at the Canterbury Museum on was really quite positive towards the POP App as a prototyping tool. This iteration provided some specific, which included:

- The links were a great idea.
- Menus worked well.
- Location based organisation in menu system.
- Good to try it on the mobile phone.
- What a good idea for getting ideas quickly.
- How would you display the virtual tours?
- It would be good to see the actual virtual tours on the mobile phone.
- Organised functionality would be essential.
- Need to see an example of the whole system.

After discussions with 9 different people about the POP application, a list of inclusions became apparent. Design considerations from the user groups were then collated and the results are briefly summarised below:

- Location based is best.
- A picture is needed for the landing page.
- Put in a map.
- Include a menu system.

The following table provides some of the collated responses received when testing the Red Zone sketch interface prototype. The ticks indicate a preference, the crosses mean not preferred and the dash means not sure.

	Layout	Map	View	Interest and Update	Thumbnails	List	Comment
Participant one. Commodore Hotel	✓	X	✓	✓	-	-	Very cool!
Participant t two. Commodore Hotel	✓	x	✓	✓	x	✓	Great clarity and view.
Participant three. Museum staff	✓	X	✓	✓	-	✓	Can we have it now!
Participant four. CERA staff	✓	X	✓	✓	✓	✓	I like it!
Participant five. Infinity Wanaka	✓	-	✓	✓	✓	✓	Ooh, that's what it
Participant six. Museum Staff	✓	X	✓	✓	-	✓	This is fantastic!
Participant seven. Family	✓	✓	✓	✓	✓	✓	Like it!
Participant eight. Family	✓	✓	✓	✓	-	-	Very cool!
Participant nine. Family	✓	✓	✓	✓	-	-	That's nice!

Table 5.1 The responses from people for the Popp App prototype when asked to give their impressions of the sketch interface shown on the Samsung Mini III; see Figure 1.8.

By showing the low fidelity sketch prototype to a number of interested and potential users feedback could be gathered and a prototype with a higher fidelity could be created. This was an effective way to determine the best practices for the design and the layout for how the Red Zone virtual tour application would be constructed. The user interface evolved over time based on the feedback provided qualitatively from the participants in the user groups during the iteration process.

The POP application was useful because of its ability for a rapid response to the iteration process. The portability of the application was a considerable benefit and it confirmed that the concept of the menu system linking to virtual tours with this type of functionality could be used efficiently. However, the application did have its limitations. The first was that it could not show a true picture of what the end product would look like. Secondly, without sitting down and actually drawing out the layout, the user was lacking some details (such as being able to pan around the virtual tour images), which may give the wrong impression of the flow and functionality of the application to some people. The final limitation was that it could not be emailed out to people as a link. Due to these limitations it was decided to move to a higher fidelity prototyping tool, Flinto [88].

What would be more useful in the next iteration would be a higher fidelity product with the ability to show imagery online through a mobile application and have increased functionality. It was decided that the Flinto application would be suitable.

5.3 Flinto Prototyping

Based on the feedback from testing the Red Zone POP application prototype, a higher fidelity prototype could now be developed, with a sample of the virtual tours from four different locations. To do this we initially chose Flinto [88]. Flinto is prototyping software that has the capability of displaying images online and also creating menu systems with hyperlinks.

The following screenshots were taken from the Flinto prototype. The first image (figure 5.3) is the landing page with a pull down menu system and the second page (figure 5.4) is a 360 by 180 degree panoramic image of the Cathedral in Cathedral Square. The flow moves from menu system to panoramic image then back again to the menu system. The image in Figure 5.3 shows how a pull down menu can provide the dates for loading other panoramas taken at different times. Tap the date and the relevant image will then load.

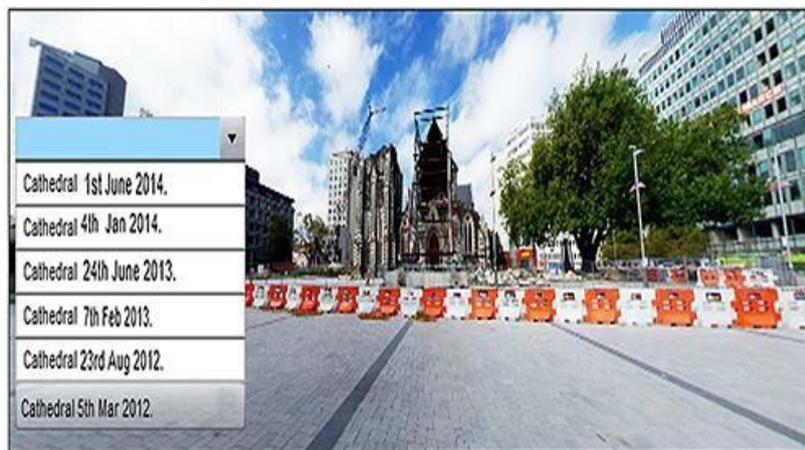


Figure 5.3: The location menu from the Flinto prototype was prepared.



Figure 5.4: A location image viewed with the Flinto prototype.

The quality of the imagery shown in Flinto was excellent, the hyperlinking from menu to screen location was efficient, and it was possible to send out the prototype as an email link, which was essential at this point in the iteration process for optimal efficiency. For example, figure 5.5 shows the different between the

POP and Flinto prototypes when showing the menu interface. However, Flinto was not able support interaction with the panorama images; it could only load 360 by 180 degree still images. With this limitation in mind it was decided not to continue with Flinto and to move on to developing a prototype that could run high quality virtual tours. This led us to develop a third prototype using the Joomla tool.



5.5 (a). POP App

5.5 (b). Flinto

Figure 5.5: The menu systems of the POP app (Low Fidelity) and Flinto (Higher Fidelity).

5.4 Joomla Website Demonstration.

The ability of the prototype to run high quality virtual tours was believed essential at this point in the research so that users in the study groups could accurately provide informed feedback. The users in the study needed to see the virtual tours functioning with a fully operating menu system. Consequently, a Joomla mobile responsive website was designed, which could also be sent out as a link to the people in the user study groups. With this creation of this Joomla website, all the functionality required to display both virtual tours and all the required capabilities could be specifically tailored for this online product.

A qualitative analysis was considered the next best option to progress in the iteration process. The following three user groups were selected simply because they expressed a keen interest in following this research:

- The Canterbury Museum
- University of Canterbury CEISMIC Quake Studies
- Pro Consulting Marketing

Design considerations were then considered and a Joomla [89] demonstration web site was constructed using Joomla 3.2 which is mobile responsive software and can be used to display the virtual tours. Joomla is an open source content management system (CMS) used to construct websites. After setting up a URL on a hosting server the free CMS Joomla software download is added to the public_html directory of the new installation. Once set up the content management system is available to add content and customize the front end of the website under construction.

A number of virtual tours were created for the following locations:

- The Christchurch Cathedral in Cathedral Square.
- The corner of Hereford Street and Colombo Street.
- The CBD site.
- Lichfield Street, High Street, and Manchester Street.

A website loaded to the Focus360 web server provided a way to demonstrate the improved functionality and prototype design as well as display the virtual tours online using a URL and HTML iframe code (see figure 5.5). The website shows the extensive damage caused to the Cathedral as a result of the February 22nd earthquake in 2011. The changes made between the POP sketches and Joomla implementation were a vast improvement in fidelity, functionality and the move to present the demonstration online. The Joomla prototype examples could be sent out to participants through email; a URL link to click enabled them to view a virtual tour.

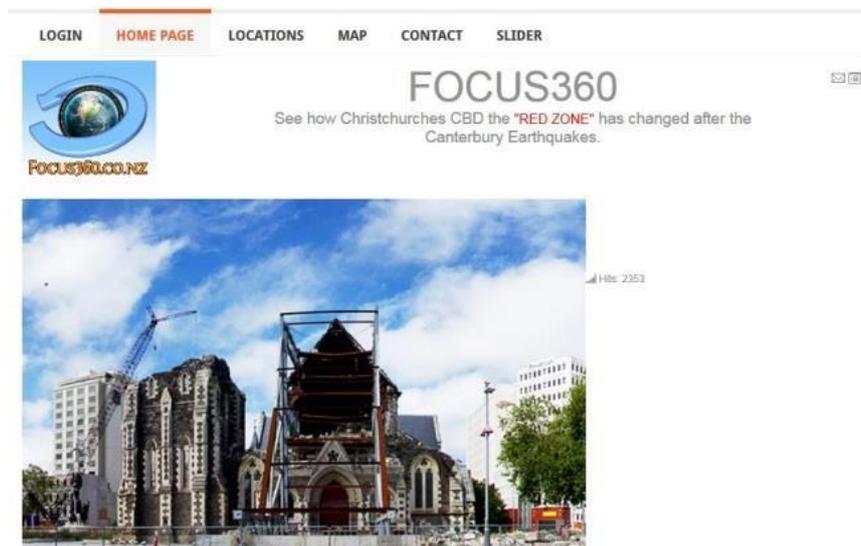


Figure 5.6: Cathedral on the 5th of March 2012.

The Joomla website is a web-based application; therefore, minimal HTML coding was needed. The only HTML coding that was required was mainly for the positioning, sizing, and framing of the virtual tours with iframes. PHP for the web [14] and CSS coding were not required. As a responsive website the demonstration became available as a link and was able to be presented on the mobile network. This provided greater flexibility to show people as well as providing a closer look and feel towards a more functional prototype.

Creation of the Joomla website provided the opportunity for users to give feedback without me having to be on location and talking directly to the potential end users. This proved to be a popular way to collect user feedback given that after 5 days the site had received well over 2000 hits. Feedback provided from Google Analytics showed that the hits were over 80% from New Zealand, approximately 8% from Australia and the remaining from a number of countries around the world including England, Canada, USA, Malaysia and Europe e.g. Germany and France. There appeared to be no significant preference for page or pages visited. The design discussed was said to that it needed to be clean, was simple to produce, and could be easily changed. This result was encouraging as it was evidence towards the potential popularity of the final products.

In addition to feedback through the website, meetings were held with several key groups and individuals. One key person was Patrick Roitiers a company director, lecturer in Marketing, and a business mentor for the Canterbury Development Corporation. He kindly sent the website example out to his business colleagues and contacts in other parts of the world. Meetings were held with key staff from the Canterbury Museum, and also the Quake Studies user group. Finally, Pro Consulting Marketing provided a summary of their feedback via an email from Mr. Patrick Roitiers, based on opinions collected from over 20 of his colleagues in Christchurch and from around the world. The key feedback from these contacts is provided below in tables 5.2, 5.3 and 5.4.

Pro- consulting Marketing	<ul style="list-style-type: none"> • A welcome screen with a tagline. • Info icons instead of text would be preferable as they are more universal. • Links added to Google maps. • Extensive historic photos, not virtual tours would add a deeper richer environment. • Landscape as well as the portrait view. • Footers should have a degree of transparency. • Top and bottom banners possibly interactive which could disappear after a few seconds or adapt colour production from video. • Full screen allowing the images to fill the mobile device window.
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Table 5.2: Feedback from Pro Consulting Marketing.

Table 5.2 provides the summary comments from Patrick Roitiers and his colleagues from Pro Consulting Marketing. A comment, but not a direct quote, from Patrick emphasizes the usefulness of the application:

“This fulfils a human need of being able to look back in time and remember what things once looked like.”

The staff at the Canterbury Museum was also surveyed at a meeting held in August 2014. There was four Canterbury Museum staff present, including the curator of Canterbury Social History. Results from their feedback are summarised in the table below:

Canterbury Museum	<ul style="list-style-type: none"> • Would be good to have more than one language. • Show the tourists where the toilets are on the map. • Don’t use Google maps because it is out of date. • Include pins to show locations. • In your own map which hyperlink to data. • Full screen panoramas. • Menu options need to be considered. • Swipe feature to move quickly between each virtual tour. • Themes can be created that are different. • Map with pins. • Ensure that the Virtual Tour windows are not cluttered with icons. • Agree that will or should have educational value. • Links to other information to enrich.
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Table 5.3: Canterbury Museum Feedback

Feedback summarised in table 5.4 is from the staff at the University of Canterbury Quake Studies office after being consulted in September 2014.

<p>QuakeStudies</p>	<ul style="list-style-type: none"> • On the landing page is there a need to have the image of a phone. Perhaps a button “saying start here”. • Consistency with topography. The CityViewAR font is Times New Roman whereas the rest of the app is Arial. • Reconsider title to and encapsulate more than the Red Zone. • Maybe in the statistical quantitative third iteration have some title choice options question. • Explanation and background as in Introduction. • Credits included. • The map needs its own page. • Button consistency. • Centre the pull down menu embedded in the virtual tour window. • Audio on off play button. • The bottom menu should be just functionality. • The branding should be in the footer • Its own white / grey footer. • No bullet points in Information and Audio. • Electronic options need to be considered. • Needs go back to Introduction [Site Overview page] being a central locus. • Same buttons and same font. • Consider “pop” up alerts.
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Table 5.4: Quake Studies Office Feedback

Other people expressed real interest in the Red Zone virtual tour application and were really quite impressed. A staff member at a local bank commented:

“Fantastic I’ll be able to show my mother in England!”

The user feedback is an invaluable resource to allow me to produce the highest fidelity prototype possible. An important point worth noting at the end of this iteration was that useful feedback may occur at any time, any place, from anyone. The Joomla iteration provided sufficient quality and specific feedback required to build the highest fidelity product possible. Features listed in the tables were taken into account when the final high fidelity prototype was constructed. Accurate demonstrations of the Red Zone application prototype sparked greater interest in the project and was now considered to be an essential product for the Canterbury Museum [92] and their tourism outreach.

5.5 High Fidelity Prototyping Using Axure

Based on user feedback collected from the Joomla website and the POP application demonstrations, it was necessary to create a working prototype with fully functional virtual tours. Upon investigation of several different software packages, the only software package which could display fully functional virtual tours online and show them correctly on mobile devices was Axure RP Pro [93]. Axure is especially advantageous because its platform is flexible and perfectly suitable for this type of prototype. For example, the Axure software contains design elements that make it very easy to rapidly create working user interface designs.

There are multiple product options available from Axure; however, the most suitable for this prototype development was the Axure RP Pro version. This is a wire framing software application that is used to make design prototypes. The software can take a user's ideas from an idea to a professionally prepared and fully functional prototype. This software provided me the ability to build a fully functional prototype that could properly run the Red Zone virtual tours online. For prototyping, it is essential to be able to show end users how the site and application will be viewed on mobile devices.

Axure RP Pro was used to create a professionally presented mobile responsive application. The image of a cell phone's exterior frame was imported into the software similar to that of the Motorola Defy. At this stage, a menu system was developed, a Google map created, and four pages with each one having a virtual tour of a particular location. Figure 5.7 shows the virtual tour interface being developed in Axure. Figure 5.8 shows the screen developed and the interaction flow between the screens that are possible when using Axure for prototyping. The arrows indicate the potential flow options that the user would need to freely and intuitively move around the application with ease. In this way, the application produced with the Axure RP Pro software was able to demonstrate the functionality of the high fidelity prototype.

The prototype was exported as HTML files and saved to a folder on the desktop. From there, the folder was loaded onto the Focus360 server and a URL was generated. Once the URLs were created, it was possible to let potential users know that this prototype was now worthy of consideration and to please provide as much feedback as possible.

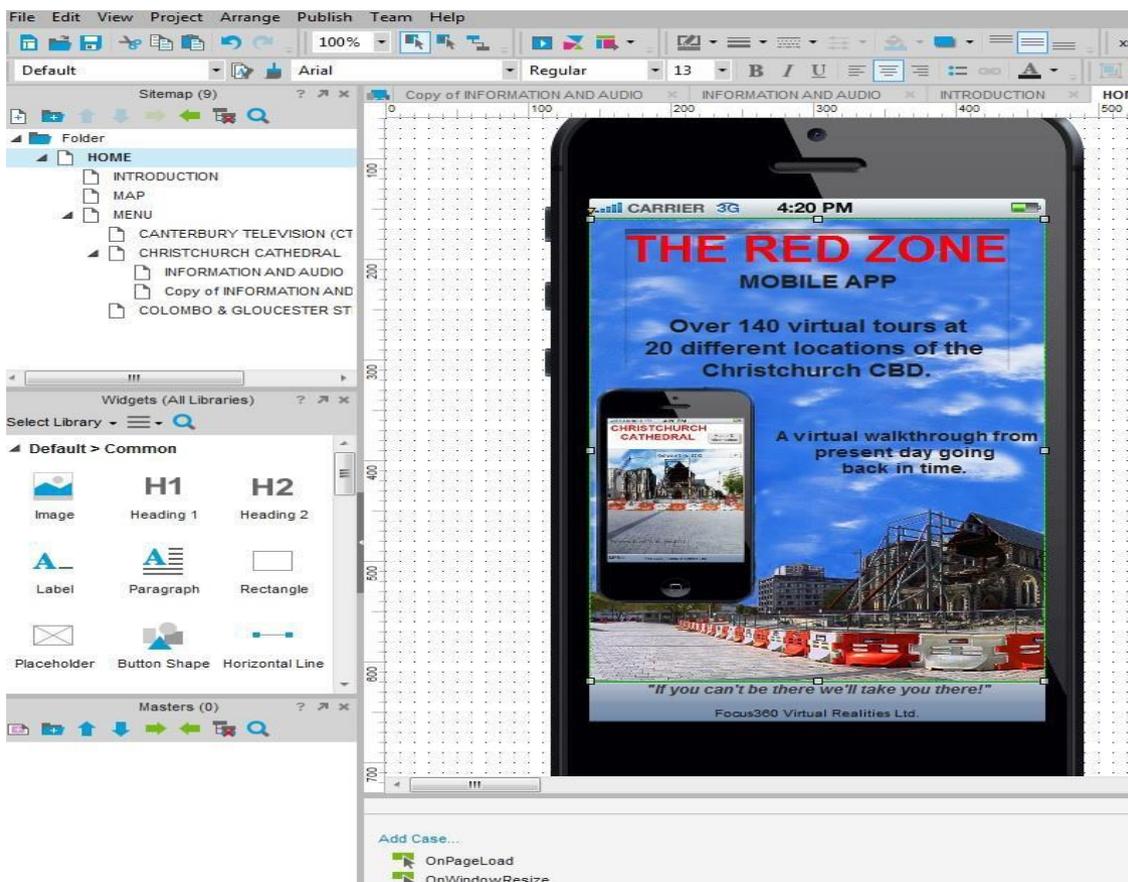


Figure 5.7: Axure development presentation for prototyping the mobile device.

Virtual Tours were able to automatically rotate upon loading through the Axure [93] software. For example, Figure 5.9 shows a virtual tour provided on the Canterbury Television (CTV) website, where the scene is automatically rotating slowly from left to right.



Figure 5.8: Screenshot of a rotating virtual tour in Axure.

To summarise, the fully functional prototype designed using the Axure RP Pro software was successful in providing end users the ability to observe some of the possible options for the Red Zone website and mobile application. Thus, people were able to easily test the functionality of the website and mobile application and provide invaluable feedback.

At this point in my research, most people were suggesting that the website and application needed to be rich environments that contained compelling content, were simple in design, and were functional across online and mobile devices.

The main lesson learned from the Axure prototype was that there were a number of different ways an application could be put together in terms of the design and layout. It was clear that there were a number of additional features that people wanted included in the application after the initial testing of the prototype; however, opinions sometimes differed with regards to the design and layout. For example, some people felt a menu system should launch the virtual tours, whereas others preferred a map to launch the virtual tours. It was also quite clear that a proper quantitative study was needed to statistically determine the preferred options.

As before, the Axure prototype was shown to the same user groups as in previous iterations and their feedback was obtained. Users were able to fully interact with virtual tours as they were rotating on their mobile device through the touch screen control. This meant the users could swipe and touch the interface. Virtual tours could be moved by swiping with a finger. They could also touch menu systems and links to navigate the application.

The overall feedback was collated and can be summed up in the following table:

Feedback	Example
Efficient to use	Responses indicated that people did not prefer a complex system with lots of clicks. Designing an interface as simple and functional as possible was considered a priority.
Simple design	The layout needed to be simple for a mobile device, particularly as there needed to be text and buttons which were easy to read and use. There seemed to be a preference for the use of Google maps.
Availability	Discussion occurred around the mobile device and mobile app. It was noted that to be available in the Play and App Stores there would need to be 2 apps written; iOS and Android. Consideration will be given to the development of a cross platform compatible jQuery app. However the app wouldn't be available in the Play and App stores.

Table 5.5: Summary of feedback from the Axure RP Pro produced prototype.

Feedback on the interface elements was quite definitive. Key inclusions were identified and these inclusions are summarised in the list provided below:

- A map would provide efficient navigation.
- Hover over buildings to pop up text and imagery information would be useful.
- A location based system which can be opened from pins embedded into a map.
- Audio if possible.
- Social media as an option.
- Mobile responsive.
- Old and new building images.
- A menu system of some form for the locations.
- Clear, sharp and good quality images.
- Virtual tour dates identified and locations clearly named.

Research was now at a point where a native application could now be developed. The overall themes of the feedback can now be taken into account, and a user study could be designed and carried out. A native application would be constructed which would enable a quantitative and qualitative analysis to be performed where the outcomes could be statistically validated. This application would need to be built using its own stylesheet and include a large number of virtual tours. It would need to present virtual tours online in a number of presentation formats and interface conditions that could be evaluated in a user study. In chapter 7 we describe this user evaluation in more detail.

The key lessons learned on user feedback was that several iteration steps were essential to gain sufficient understanding to develop the prototype through from a low fidelity to a high fidelity application. Secondly different user groups in different industries provided a wide variety of responses. This greatly assisted in refining the design particularly identifying the key features that should and needed to be included.

This chapter has presented the prototyping iteration process. This involved moving from rapid prototyping of a design using the POP App and a sketched interface through to the higher fidelity products of the Flintio and Joomla website prototypes. The final iteration step was the qualitative feedback received with regards to the high fidelity Axure prototype. Feedback from each of the prototypes developed was used to improve the next prototype, ensuring that the final version developed addressed as many of the user needs as possible. This then set the stage for a native application to be built which would create a platform to carry out a user study which could collect qualitative and quantitative data for statistical analysis. The educational value of the prototypes is worth investigating therefore the next chapter looks at the visual, audio and kinesthetic modalities and how these impact understanding and learning.

Chapter 6: Visual, Audio and Kinesthetic

Visual, audio, and kinesthetic are three of the senses by which people interact with the world. Sensory perception influences the way we interact with our environment. Kolb [24] states that active experimentation leads to a concrete experience, reflection based on observations, and finally a better understanding.

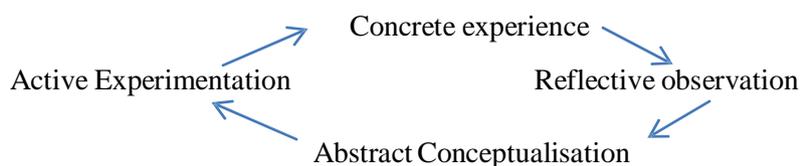


Figure 6.1: Sense Interactions, [25].

In relation to mobile devices learning styles are a combination of the individual's preferred approach Kolb[24]This suggests that the Red Zone mobile device needs to accommodate the different visual, audio, and kinesthetic styles of all mobile device users.

Concrete experience.

Users who require a concrete experience will want to receive information from others and require hands-on help with their experience. To include this in the design would mean that users need to actively engage in the interface. For example, when the users are on location they could see the changes to the CBD's buildings and at the same time view this on their mobile device. Pop up images of demolished building would reinforce those changes.

Active experimentation.

Users who prefer this type of experience, prefer working alone, using a hands-on approach, and explore the technical aspects of the interaction rather than interpersonal relationships. They also enjoy analogies and problem-solving. The design is influenced in a sense that it needs to be an interactive and engaging environment. This means that there needs to be a rich source of information and functionality. For example in the Red Zone it is possible to use a map with mouse over text in the virtual tours.

Reflective observation.

Someone who prefers reflective observation will enjoy a real-life experience and a discussion about their experience. They would rather be an observer of the experience, but appreciate the availability of additional background information to enhance their experience. The inclusion of background information such as text, audio, images would facilitate reflection through reviewing the material. For example, audio files of each location can be played as mp3 when a location is opened.

Abstract conceptualisation.

It is important for someone who likes abstract concepts to be presented with facts and theories in logical formats. For example, by organising the material into locations, launching virtual tours from menu systems or using a map to logically present the information. Text and building information and possibly scientific data would allow an opportunity to present content in a logical way to an abstract conceptualist.

There are three perceptual preferences for understanding and learning. In relation to mobile devices, the visual sensory input is intrinsic to the way any information would be displayed. The kinesthetic and auditory senses are certainly ways a user's experience on a mobile device can be enhanced. These three sensory imports are called learning modalities [25]. Depending on a user's preference these modalities will influence the way the user interacts with the mobile device. It is our thinking that everyone will be encouraged to use the mobile device application if they have an interest in viewing the demolition and subsequent rebuild of the CBD.

It is intended that all three of the sensory imports are included in the design of the final product because it will be necessary to facilitate learning and understanding for all users. Therefore, participants in the user study of the prototype interface will be questioned about their preference between the sensory imports of visual, audio, and kinesthetic.

We learn through the experience of active engagement. We tend to remember 90% of what we say and do, 70% of what we say, 50% of what we hear and see, 20% of what we hear and 10% of what we read [25]. Therefore our level of involvement moves from active doing through to passive receiving. To gain a real understanding and appreciation of the scale of the devastation that happened in the Red Zone it is important to ensure that any mobile device presents material in an active doing format. With regards to making this, and relating to a mobile device, we should consider simulating the real experience, doing the real thing, participating in discussion and seeing it done on location. Therefore the users who are able to go on location and view the virtual tours will have a much greater experience of understanding and learning. This has been described as a cone of learning by [33].

Kinesthetic and audio are ways in which we engage with the environment with our senses with a mobile device. There is evidence to support the statement that the more senses we use in any given situation the more we will learn and understand [24]. The mobile device is definitely visual so including as much interactivity would be of benefit to facilitate understanding.

Visual stimuli are provided through the tablet's screen, whereas audio needs to be recorded and uploaded as an mp3 file. Kinesthetic is commonly referred to as touch, and would be provided by gesture interaction with the mobile user interface.

This chapter presented how perceptions influence how people interact with environment Kolb [24] and therefore how it is important to include interactivity on the mobile application's design and functionality. The next chapter will look at evaluating the mobile application's interface through a user study which will quantitatively and qualitatively analyse the data to seek statistically valid outcomes.

Chapter 7: Interface Evaluation User Study

After developing the final prototype presented in Chapter 5, a series of four user studies were conducted. Each user study looked at different aspects of the quality of the user interface. The conditions being analysed were based on the conclusions acquired from the iteration process described in chapter five. The user studies are summarised below.

- *Experiment 1 – User Performance:* An operational efficiency task focusing on the user interface. This was a quantitative analysis where participants had been timed to find a small object that was part of the image in one of the four virtual tour conditions. Each condition had a timing exercise for the chosen locations. The goal of the study explored how quickly users could search through panoramic images with different interaction methods.
- *Experiment 2 – Design and Layout:* This was a design and layout experiment analysing participant perceptions. Participants were asked to comment on and record their preferences for different designs and layouts using Likert scales and noting down comments. Layout and design was based on results obtained from the iteration process. For example using a map or a menu design options.
- *Experiment 3 – Visual, Audio and Kinesthetic:* A task where participants had to show their preference for their learning modalities [25]. This was a study designed to explore visual, kinesthetic and audio aspects of the user interface.
- *Experiment 4 – Electronic Options:* An experiment to determine the preferred electronic options for virtual tour products, e.g. mobile app, website, which could be available online after being fully constructed.

The user study required an application where participants could engage with virtual tours to carry a timing exercise or other tasks. There were a number of other exercises that required an interface to access the presentation of text material as well as websites. This meant that an application was required to show the participants the different experimental conditions.

The user interface was designed as an application so that it ran from the and through a browser. The virtual tours were added as URL links and appeared within an iframe. Figure 7.1 shows the home page of the website used for the user testing. Buttons were added to ensure simple navigation and the sub menu linked directly to a particular experimental session.

All four experiments were carried out with each participant in one session which took approximately one and a half hours. A typed hard copy booklet was used to record the data. Confidentiality was assured through the normal and expected protocols of the research methodology.

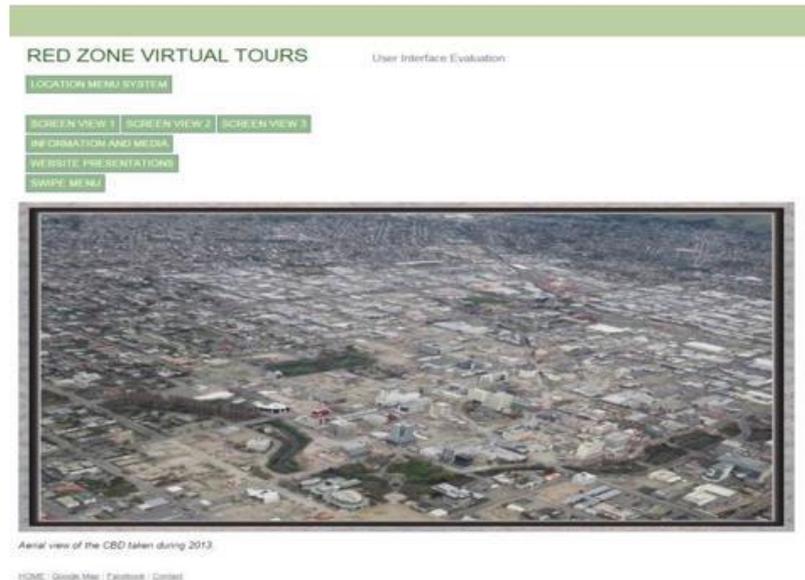


Figure 7.1: Home page of the native application used in the user study.

7.1 Experiment 1: User Performance

This experiment has two parts. Part one is the user performance where the efficiency and ease of use of the interface is researched. Part two is the investigation of a virtual tour slider. Virtual tours typically slide the panorama either left or right in response to a user swipe or mouse click input. This second part of the experiment investigates whether this swipe functionality and sliding nature of the virtual tours facilitates a better understanding of movement through time.

The sessions took about an hour to complete. Each participant was asked if they could give approximately an hour of their time and complete four sections of the user study. Along with the website a results booklet was created where participants could write their answers to qualitative and quantitative questions. Further explanation for each part of the experiment is provided below.

Part One: User Performance

The aim of the first part of experiment 1 was to evaluate the operational performance of four interface conditions and determine whether there is a difference in ease of use and efficiency. It is important to note that the interface was for selecting the different virtual tour images at a given location. The second part of experiment 1 was for the participant to interact with the computer and use the mouse to swipe and move a calibrated time line. The intention of this was to explore if the timescale better portrayed a progression through time.

Procedure

Participants involved in the user study recorded their results on paper as a hard copy. They used a web interface to the Virtual Tour loaded onto a desktop PC from the Focus360 server. The experiment was carried out in surroundings that were quiet and at a comfortable temperature. Each session took approximately 1 hour. There were 15 participants, 9 males and 6 females with an average age of 32.4 years. Of these, 7 participants stated they had previous experience with the virtual tours, 4 of these being male.

The first part of the experiment involved a timing exercise where participants were asked to find a small image within a virtual tour for each of the conditions. The time taken to find the image was then recorded. The second part involved an exercise where the participants looked at and gave their impressions of a calibrated time line slider bar.

An explanation was provided to the participant of how the session was structured. They were shown and explained how to use the virtual tour application. If required, there was an extra virtual tour exercise added so that participants could practice locating an image within a virtual tour condition. Once the subjects understood the task, the experiment began.

Conditions

This section will explain the four user interface conditions; (1) list menu, (2) frame slider, (3) swipe slider and (4) thumbnails. Each subject experienced all four conditions, and they were shown the conditions in a counterbalanced order.

List Menu Condition

This condition is a virtual tour operating with a pull down list menu on the top right hand corner of the user interface. To change between dates on that particular tour location the user pulls down the menu system and clicks on the date they wish to view next. The next virtual tour then loads into the frame of the window, replacing the previous virtual tour image. Figure 7.2 shows the list menu interface for the Christchurch Cathedral location.



Figure 7.2: List menu items at the Christchurch Cathedral location.

Frame Slider Condition

The frame slider has the virtual tours of the different times at the same location all sitting in a frame, each one displayed above the next. To access the next virtual tour the user scrolls down or up the frame of the images. Figure 7.3 shows the three-frame slider condition which scrolls up and down. The virtual tours are loaded and appear all at the same time, one above the other.

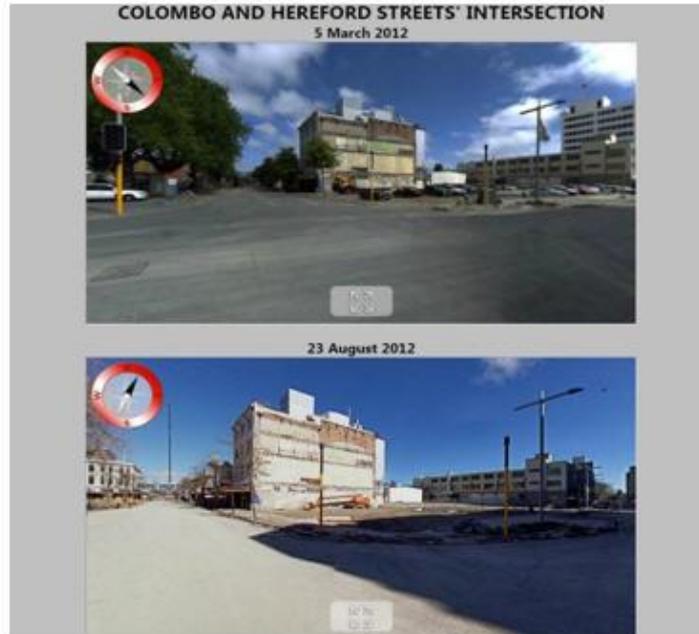


Figure 7.3: Frame slider at the Colombo and Hereford streets intersection location.

Swipe Slider Condition

The swipe slider uses a swipe bar to slide the virtual tours over to the left or right. The dark red circle moves along the grey bar and it changes the date at that particular location. The bar is approximately calibrated to time even though it does not show this with a scale. Figure 7.4 shows the swipe bar interface for the CCTV location. By swiping with a finger on a tablet or left mouse button click the virtual tours transitioned either left or right a single step.

Canterbury Television (CTV)



Figure 7.4: Swipe slider at the Canterbury Television site.

Thumbnail Condition

Thumbnails with mouse over text which revealed the date are embedded in the virtual tour. By clicking any thumbnail the user will transition to that tour.



Figure 7.5: Thumbnails menu at the Pyne Gould Corp. site.

Experimental Task

The first part of the experiment involved an activity where the participants were asked to find an image fragment that was taken from one of the online virtual tours, but was not present in any of the other online virtual tours. Figure 7.6 shows an example of this taken from a virtual tour.



Figure7.6: A small portion of a virtual tour taken from the Christchurch Cathedral.

There were five sets of virtual tours allocated to each condition. An image fragment from each location was identified as being unique to the scene for that condition. The task of the participants was to look through the locations of that condition and locate the image fragment. The time taken would be recorded. The virtual tours were:

- *Christchurch Cathedral*: A virtual tour taken directly in front of the Christchurch Cathedral (Figure 7.2)
- *Colombo and Hereford Street Intersection*. A virtual tour taken from the corners of this intersection (Figure 7.3)
- *Canterbury Television site*. A virtual tour taken by the empty section in the front of the fence. (Figure 7.4).
- *Pyne Gould Corporation site, (PGC)*. On Cambridge Terrace next to the Avon River. (Figure 7.5).

The second part of the experiment was to use a timeline swipe demonstration. Participants were asked whether they got a better impression of progression through time with a swipe bar with a timeline (see figure 7.7), or using a swipe bar with no obvious timeline as displayed in Figure 7.4. The timeline at the bottom of the image has a red dot to indicate the position alongside the date. The year is directly beneath. Years are sectioned off for greater clarity.

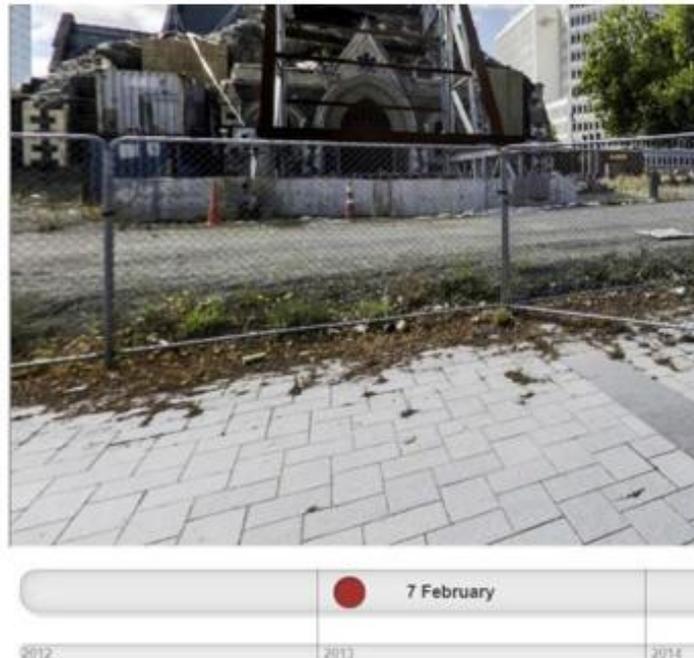


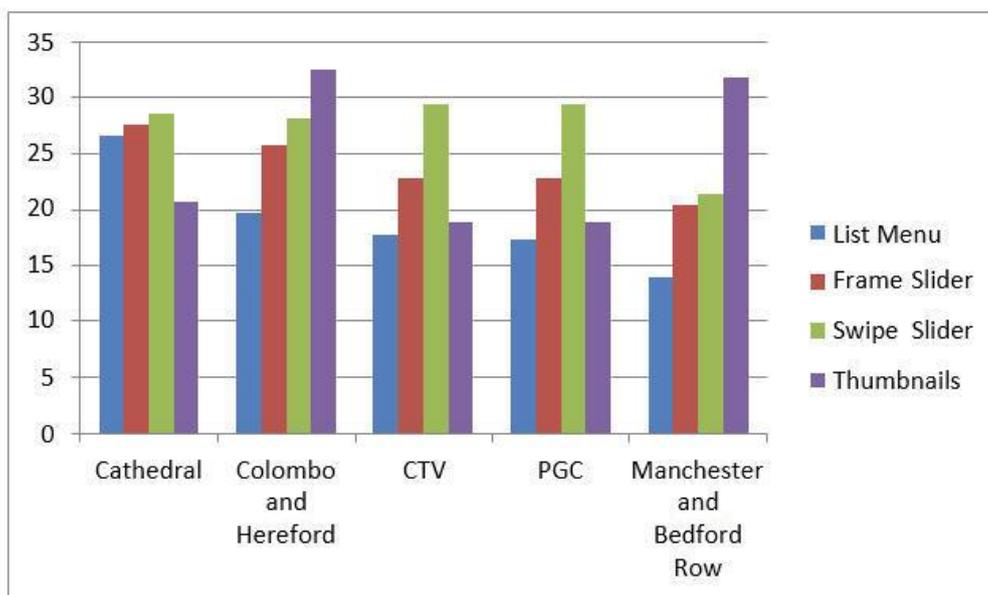
Figure 7.7: Timeline slider.

Operational Timing

For each virtual tour location, the average time it took to find the target image region was measured for each interface condition. A two-way ANOVA was performed using an alpha level of significance set at 0.05 to verify if there was any significant difference between the four conditions used by the study participants. After analysing the data from the performance measurement tests of the four conditions, the results indicated that there was no significant difference between the average times required to complete the different tasks. For all the 4 conditions the p value verified that there was no significant difference. For all 4 p was greater than 0.05. See the proceeding graphs and tables.

	List Menu	Frame Slider	Swipe Slider	Thumbnails
Christchurch Cathedral	26.60	27.60	28.53	20.67
Colombo and Hereford	19.67	25.80	28.07	32.50
CTV	17.70	22.73	29.40	18.80
PGC	17.27	19.00	17.73	17.70
Manchester and Bedford Row	13.93	20.47	21.40	31.80

The table 7.1 shows timing vales determined for the different locations.



Graph 7.1: Average times at locations by Condition.

Locations	F value	p Score
Christchurch Cathedral	F(3,15)= 0.843	p = 0.663
Manchester Street and Bedford Row	F(3,15)=0.470	p = 0.479
Pyne Gould Corp. site (PGC)	F(3,15)= 0.843	p = 0.775
Canterbury Television site (CTV)	F(3,15) =0.470	P = 0.370
Colombo and Hereford Street intersection	F(3,15)= 0.343	P = 0.143

Table 7.2: Operational timing between the conditions.

Ease of Use and Efficiency

The ease of use is defined as: how simple the condition was to use. The efficiency was defined as: was there any feeling that the particular condition wasted time when it was being used.

The ease of use and the efficiency was measured directly after the operational performance testing using two Likert scale perceptive questions on a scale of 1 to 7. For the ease of use condition 1 meant to be not very easy to use, and 7 meant very easy to use. For efficiency 1 meant very inefficient to use and 7 meant very efficient to use.

These questions are:

- Did you find the interface / display efficient to use?
- Is the interface / display easy to use?

Tables 7.3 and 7.4 display the descriptive statistics for both ease of use and efficiency in response to these two questions.

The Location	List Menu		Frame Slider		Swipe Slider		Thumbnails	
	Ease	Efficiency	Ease	Efficiency	Ease	Efficiency	Ease	Efficiency
Cathedral	5.67	5.20	6.13	5.20	4.60	4.33	6.27	5.87
Colombo	5.60	5.60	6.00	5.53	4.33	4.47	6.00	5.80
Hereford								
CTV	5.47	5.40	5.93	5.20	4.87	4.93	6.33	6.33
PGC	5.47	5.33	5.60	5.60	4.47	4.40	6.13	5.87
Manchester	5.53	5.13	5.87	5.60	4.47	4.60	6.27	6.07
Bedford								
AVERAGES	5.55	5.33	5.90	4.43	4.55	4.55	6.20	5.99

Table 7.3 Summary of means (μ) for conditions by location, for ease of use and efficiency

The Location	List Menu		Frame Slider		Swipe Slider		Thumbnails	
	Ease	Efficiency	Ease	Efficiency	Ease	Efficiency	Ease	Efficiency
Cathedral	1.05	1.32	0.74	1.08	1.88	1.50	0.88	1.36
Colombo	1.64	0.97	1.10	1.64	1.84	1.37	1.13	1.57
Hereford								
CTV	1.55	0.97	0.88	1.32	1.801	1.53	0.62	0.49
PGC	1.51	1.50	1.24	0.91	2.20	1.55	0.99	1.41
Manchester	1.60	1.60	0.83	1.30	1.92	1.40	0.80	1.16
Bedford								
AVERAGES	1.47	1.28	0.95	1.25	1.93	1.47	0.89	1.20

Table 7.4: Summary of standard deviations (σ) for conditions by location, for ease of use and efficiency

The results in tables 7.3, 7.4 are for the 5 different locations and for all the 4 conditions.

Ease of Use

A Friedman test was conducted to explore if there was a significant difference between ease of user values for the different conditions at each location. Table 7.5 shows the Friedman F values for each of the virtual tour locations tested. The results indicate there is a significant difference in perceptions for ease of use between the four different interface conditions.

Locations	F value	p Score
Colombo and Hereford	$\chi^2 = 13.710$	p = 0.009
Christchurch Cathedral	$\chi^2 = 19.022$	p = 0.001
Manchester Street and Bedford Row	$\chi^2 = 10.244$	p = 0.004
Pyne Gould Corp. site (PGC)	$\chi^2 = 9.198$	p = 0.004
Canterbury Television site (CTV)	$\chi^2 = 11.103$	p = 0.009

Table 7.5: Friedman test for ease of use.

Further analysis was required to establish the nature of the difference. The method of analysis was a Wilcoxon Signed Rank test with a Bonferroni correction. For this test the alpha level was set to 0.05/number of comparisons. Which in this case with 4 conditions and 6 pairs the p values must be less than 0.0083 to show a significant difference. Table 7.6 shows the results from the analysis.

Pairs	p Score	Significance
Frame – Swipe	p = 0.001	Reject null
Frame – List	p = 0.809	Retain null
Frame - Thumb	p = 0.001	Reject null
Swipe – List	p = 0.003	Reject null
Swipe – Thumb	p = 0.001	Reject null
List - Thumb	p = 0.001	Reject null

Table 7.6: Wilcoxon matched pairs test.

The results showed that there was no significant difference between only the frame menu and list menu conditions; whereas there were significant differences between all of the other paired combinations. Thus the Wilcoxon's Signed Rank matched pairs test showed for ease of use there is a definite perceptible difference between the different four conditions. Participants felt like some conditions were better than others.

Efficiency

The next stage was to analyse the data for the differences (if any) for efficiency. The raw data on the user perceptions for efficiency was analysed using a Friedman test with an alpha level set to 0.05.

Locations	Friedman Score	p Score
Colombo and Hereford	$\chi^2(4) = 11.610$	p = 0.003
Christchurch Cathedral	$\chi^2(4) = 9.280$	p = 0.001
Manchester Street and Bedford Row	$\chi^2(4) = 13.206$	p = 0.017
Pyne Gould Corp. site (PGC)	$\chi^2(4) = 13.579$	p = 0.011
Canterbury Television site (CTV)	$\chi^2(4) = 11.561$	p = 0.027

Table 7.7: Friedman test on Efficiency for the 4 Conditions.

The results indicate there is a significant difference in perceptions in efficiency. This meant further analysis was required to establish the nature of the difference. The method of analysis was a Wilcoxon Signed Rank test with Bonferroni correction. For this test the alpha level was set to 0.05/number of comparisons. Which in this case with 4 conditions and 6 pairs the p values must be less than 0.0083 to show a significant difference. Table 7.7 shows the results from the analysis.

Pairs	p Score	Significance
Frame – Swipe	p = 0.001	Reject null
Frame – List	p = 0.637	Retain null
Frame - Thumb	p = 0.001	Reject null
Swipe – List	p = 0.001	Reject null
Swipe – Thumb	p = 0.001	Reject null
List - Thumb	p = 0.001	Reject null

Table 7.8: Wilcoxin Matched Pairs Test

The results in table 7.8 from the Wilcoxon Matched Pairs signed-rank test comparisons showed that there was no difference between the list menu and list menu; whereas there were significant differences between the other conditions. There was no performance difference between interface conditions, but that there were user preference differences in terms of ease of use and efficiency.

With reference to the descriptive statistics and table 7.10 it would be reasonable to now look at the averages. The most preferred is clearly the thumbnails, there is little difference between the frame and list menus and the frame slider is the least preferred.

The swipe slider is clearly the least preferred because it is a taught skill and requires a small amount of practice to be quite competent. The thumbnails gave a visual impression of what the next virtual tour would look like when loaded. Participants appeared to like this impression and also that was easy to click and open. The frame and list menus had no difference in preference in terms of either ease of user (table 7.7) or efficiency (table 7.8).

The implication for the virtual tour design and layout are that thumbnails should be the first choice and a swipe slider is the last choice.

Observations from the study showed that everyone like a menu system of some form or another. Anything that made navigation easy was preferred.

Part Two: Swipe Bar with Timeline

The purpose of this part of the experiment was to develop an understanding of participant perceptions of movement through time and what would help them to improve this perception. The condition being analysed was the swipe slider. Years were added to the swipe slider to show a more informative layout (see Figure 7.8).

To gain a better understanding about whether or not a timeline would give a better impression of movement through time, the virtual tour website for the Christchurch Cathedral location was rebuilt with a swipe bar and timeline (see Figure 7.8). The perceptions of the participants were gathered by using the online interactive presentation with a Likert scale question asking whether or not the calibrated time scale gave a better impression of movement through time. The question asked was:

Does adding a timeline provide a better understanding of progression through time?

This movement can be either backwards or forwards through time along the slider bar. Values used for perception were: 1 labelled “No sense of movement through time” indicated no impression of movement through time whereas 7 labelled “Strong sense of movement through time” indicated a very good impression of movement through time.



Figure 7.8: Timeline included in Swipe Menu

Analysis of the descriptive data collected from the participants (N = 15) produced a mean of $\mu = 5.47$ and standard deviation of $\sigma = 1.64$. To determine whether there was a valid significant difference in spread, a One Sample Wilcoxon Matched Pairs test was used to compare the mean against a hypothetical (ideal) mean of 4, where $p=0.001$. This shows that the mean found is significantly higher than 4.

For the swipe slider this indicates quite clearly that participant's felt that a timeline would help them understand progression through time. The implication for the design and layout is that a timeline should be used as it engages the participants better because it gives a better impression of movement through time.

Qualitative Data

At the end of session 1, a brief non-structured interview was conducted to gather qualitative data about the participants' impressions of the different conditions. The comments were recorded and a tally was taken of common themes (see Table 7.9). The results show how often participants stated mentioned a particular comment.

Theme	Participant Comment	Tally
Navigation	Scroll through with keyboard i.e. arrow keys.	I
	Easy to follow.	I
Timeline Dates	Would prefer dots to press b/c of swiping on screen can easily swipe the wrong date. Plus with dots you could skip ahead a few rather than going in sequence.	II
	Multiple buttons active is green which can be touched or swiped. Just one band but the year inside next to the buttons.	II
Swipe	Same as before as there is no indication where the stops are i.e. where I am sliding the control too.	II
	Swipe slider is easier to use on a tablet or anything with capacitive touch screen.	II
	Swipe makes more sense on a touch screen. Extra feedback on swipe (timeline or similar) would improve it.	II
	Swipe for tablet. Clicking better for PC.	II
	Swipe is much easier to use on a tablet.	II

Table 7.9: Participant comments for the swipe slider with timeline.

Further questioning was required to explore whether or not the participants preferred swipe input as opposed to a click on a mobile device, such as a tablet. To determine whether or not the swipe was preferred on all participants were contacted again and asked to use a tablet or mobile device and see what they thought of the swipe functionality on a touch screen. The website was shown on an Android tablet with both swiping and tapping on the tablet screen. The response was extremely positive as everyone agreed that swipe worked efficiently and easily on a tablet or mobile device. All the participants expressed that a swipe was much better on a touch screen mobile device as opposed to a computer.

Discussion

The results show quite clearly that there was no operational performance difference between the operational times that it took the users to navigate through the different conditions in the virtual tours. From the data obtained and the results processed, the following is how people prefer the four different conditions in descending order of preference. Thumbnails are the preferred navigation system, followed by the frame and list with no significant difference in user preference between them, and with the swipe slider menu being the least preferred. All of these conditions were based on interaction on a PC application as opposed to using a tablet. The preference changed when a tablet was used, as the swipe slider became a preferred method of interaction with interface. The preference changed when a tablet was used as the swipe slider became a preferred method of interaction with interface. The two things that can be said about these findings are firstly even though some conditions are preferred more than other conditions it doesn't mean they should not be used. Secondly for a time slider to be useful it will need to be the calibrated time scale which includes both a click function and a swipe function. This means it is compatible with both PC and tablet applications. This would provide the user with choice. A small amount of difficulty experienced by some users with swiping on a PC would be replaced by the ability to click on any date to move the slider.

Some participants using the PC experienced difficulty controlling the swipe slider with their mouse. There was a skill needed that was not intuitive. This was not the requirement of a touch screen of a tablet as the screen sensitivity made it very easy to make the virtual tours to slide without any acquired skill or explanation. Consequently the functionality needs both click and swipe to be included into the design. Evidence was provided by re-contacting the participants and asking them why.

It was preferred that the time line slider needed to include thumbnails. The date locations should also be on the timeline aligning themselves with the thumbnails, see Figure 10.4. Comments made about the thumbnails were that it provided a form of informed choice of what they could choose to view next.

The qualitative data obtained during the interviewing/discussion session following the sessions suggested that virtual tour navigation windows should include the following:

- A swipe functions for tablet mobile devices.
- Click functionality on different dates, which would be suitable for PCs.
- A way of identifying what date is being currently watching by using different coloured buttons.
- Enabling the arrow keys and greater simplicity.

Comments from participants:

"It was great to swipe on a tablet."

"Using a PC definitely needed a mouse click."

"The layout clearly showed the timeline of buildings being demolished."

The impression was that the functionality required a swipe and a click to operate across the mobile and desktop platforms.

It is important to note that the swipe slider was significantly preferred over the clicking input when it was used on a touch screen mobile device. The implication of this is that in the final design, the menu system should have a click option for a desktop interface and a swipe option for a mobile device. With regards to the swipe slider the inclusion of more information, e.g. years, was one of a number of preferred features that participants thought would be useful to show progression through time. Adding vertical lines to the slider bar indicated different years and the thumbnails showed where you're moving too. These were suggestions from the participants for improving the design and layout inclusion.

All of the participants were able to locate the images within the virtual tours, however they preferred something that worked efficiently and was also easily understood.

For a time slider to be useful it will need to be the calibrated time scale that includes both a click function and a swipe function. This means that it is compatible with both PC and tablet applications. This would provide the user with choice. A small amount of difficulty experienced by some users with swiping on a PC would be replaced by the ability to click on any date to move the slider.

Participants preferred that the time line slider included thumbnails. The date locations should also be on the timeline aligning themselves with the thumbnails, see Figure 9.4. Comments made about the thumbnails were that it provided a form of informed choice of what participants could choose to view next.

The results may have occurred for several reasons. Thumbnails were also preferred because they gave an impression of what they were going to view next. The timeline slider was strongly preferred as it provided a very good impression of movement through time. The timeline's functionality of being able to click on a desktop and swipe on a tablet improved the impression of the application's usability. Other information being included was considered a very good idea because it enriched the understanding of what was once there and what was happening to the CBD as a consequence of the earthquakes. Overall all of these features together contributed to the environment being engaging and interesting. The movements preferred are all naturally easily managed and have normal acceptance as functions on mobile devices.

Overall combining these functionalities together as well as using as many senses as possible contributed to the environment being more engaging and more interesting.

7.2 Experiment 2: Design and Layout

The purpose of this next experiment was to establish what the best presentation format would be to present all the virtual tours online. Collectively called screen views part of the virtual tour application was the development of new code using CSS and HTML (with iframe links) to launch virtual tours from the Focus360 server (see Figures 7.9, 7.10 and 7.11). This new code created three screen views within the application, these being: Tours: figure 7.9, Text: figure .10 and Map: figure 7.11. Buttons were created on the landing page of the web application to link directly through to the screen views. Navigation was included in the screen views for ease of use.

A second part of the experiment was conducted to collect information about user preferences for the interface design layout. Three presentation display interfaces were presented to the online participants:

- Tours presented a menu system, title, and virtual tour (Figure 7.9).
- Text presented a virtual tour accompanied with text information that documented the history of the building view and surrounding area (Figure 7.10).
- Map presented the information in a virtual tour with a Google map, which had locations identified by pins (Figure 7.11).



Figure7.9: Tours

Tours: Figure 7.9 is the Christchurch Cathedral and is a virtual tour by itself.



Figure 7.10: Text

Text: Figure 7.10 is a virtual tour with text information included.

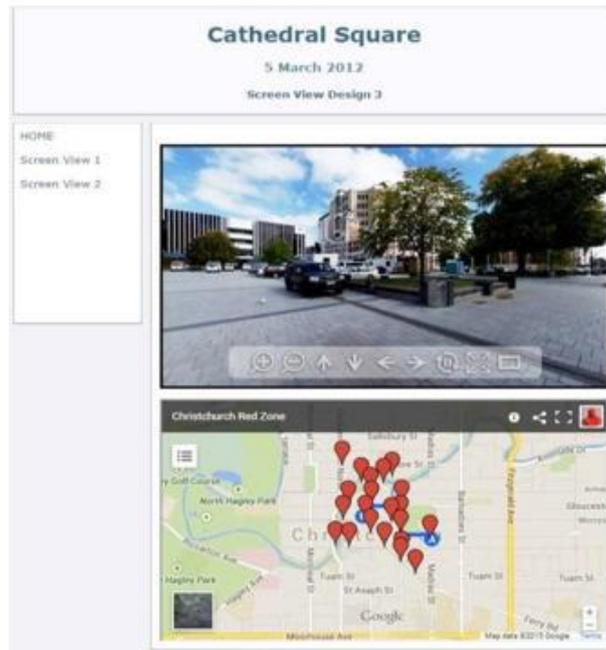


Figure 7.11: Map

Map: figure 7.11 is a virtual tour included with a Google map and pinned virtual tour locations.

To collect user feedback the following three screens were explored by ranking which presentation screen gave the best sense of being there on location by ranking them in order of preference. The screens were: virtual tours only, virtual tours and text information, virtual tours and a Google map.

The task for question one was to view each of the screens and rank them in order in terms of which screen view provided the best sense of location or a feeling of being there. Participants were given the opportunity to view and consider each different presentation. They were invited to explore what they were looking at and to ask any questions about any particular functionality. They were asked if they clearly understood the difference between the 3 different screens. This was to ensure they had a clear understanding of difference with the 3 different presentation options.

The task for question two asked whether or not extra information should be included with virtual tours. This meant that participants had been asked to review the three screen views and had recorded their answers in the answer booklet.

Question three reviewed the available media that can be added to any web page for any online device. Participants had been asked whether or not certain media should be included or excluded. They had answered in terms of what they wanted included the most and what they wanted included the least.

The last question investigated the educational value that the online application may have. It was worth considering this because it may have an impact on the engagement of the final online application. The audio and kinesthetic aspects of user engagement with the user interface were explored. Had the participants preferred audio over kinesthetic and which one did they prefer the most? At the end of this session participants were asked in an unstructured way if they had any further comments and would they mind noting down.

Question 1: Preferred ScreenView

The results obtained from the question about the preferred ScreenView were analysed using a Friedman test. The results indicated clearly that there was a difference in perception in preference between the three screens. Reporting these results: $\chi^2(2) = 2, p = 0.343$.

There was a clear significant difference with these results, therefore to determine between the different conditions, a Wilcoxon Matched Pairs test with a Bonferroni correction was carried. For this test the alpha level was set to $0.05/\text{number of comparisons}$. Which in this case with 3 conditions and 3 pairs the p values must be less than $0.05/3 = 0.017$ show a significant difference.

Pairs	p Score	Significance
Tour and Text	p = 0.001	Reject null
Tour and Map	p = 0.001	Reject null
Text and Map	p = 0.660	Retain null

Table 7.10 Wilcoxon Matched Pairs test Results with Bonferonni correction.

Discussion

These results indicate that there was no significant difference between the text view and Google Map interfaces, but a significant difference between the virtual tour and each of the other two conditions. Participants seem to appreciate extra information alongside the virtual tour. Even though the participants liked virtual tours by themselves there was definitely a sense of location or sense of being there better created by including text information and/or a Google map.

Question 2: Information Inclusion.

Qualitative feedback from all participants when questioned expressed a preference for having text information included with the virtual tour. They all also felt a Google map would help with navigation.

Question 3: Media Types

Study participants were asked whether or not to include different types of media in the virtual tour application. To determine which media software should be included in the final design the following question was asked of the study participants.

*“What is your most preferred media type and what is your least preferred media type?”
Rank them in order of preference. Where 1 is the least preferred and 8 is the most preferred.*

Results from this question are shown in Table 7.14. A Friedman test on the participants preferences indicate a significant difference that some media should be included and while other media should not be included: $\chi^2(7) = 27.875, p = 0.001$.

Media	Mean (μ)	Standard Deviation (σ)	Median (M)
Video	$\mu = 4.667$	$\sigma = 1.496$	M = 5
Audio	$\mu = 3.867$	$\sigma = 2.294$	M = 4
PDF	$\mu = 6.000$	$\sigma = 2.287$	M = 7
Images	$\mu = 4.357$	$\sigma = 1.499$	M = 5
Text	$\mu = 3.214$	$\sigma = 2.547$	M = 2.5
Facebook	$\mu = 5.000$	$\sigma = 1.710$	M = 5
Google map	$\mu = 3.500$	$\sigma = 2.247$	M = 3.5
Other...	$\mu = 6.200$	$\sigma = 2.704$	M = 8

Table 7.11: Means and standard deviations for different media types.

It was still unclear at this point was the most preferred media type, least preferred media type and what should not be included. A qualitative tally was taken by asking the participants what they preferred to include and preferred not to include (see Table 7.11).

Media Type	Include	Don't include
Video	8	7
Audio	11	4
PDF	4	11
All Still Images	13	2
Google map	14	1
Text	14	1
Facebook	11	4
Other...Pinterest, 4 Square.	9	6

Table 7.12: Tally of Preference for Inclusion of Different Media.

It was now clear from these results that audio, still images, Google map, text, and Facebook should be included. Video and other media were of interest; however, there was no preference for the inclusion of PDF files. By comparing this table with the means, standard deviation and median from Table 7.12 there are 3 categories. These categories are *definitely include*, *include if possible* and *prefer not to include*.

To validate this decision of the three different categories the qualitative data choices from the tally count (table 7.12), agree with the means and medians for the inclusions (table 7.11). This agreement is based on a ranking of means and medians and is detailed in table 7.13.

Category	Media Type	Definitely Include	Include if Possible	Prefer not to Include
Category 1	Google Map	3.500	14	
	Text	3.214	14	
	Audio	3.867	11	
Category 2	Facebook		5.000	11
	Video		4.667	8
	Others e.g.		6.200	9
	Pinterest			
	4Square			
Category 3	Still Images		4.357	13
	PDF			4 6.200

Table 7.13: Means and medians for category agreement

For table 7.13 the category of *definitely included* was defined by the majority of participants wanting the media type included and the media types average showing a preference for being included. The next category being *preferred* required either the majority of participants wanted it included or its average showing a preference for inclusion. The final category of *preferred not to be included* had a minority of people not wanting it to be included and having a preference with regards to its mean for no inclusion.

Discussion

The implications for the mobile application was to definitely include a map with as many other features integrated into the design as possible, without making it too cluttered. The results seemed to indicate that engagement was an extremely important feature that should be carefully included in the design of any online mobile application. Consideration should definitely be given to include social media as it would help to assist promoting user engagement.

Category two establishes a basis for supporting material and social media. In terms of the mobile application a preferred inclusion means there is space available in the design and layout and that the media type will be included where possible. The main reason discussed for not including PDF files was the presentation is not good enough for a professional website, although for some situations where files should be scanned and included this might be considered acceptable.

With regards to the inclusion of media, there were three categories. The first category was *definitely include* and in this was Google maps, text and audio. The second category was *preference to include where possible* which included Facebook, video, Pinterest and 4 Square. The last category was *preferred not to include*, and the feature that people did not want was inclusion of PDF files.

There was also a preference for the inclusion of Facebook, video, Pinterest, and 4Square; however, there wasn't a strong preference for including PDF files.

Hand Drawn Images

Hand drawn images were suggested to all participants as a way of getting a better impression of what the participants were thinking

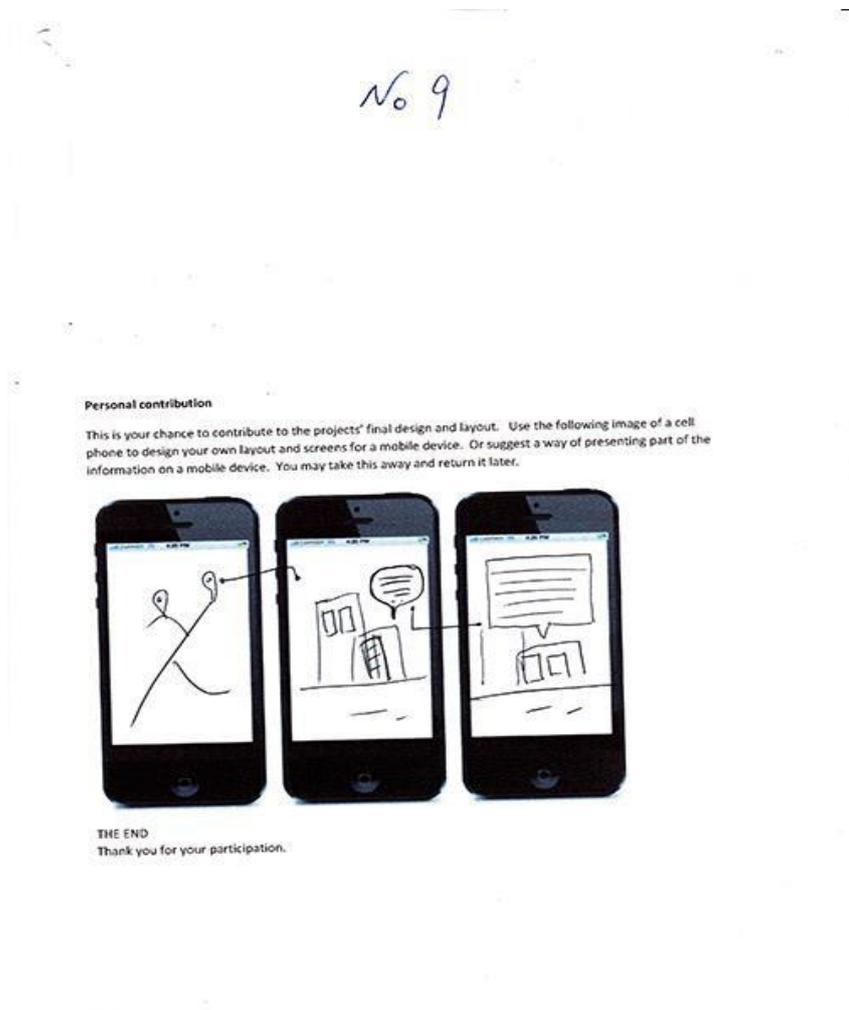


Figure7.12: Hand drawn images suggesting the inclusion of a Google map with pinned locations.

Three participants drew these diagrams that by using Google maps you could put locations and pop-ups of buildings with text information.

12

Personal contribution

This is your chance to contribute to the projects' final design and layout. Use the following image of a cell phone to design your own layout and screens for a mobile device. Or suggest a way of presenting part of the information on a mobile device. You may take this away and return it later.



THE END
Thank you for your participation.

Comp. Attribution

Figure 7.13: Hand drawn images suggesting timeline and text information.

The timeline includes a picture of Christchurch to help with design.

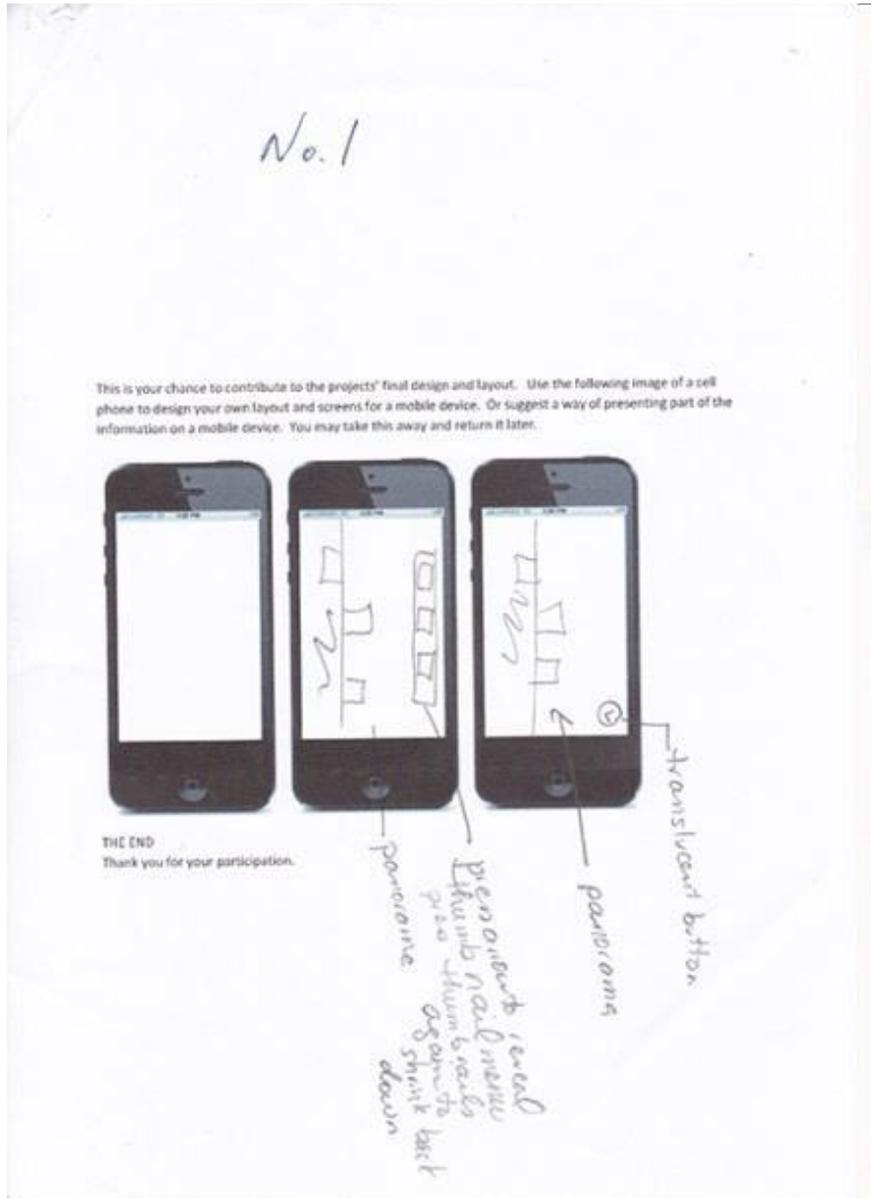


Figure 7.14: Hand drawn images suggesting the inclusion of other information.

In these drawings the emphasis was on including information as hotspots included on the buildings particularly ones that have now been demolished.

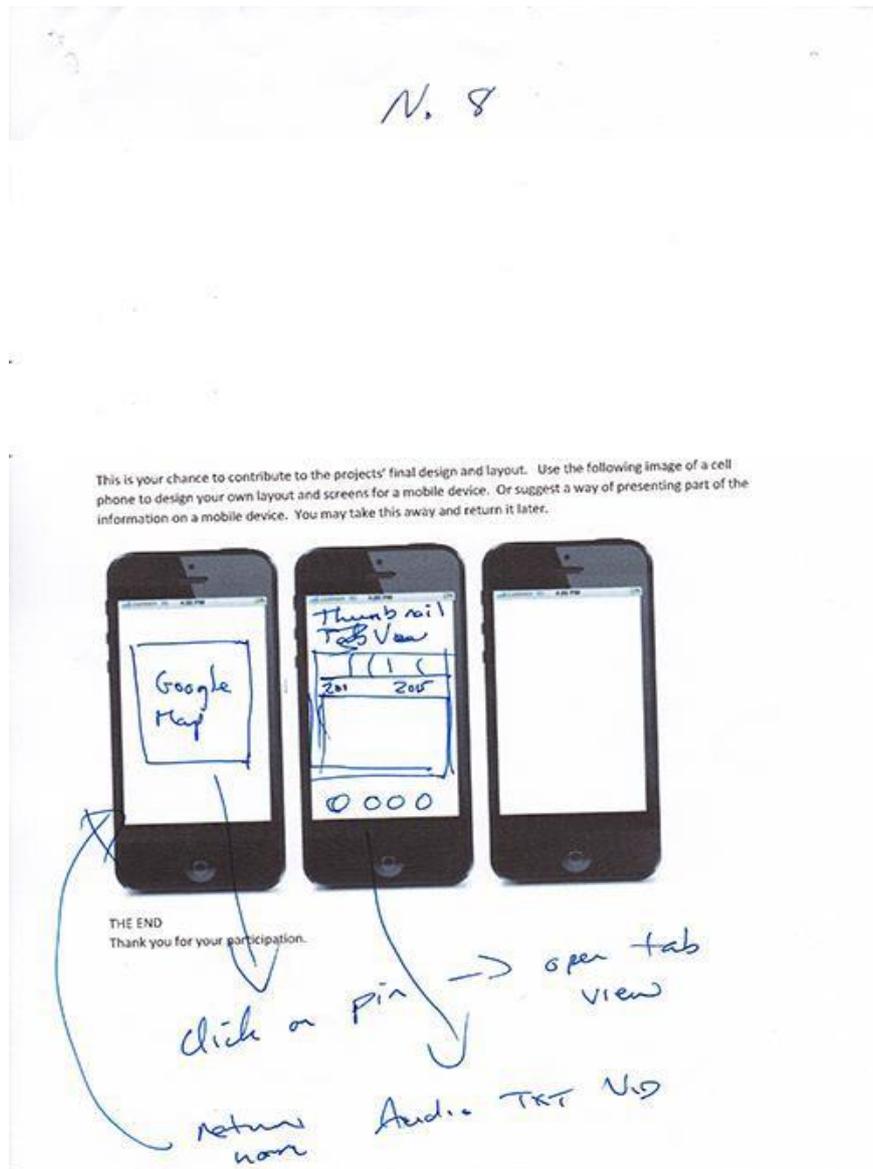


Figure 7.15: Hand drawn images suggesting the inclusion of audio and emphasising thumbnails.

These drawings show use of Google maps linking to audio systems opening in a new tab.

Discussion

It is not surprising that participants thought a Google map should be included as Google Maps are such a well-established part of everyday life. Text and audio are also a preferred option and even though it is not statistically proven within the scope of this research. Written and hand drawn comments about inclusion of a Google map suggested a preference for the inclusion of features like walking distances, bathroom facilities, cafes etc. A different coloured pin identifying your location was also suggested as a preferred feature.

To create a sense of being present on location, results indicated that text information or a Google map needed to be included with the virtual tour. Virtual tours by themselves, apart from a full screen view, were not preferred as it did not create a sense of being on location.

Written and hand drawn comments reaffirmed the need to include a Google map which suggested a preference for the inclusion of features like walking distances, bathroom facilities, cafes etc. A different coloured pin identifying your location was also suggested as a preferred feature. There was a strong preference for the inclusion of still images, Google map, text, and audio. There was also a preference for the inclusion of Facebook, video, Pinterest, and 4Square; however, there was a strong preference not to include PDF files.

With regards to the inclusion of media, there were three categories. The first category was *definitely include* and in this was Google maps, text and audio. The second category was *preference to include where possible* which included Facebook, video, Pinterest and 4 Square. The last category was *preferred not to include*, and the feature that people did not want was inclusion of PDF files.

The implications for the mobile application was to definitely include a map with as many other features integrated into the design as much as possible, without of course making it too cluttered. The results seemed to indicate that engagement was an extremely important feature that should be carefully acknowledged in the design of any online mobile application. Consideration should be given to include social media and its respective updates to assist with promoting user engagement.

7.3 Experiment 3: Visual, Audio and Kinesthetic

All participants expressed a strong preference for audio and kinesthetic features to be built into any mobile device's software platform. The preference was for kinesthetic; however, this did not mean that audio should not be included.

Participants liked interacting with the mobile devices screen as it was a visual action they could engage with and enjoy. The audio was a feature that participant's definitely wanted but the comments made were that the ability to turn the audio on and off should be available. All users like to engage and interact with the userinterface. When the interface displayed a variety of different information and engaged more senses that seemed that participants found it more engaging.

A mobile device is definitely a visual, audio, and kinesthetic device so including as much interactivity as possible would be of benefit to facilitate understanding. Visual stimuli are provided through the tablet's screen, whereas audio needs to be recorded and uploaded as an mp3 file. Kinesthetic commonly referred to as touch, would be provided by interacting with the mobile user interface.

Participants were asked whether or not audio and video should be included and enhanced where possible and what do they prefer the best, audio or kinesthetic cues. This experiment simply involved the participants answering these two questions. These questions asked were:

“Should audio and kinesthetic be included in the design and layout”?

“What do you prefer the most if it was added to the design and layout, audio or kinesthetic?”

Discussion

It is important to note that visual cues are a natural intrinsic part of any mobile device. Participants were questioned whether they thought including audio and kinesthetic was an important priority when constructing any mobile device. Kinesthetic was considered the preferred option as all candidates expressed this as being the most desired inclusion when questioned.

All of the participants, when asked, expressed a strong preference for audio and kinesthetic features to be built into any mobile device's software platform.

7.4 Experiment 4: Electronic Online Options

Virtual tours can be launched using different presentations. These presentation methods include hyper-linking an image, map or menu system. If the hyperlink is written into the code of an iframe, normally it opens the virtual tour resized on the webpage. Consequently it is important to understand what people prefer in terms of how they might open the virtual tours. This information will assist with the mobile application providing information of the preferred launching method.

Participants were asked to review actual examples of virtual tours that were available at online business websites. Participants went to three different websites of The Department of Conservation, Lamb and Hayward and View360 and launched the virtual tours.

There were three different options for loading the virtual tour:

1. Virtual tours launched from a menu system. This menu was located on view360's website.



Figure 7.16: View360's menu system.

2. Virtual tours launched from a series of images. Located on Lamb and Hayward’s [95] website.

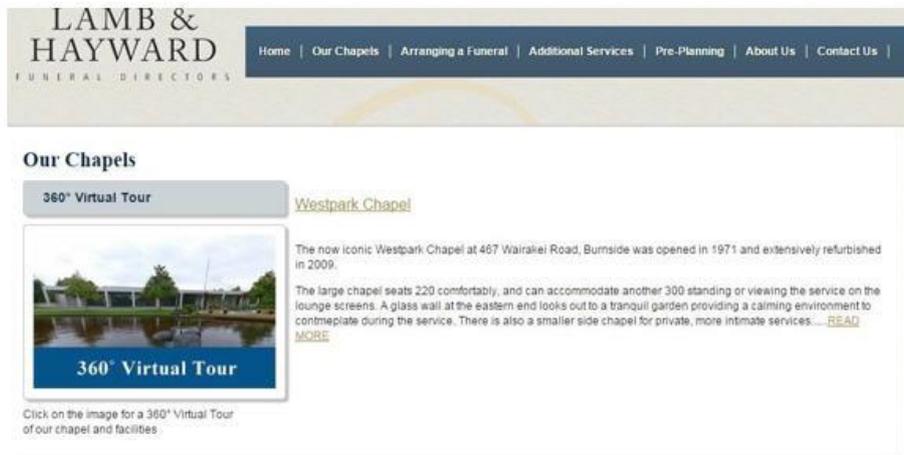


Figure 7.17: Lamb and Hayward’s website.

3. Virtual tours launched from a map with hotspots, which are located on the Department of Conservation’s [95] website.



Figure 7.18: Department of Conservation’s website.

Participants were asked to say whether they liked or didn’t like a particular way a virtual tour can be opened online i.e. menu, image or map.

What presentation format to launch the virtual tours did you like the best: image, map or menu system?

Participants were also asked to rank the three systems on a scale of 1 to 7 from most preferred to least preferred.

Preferences

Table 7.17 shows the average ranking for each of the virtual tour launch options. To establish if there is a statistically significant difference in reference a Friedman’s test was undertaken. The results showed a statistically significant difference for one or more of the three conditions: $\chi^2(2) = 12.933$, $p = 0.01$.

Virtual Tours Launch Method	Mean (μ)	Standard deviation (σ)
Image	$\mu = 3.867$	$\sigma = 2.696$
Map	$\mu = 6.200$	$\sigma = 1.146$
Menu	$\mu = 4.200$	$\sigma = 1.320$

Table 7.14: Preference for Presentation Methodology

A Wilcoxon Matched pairs test was undertaken with a Bonferonni correction and results are recorded in table 7.15. For this test the alpha level was set to 0.05/number of comparisons. Which in this case with 3 conditions the p values must be less than 0.017 to show a significant difference.

	p Value
Image and Map	0.239
Image and Menu	0.002
Menu and Map	0.003

Table 7.15: Wilcoxon matched pairs test

Discussion

The results show a strong preference towards the map but there is no clear statistical evidence for a preference for either an image or a menu. The implication for an online mobile application is that the preferred method for launching the virtual tours would be a map using hotspots, see Figure 7.18. The reason for this is the map gave participants a better understanding on where they were geographically which the other two systems could not provide. However this is not to say that a menu system or image should not be considered. Knowing that a map was the preferred method and that an image and a menu were both close to the midpoint in terms of their mean was enough information to carry through to the mobile application.

Electronic Products.

To determine what people would like to see available online, participants were asked to rank the data according to their preference. The five conditions of this ranking of 1 to 5 (1 = least preferred, 5 = most preferred) are as follows:

- iOS app.
- Android app.
- jQuery app
- Mobile responsive website.
- Mobile responsive website able to upgrade by adding or in deleting content.

To create a sense of being present on location, the results indicated that text information or a Google map needed to be included with the virtual tour. Virtual tours by themselves, apart from a full screen view, were not preferred as it did not create a sense of being on location. Other media needed to be considered.

Table 7.19 shows the mean responses for each of these conditions. It was evident that easiest to manage a mobile responsive website for updates however apps were not a dismissed option. A Friedman’s test determined no significant difference between the 5 conditions. The Friedman’s test result was set with: $\alpha = 0.05$. The result was a p value where: $p = 0.686$.

Electronic Option	Mean (μ)	Mode (Mo)	Standard deviation (σ)
iOS App	$\mu = 2.800$	Mo = 3	$\sigma = 1.424$
Android App	$\mu = 2.800$	Mo = 2	$\sigma = 1.781$
jQuery App	$\mu = 2.800$	Mo = 3	$\sigma = 1.320$
Mobile Responsive Website	$\mu = 3.143$	Mo = 3	$\sigma = 1.512$
Mobile Responsive Website with Managed Content	$\mu = 3.600$	Mo = 4	$\sigma = 1.183$

2.

Table 7.16: Means, Modes and standard deviations for preferred online options.

Discussion

These results for the electronic products showed that there was no preferred option and therefore no further analysis of the data was required. The knowledge that the application should be available across all platforms made common sense. Several participants did comment that they preferred any updates to be automatic.

Chapter 8: Design Considerations

8.1 Design Implications.

The main lesson learned that applies to the user interface is that the interface needed to suit the participants' needs. Simply providing an interface that is functional is not enough. People using a mobile device will probably not use the interface if it does not meet their needs and their preferences.

Virtual tours can be viewed in a number of ways online and there is a variety of other formats to code and present the tours online. With regards to design this means that simplicity in functionality was very important. There was no need to complicate with numerous clicks or touches when the same task could be achieved with fewer clicks or touches.

It was felt that the participants were looking for an environment that was immersive and the virtual tours help to provide this by fulfilling the human need to look back and see what the place once looked like. There is no direct statistical evidence for this except that people anecdotally said things like:

“Is that what it looked like?” and “I wish I could remember what was there?”

The Canterbury Museum saw real value in this application as it provides an insight into modern social history. It uses the application to help provide a richness of depth to the Quake Cities Exhibition. Any mobile application would take their visitors out beyond the walls of a Museum and therefore help to market the place. The Commodore Airport Hotel also understood the worth of the virtual tours as they have now included them in their concierge computers. They see this as a valuable asset to help add interest to the hotel by providing their customers with interesting things to do. They want their customers to have an interesting and enjoyable stay and will go the extra distance to achieve this goal.

In a recent discussion with Mr. Patrick Roitiers from Pro Consulting Marketing he expressed his opinion that there is a need to communicate historical disasters and natural events as effectively as possible. We discussed how helping people to personally understand or experience what it was like to be there would fulfil the human need of being able to look back intime. In this way, people can recall the experience they personally had or try and understand what it is like if they weren't there. The presentation of the virtual tours with supporting information as discussed in chapter 8 would provide a very effective way to help people engage with and understand the earthquake experience.

8.2 Design Choices for Interface Functionality.

The design choices need to be directly influenced by the user study findings. All virtual tours should launch from a map which is accessed directly from the landing page. The Google map is commonly known and is a readily available mapping system that could be embedded with as much information as possible and will enhance the kinesthetic modality. By removing any other buttons within the virtual tour this will make the screen on a tablet or mobile device more kinesthetic and engaging.

The preferred navigation system is the map. The preferred virtual tour interface at each location is the time slider and the preferred menu system is the thumbnails. The time slider needs to include calibration and years and dates. The thumbnails could be included on the timeline. This means a calibrated timeline and being able to slide to a predetermined thumbnail location indicated by a date time which is clearly indicated on the timeline. To allow for the need for PCs the thumbnails will be linked to open the virtual tour. All virtual tours need a full screen option as part of their functionality.

Information and imagery are a preferred inclusion and should be available as pop-up windows through hotspots which could be included in the virtual tours. Text information and still imagery are also a preferred option and should be made available through hotspots embedded into the virtual tour. There should be an icon available to play the audio track that can be turned on and off. With regards to all the social media and other media they can be included as part of any menu system.

8.3 Software Development Choices.

The next software development with regards to the Red Zone application is to create a mobile application. Three options have been considered and are available:

- iOS Available in App Store.
- Android. Available in Play Store.
- jQuery app available across all mobile devices, but not available in both the App and Play store.
- Mobile responsive website.
- Mobile responsive website with content management system.

Users were presented with these options and a statistical analysis on their feedback provided no significant indication of preference for which product should be made as the first choice.

For the iOS app it is likely that a web company capable of producing the product will be contracted to develop the application. With regards to jQuery this will be on commercial request where a business that wishes to use the product as app customers can download it from their website. This means that the app is not required to be available in the App or Play stores but will run across all the mobile platforms when downloaded into a mobile device.

8.4 Conclusions

The Red Zone mobile website tours have proven to be extremely popular since they were first made available in 2012. When the first virtual tours were posted online, there was an enormous degree of interest in seeing what happened to the central business district (CBD) of Christchurch. The project is supported by the University of Canterbury Quake Studies office and special permission was obtained from the Canterbury Earthquake Recovery Authority (CERA) to record the Red Zone with virtual website tours. The collection slowly grew and now there are over 180 virtual tours ready to go online. The collection has now become reasonably large, and is on display in the Canterbury Museum and the Quake City's exhibition on Cashel Street in Christchurch, so the challenge has become how to effectively display the virtual website tours online. Consequently, the collection was taken to the Human Interface Technology New Zealand (HIT Lab NZ), at the University of Canterbury in 2014. At the HIT Lab NZ, research has focused on an evaluation of the user interface where the results are confirmed and validated by statistical analysis. These results have determined the preferred method for presentation online.

Through a process of interface iterations from rapid prototyping through to a high fidelity prototype a series of recommendations were decided. Each decision to either include or not include a particular feature was taken from data processed either quantitatively or qualitatively. Qualitative analysis was carried out by identifying keywords or key phrases in the text from responses either written or recorded and provided from the participants.

The initial iteration process was rapid prototyping using sketching and the Pop software. This was extremely useful in the sense that it identified the areas that needed research, including:

- Efficiency and ease of use of operation.
- Design and layout.
- Visual, audio and kinesthetic.
- Electronic options available online.

These areas cover the requirements that would provide the data for an online product(s) that could be made according to validated statistical outcomes. Following this a high fidelity prototype was developed using the Axure software.

8.5 Before and After

To highlight the changes that occurred as a result of the research a before and after mock-up has been created. The before mock-up has been created using Axure. Provided below are some of the initial ideas for presentation that occurred earlier on in the iterations. Further on is the final product which is built on a Joomla mobile responsive website. The current development site for the virtual tours can now be found on the Focus360 server at: <http://view360.co.nz>

The following diagrams illustrate the changes that have occurred as a result of the iteration process. Important changes are noted after the initial prototype mock-up of the Joomla responsive website. Figure 8.1 is the before interface whereas Figure 8.2 is the after interface.

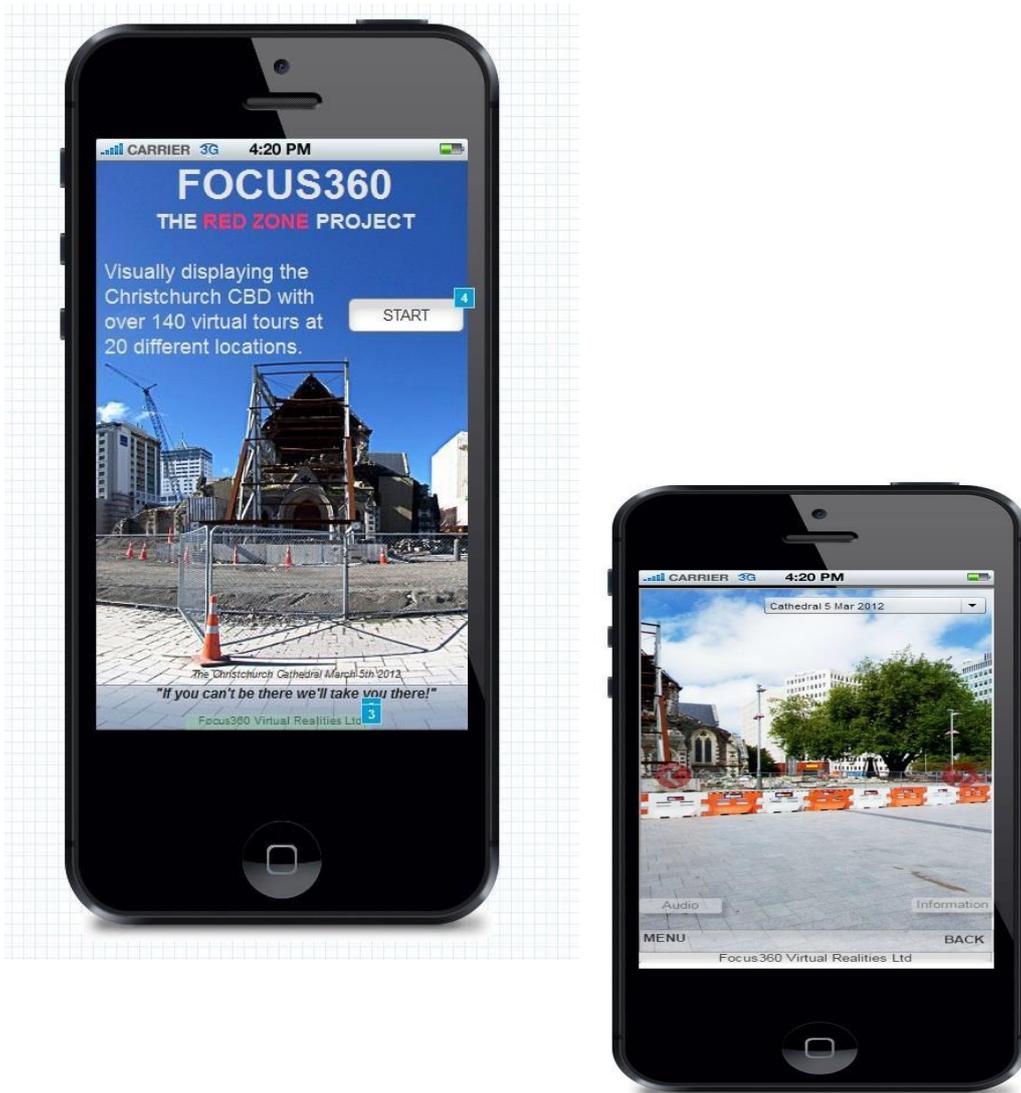


Figure 8.1: Before: Initial high fidelity mock ups built in Axure Pro with the home page and a virtual tour.

The main differences between the before and after designs include the following:

- Changes made include the launching of the virtual tours from a map or images directly, from the home page.
- No list menu inclusion.
- The use of thumbnails as the menu system.
- Ensuring audio is present by embedding the mp3 files for auto play in the website of the opening virtual tour of each location.
- Including extra information with the virtual tour so the text and the tour together create a sense of presence for the user.
- No time line on the swipe slider in this prototype
- Limited features added to the Google map

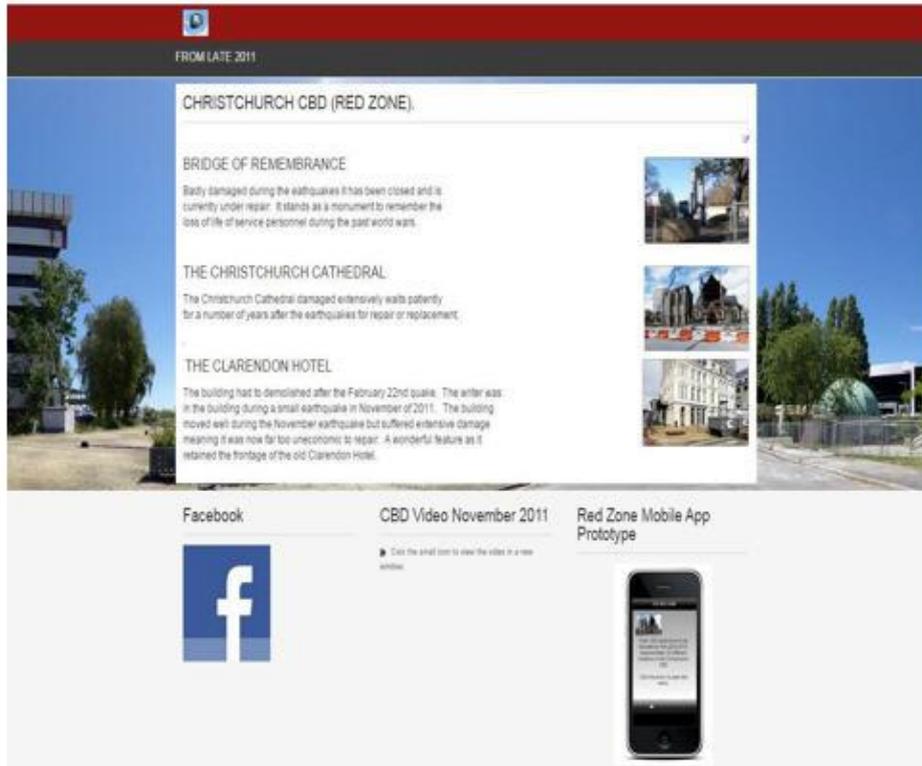


Figure 8.2: After: Landing page with virtual tours launching from image thumbnails

Figure 8.2 shows a page describing the location and providing a still image which when clicked opens a virtual tour in another window. This is a possible option if the user study identified launching virtual tours from images as one preferred method of displaying the Red Zone online. The thumbnails clearly show the location of participants were able to identify with and helped bring about a sense of location.



Figure 8.3: Virtual tour mock-up with a pinned location on an Open Source map.

Figure 8.3 integrates an open source map into the design with a pinned location. The map slides from left to right and right-to-left and the location can be identified by clicking on the red pin. This presentation was also an outcome of research as it helped create a sense of presence and also helped participants to exactly know where they were within the Red Zone.



Figure 8.4: Virtual tour mock-up of the Red Zone with a still image inclusion.

The interface shown in Figure 8.4 is a great example of blending a number of the research outcomes into one screen. A sense of presence was created by the inclusion of the still image. Thumbnails were introduced into the time slider which is a preferred research outcome. Dates and years were included and the time slider to create an understanding of progression through time. Touching the thumbnails opens a full screen virtual tour. Also in this opening virtual tour an audio track automatically plays in and adds insight by providing additional information.



Figure 8.5 Virtual tour mock-up of the Red Zone with text information included.

There are a number of options in which the research outcomes can be implemented because the designs are not linked to any particular layout. For example, figure 8.5 shows a possible layout including a text window for more information.

Chapter 9: Future Work

An exciting option available for further development of the Red Zone mobile Virtual Tour application would be the development of an augmented reality (AR) product. This development would add virtual pop-up balloons by Geolocation with accuracy to approximately plus or minus 30 m. There are many commercial systems that could be used to implement this, such as Junaio [59]. The Junaio platform has location based AR balloons. These can be added to the Junaio server and when touched can open a hyperlink to a website for more information. With a large number of different locations the window will quickly fill up with augmented reality balloons that are being viewed via a mobile devices camera.

Mobile devices have the potential to create a very effective educational platform. They have the ability to communicate information in a variety of modalities while a user is at a specific location. How the technology is implemented, communicated and how it could provide educational value is worthy of further consideration.

The outcomes of the research provided evidence that participants wanted the inclusion of audio and kinesthetic information included in the mobile device. How this is done to provide educational value may be an area for future work.

Other themes are possible for the virtual tours. The Canterbury Museum has suggested applying these outcomes to the World War 1 Walk. Further investigation into the educational value of the virtual tours with other themes warrants consideration. Even though the Red Zone virtual tours, when presented with the results from this research, are made available for viewing online it is not clear that these outcomes would be suitable for other themes. This warrants further work.

Further work and development will focus on developing software that can launch virtual tours from a map. The Commodore Airport Hotel has requested that they have the Red Zone virtual tours loaded to their concierge computers. As a consequence a web application has been developed so that the front staff can show customers to the hotel the Red Zone imagery. Each pin has an area which can be clicked to open the Virtual tour console. This area is located using image pixel co-ordinates and a shape which is not visible e.g. circle or square. Also included, where available, is audio and text information. Tool tips are provided with mouse over text providing each location's name. Other features are a full screen option. To facilitate updates the actual virtual tours are loading from the Focus360 server and are embedded as an iframe on the web page. It is worth noting that a Facebook link is included.

Figure 9.1 which is a screenshot shows the map with the red pins hyperlinked to each console of virtual tours at that location. If the mouse hovers over a red pin or it is touched the virtual tour console of that location will open in a new page. This page is the home page for the mobile responsive website.

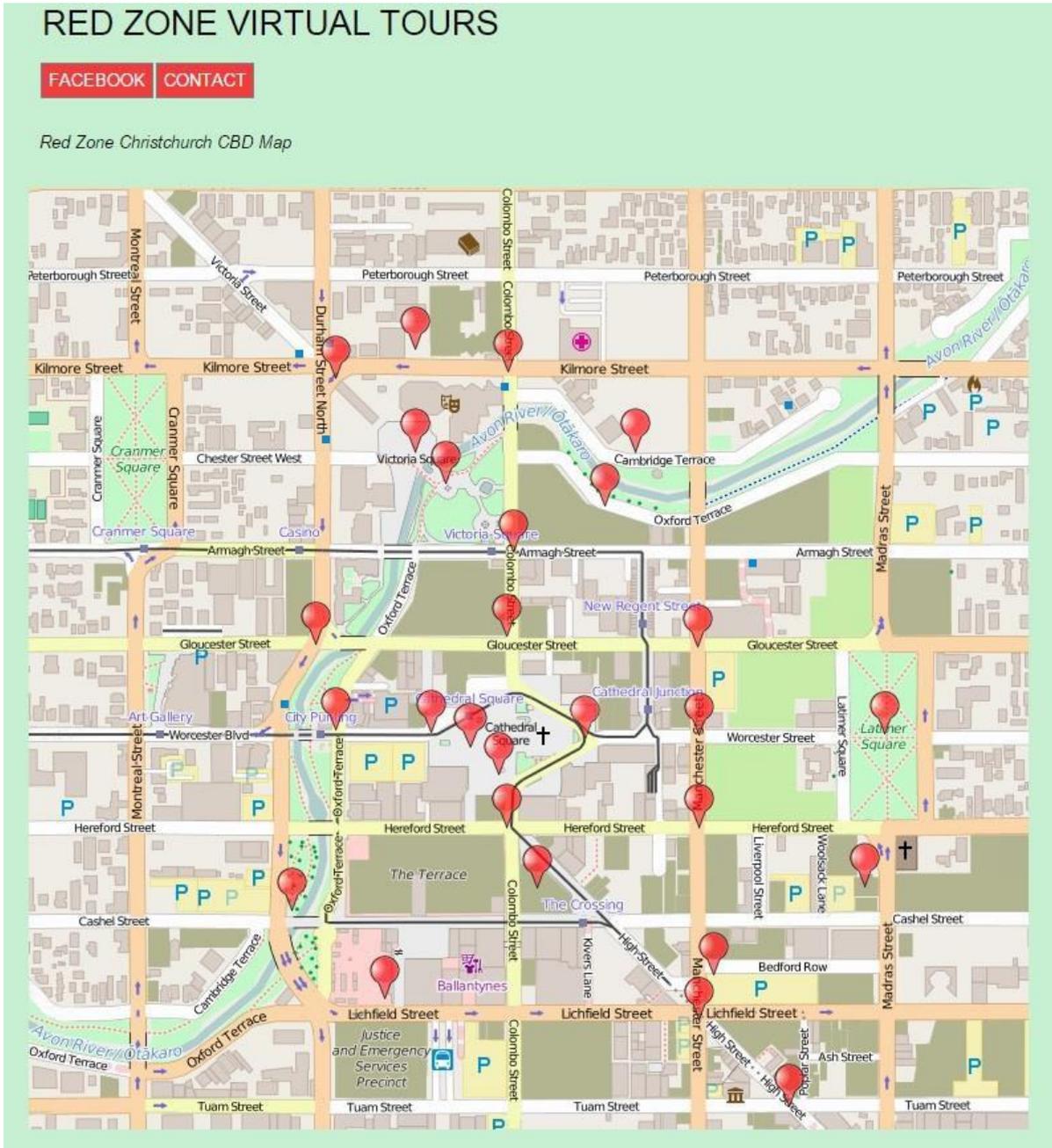


Figure 9.1: Red Zone map screen shot with hyperlinked pins.

Finally it is worth noting that another area for future research is more user studies. Especially when using the real application outdoors on any mobile device.

The Red Zone project is ongoing and will continue to provide virtual tours to the Canterbury Museum and the University of Canterbury’s Quake Studies Office until the CBD in the central city is rebuilt. It is difficult to define a date but possibly within the next 5 years.

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