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Design and Evaluation of Text-free Map Interfaces

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Design and Evaluation of Text-free Map Interfaces

Abstract

The aim of this research is to design and evaluate a text-free online map interface for illiterate people and non-local-language speakers. The use of online maps is developing rapidly and while a large majority of people are using these applications, there are many illiterate people who find them extremely difficult to use due to their inability to read the text on the maps. Symbols and audio are two methods that can be used to replace the reliance on traditional text. The research conducts two surveys to define the suitable symbol type and identify features for online map design; designs a set of text-free online map applications and finally, evaluates each designed map application based on a sample of 90 participants (Native English Speakers, non-English Speakers and Illiterate People). The results illustrate that illiterate people find it more difficult to use the online map application compared with literate people. Text-free online map interfaces are necessary to support illiterate people and the map that included both symbol and audio was the most suitable type of text-free online map.

Key Words: Illiterate People, Text-free online map, user interface design

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1. Introduction

1.1 Overview

Online map technologies change frequently and the number of online map applications has increased dramatically (e.g. Google Maps, Yahoo Maps, and OpenStreetMap are all mature applications). Electronic maps are able to help people with positioning, navigation, and route planning. However, there are many illiterate people in the world who cannot read or use any text-based map interface and a large number of non-local-language speakers who travel internationally but are unable to expertly read the text or use text-based interfaces in the countries to which they travel. For both illiterate people and non-local-language speakers, text-free interfaces are strongly preferred over standard text-based interfaces. Audio, video, static drawings and photography are all able to assist in information sharing for these groups. They may benefit from improved map technologies that allow them to use online maps and plan their journeys. Text-free online map interfaces are a vital tool to support them in way-finding.

1.2 Background

1.2.1 Illiterate People

Illiterate people are not able to read or write text (Fingeret, 1983; Elmeroth, 2003; Cooter, 2006) and almost all of them have very low skills in using electronic devices such as computers, mobile phones and tablets (Lohse, 1998; Benseman, 2011). For example, Benseman found that women with Entry 2-level literacy have few opportunities to use computers and only 18.5% of illiterate people with both Level 1 document literacy and numeracy have computer skills (Benseman, 2011). Although literacy levels have increased in recent years, there are still a large number of illiterate people in the world. In 2009, more than 700 million adults (Warrilow, 2009) lacked sufficient education in English or another major language to read text and use interfaces. In 2011, 897 million illiterate people could not read or write, with 569 million (63.4%) being female and 123 million (13.7%) being young people (less than 15 years old) (UIS, 2013). In 2013, illiteracy affected over 785 million adults in the world, with 518 million people being women (Speaking Books, 2013), which means 20% of adults worldwide are illiterate, and 66% of illiterate people are women. As of 2015, the proportion of illiteracy dropped to 17%, two thirds of them being women (UIS, 2015). The illiterate people in developed countries are much fewer than in developing countries (Frewer, 2014). UNESCO Institute for Statistics uses a histogram to show the correlation between national wealth and literacy rate, which illustrates that countries with a higher GDP have a higher literacy rate (UIS, 2013). The South and West Asia, Sub-Saharan Africa, and the Arab States have a concentration of nearly 98% illiterate people (e.g. Benin, Democratic Republic of the Congo, Ethiopia, Guyana) and some developed countries are also facing the problem of growing illiteracy (e.g. in the US, more than 93 million people had low literacy skills in 2013 (Speaking Books, 2013), while there were only 15 million illiterate people with very low reading skills in 1992 (Weiss, 1992)). Kozol said the largest number of illiterate adults is found to be white and native-born Americans, such as in Boston, Massachusetts where illiterate adults occupy 40% of the population. Moreover, a large number of functionally illiterate adults live in the world with low reading skills and need the assistance of the government (Kozol, 2011).

In New Zealand, teenagers generally have good reading levels. In 1981, Guthrie compared the different reading levels in New Zealand, US and Iran based on age groups of 14 and 18. Reading volume and speed were two indicators for evaluation. Final results showed the reading level of teenagers in New Zealand was much higher than that of other countries studied. The main illiterate people in New Zealand were adults (Guthrie, 1981).

Illiterate people are more likely to have poor health and high mortality rates. The relationships among illiterate adults is interdependent and it is difficult for them to conceptualize life (Fingeret, 1983) without reading and writing skills. Weiss conducted quantitative research to prove that low reading skill levels can affect physical health significantly. The main reason for this phenomenon is that illiterate people cannot read the information on foods or medicines, so it is difficult for them to make healthy decisions in their work, private life and diet (Weiss, 1992). Millions of US people are functionally illiterate and most are more likely to be older, poorer and have various health problems Studies show that illiterate people are more likely to contribute to crime compared with literate people. In order to discover the relationships between illiterate people and crime, Graff investigated the cases of criminals with different levels of literacy. Results showed that a larger percentage of criminals are people that can neither read nor write compared to literate people. Graff said that illiterate people are more likely to cause crimes than educated people (Graff, 1977).

1.2.2 Non-local-language Speakers

Compared with illiterate people, many non-local-language speakers have good independent living skills. They can read text interfaces with their own language, they don't particularly lack education and are no more likely to commit crimes than the general population (Alptekin, 1986; Hornberger et al., 1996). However, when in an area that does not speak a language they know, they may also find it difficult to use a map interface. Map interfaces may present place names in a character set that the user does not know, and features may be presented in the local language (e.g. search bar).

1.2.3 Mapping Technology and Text-free Interfaces

Mapping technology is evolving rapidly and the facilities offered by mature online mapping software applications like Google Maps, Yahoo Maps, and OpenStreetMap are becoming increasingly popular and advanced. Compared with traditional maps, electronic maps can help people with positioning, navigation and choosing transport modes. In order to convert people's mental maps (conceptualizations of space) into real space, during the last 20 years, mapping technology has evolved rapidly and the facilities offered by mature online mapping software applications have helped people learn how to use maps (Fisher, et al., 2007; Hunsberger, et al., 2015). These are useful for improving lives. However, there are many illiterate people in the world who cannot read or use any interface containing text. With maps people may not be able to know where they are, how to get to their destination, and it can become dangerous if they are lost. The growth of online map technologies and categories in current years has provided assistance in learning basic geography and map-using. In the past 15 years, the usage of online maps has increased dramatically. Online Google Maps was used by 71.5 million people and Google Earth by 22.7 million people at the end of 2007 (Wall Street Journal 2007), and there were more than 50,000 new websites based on Google Maps in 2007 (Tran 2007). Compared with traditional maps, online maps provide many useful dynamic functions to allow people to access and use geographic information much more easily (e.g. the Search Bar for searching for a place, Route Planning illustrates how to travel to a desired place, and Positioning for knowing one's location). The API of online map is a flexible tool with reasonable speed for developing destination-specific online services. For mobile tools, the computing power and wireless connections of small devices are the bottlenecks when communicating with online services (Berthold, 2009). More than 50,000 new websites based on Google Maps were created and 43% of mashups apply the Google Maps API (Tran, 2007; Svennerberg, 2010). The two main drawbacks of online map applications are the application developer utilizes open source methods are not suitable for data sources in the format of a commercial database stored on a secure data server (e.g. XML, Fusion Tables, CSV, or KML) and use of the Maps API platform lack of sophisticated functionalities and intuitive user interfaces that can offer the user the capability to manipulate the data (Hu, 2013; Verma P).

For illiterate people and non-local-language speakers, text-free interfaces may be more suitable than standard text-based interfaces (Medhi and Toyama., 2006). Audio (voice annotation) gives important assistance for supporting a text-free interface, and audio explanations could help illiterate people understand the meaning of the corresponding interface more accurately (Medhi and Toyama, 2007). Illiterate people may not be able to use general online maps (e.g. Google or Yahoo) since they may not be able to read place names, which is a big restriction when travelling. People may need special symbols or dynamic functions like positioning or audio to replace the words on maps in order to discover their position and their destination for improving their travelling experience.

1.2.4 The Need for Text-free Maps to Help Illiterate People and Non-local-language Speakers to Find their Way Around

Currently, universal signs that are pictorial and widely understood and text-free maps are two main methods to help illiterate people and non-local-language speakers to find their way around. However, both are limited. Universal signs only illustrate current or nearby landmarks, and the development and availability of text-free map technology lags far behind that of text-maps and there is no specific text-free category with new technology to replace the text for illiterate people and non-local-language speakers (e.g. audio or symbol functions to replace the text, positioning and navigation). In addition, previous work has not yet evaluated whether text-free maps are not really necessary for illiterate people and non-local-language speakers, and if so, which kind of text-free map is most suitable.

1.3 Aims and Objectives

The aim of the project is to design and evaluate text-free maps for illiterate people, and to consider whether these might also be useful for non-local-language speakers. The process includes defining how maps should be designed (e.g. using only symbols, using only audio, or using symbols with text), designing each defined map, and running user experience testing to evaluate maps. Finally, the results of the evaluation will illustrate which kinds of text-free maps would best suit illiterate people and non-local-language speakers. The objectives are shown below:

a) By studying the literature, define the main potential categories of text-free maps (e.g. audio-only, symbol-only) that will be designed and evaluated.
b) Define and design the suitable symbols for landmarks on text-free maps.
c) Design text-free maps and text maps for comparison.
d) Explore the best kinds of text-free maps for illiterate people and non-local-language speakers through corresponding surveys and discover the best methods for improving text-free maps.

1.4 Research Questions

Previous research has not yet addressed the question of whether illiterate people can use online maps as effectively as literate people and hence whether they are necessary or useful for the former group, and if they are, what form they should take. Furthermore, the question of whether text free maps are also useful for non-local-language speakers (e.g. tourists, migrants) has not been considered previously. The specific research questions we address are:

1. What are the differences between using online map interfaces for literate and illiterate people?
2. Is it necessary to develop a text-free online map interface for illiterate people?
3. Which kind of text-free map is most suitable for illiterate people?
4. Is a text-free map easily and effectively used by non-local-language speakers, over a text map?
5. How do text-free maps of different types compare to textual maps for literate, local-language speaking people?

2 Literature Review

This Section discusses previous research in the area, and provides relevant background theory.

2.1 Conveying Information in Text-free Interfaces

A text free interface is an interface with no text, that instead uses components without words, like images and audio. Such interfaces have proven successful for users who have very low reading skills (Elmeroth, 2003; Cooter, 2006). Text provides an unambiguous mode for literate people to interact with a computer device and may offer accompanying improvements in reading skills (Head, 2012). Semiliterate users can combine text with audio to aid in the use of the interface. Audio can help people gradually grasp the meaning of text. Experiments have been conducted in which the interface uses audio that is gradually reduced over several hours, and ultimately combined to create a text and audio interface. In this way, semiliterate users can become accustomed to word recognition (Findlater, 2009). However, compared with literate and semiliterate people, illiterate people have fewer opportunities to learn text, and their cognition of text is not improved with the help of other information carriers such as audio and video. Therefore illiterate people rely heavily on information without words when using interfaces (Friscira, 2012).

Developing a text-free interface is the most popular way to deliver information to illiterate people, converting text to other methods of delivery to express the same meaning as the text in the interface. The basic features of a text-free interface can be understood by using graphics and photographs for visual information, and voice to replace words or text (Medhi, 2005). Various icons also have been designed for text-free interfaces and evaluated to replace the text. The icons in text-free interfaces were defined as "Icons with high concreteness" (extremely similar with the real world), "Icons without too much detail" (icons should not have too much information causing possible misunderstanding of depicted items), "Action-elements in icons with action" (icons for representing actions, such as shake and movement lines) and "Icons with a human factor" (for representing real context) (Nordberg, 2010).

For text free interface design, people need to convert all complex information carriers into simple information carriers. Medhi and his group designed two kinds of text-free user-interfaces for illiterate people seeking employment as domestic laborers using digital maps. The corresponding design goals were: easy use for illiterate users, improvement in understanding of the area relevant to illiterate people. The research aimed to understand how illiterate people respond to computing technology and understanding how illiterate people react to user interface elements (Medhi, 2007).

2.2 Illiterate People and Non-local-language Speakers need Text-free Maps

2.2.1 Illiterate People and Non-local-language Speakers Need Text-free Interfaces

In relevant research, a text-free interface based on ethnographic design allowed illiterate people to learn an interface in their own way. In the testing process, experiments showed that users who had seen the textual interface were not aware of how it worked unless there were clear instructions regarding clicking on the text to cause an action. Voice feedback encouraged the illiterate people to explore all features in the text-free interface (Medhi et al, 2007a). In text-free interfaces, the possible information representations include static drawings (e.g. symbols), audio, photographs and video. Audio notice is the best information representation for understanding by illiterate people (Medhi, 2006).

Audio was the favored media accepted by illiterate people out of five popular visual representation types (Audio, Video, Photograph, Animation and Static Drawing) (Knoche, 2012). Compared with video, audio has a large influence on the understanding of the interface. Like an assistant, audio explanations for visual interfaces, especially text-free interfaces, can help illiterate people explore the interface and help them to understand the features more accurately (Knoche, 2012). A survey based on 200 illiterate people from the age of 25 - 55 who belong to lower income groups (20 - 50 USD per month) was conducted to discover how audio improves the understanding of text interfaces. Each participant was required to describe 13 different health symptoms (e.g. headaches, vomiting and difficulties in getting up from a sitting position) using five popular visual representation types. They were required to explain the corresponding symptoms while the time-taken and response times were recorded in different cases – each with and without voice annotation. The results illustrated the visual interface with audio was much more effective and easily understood by illiterate people than the interface without audio. The experimental session showed audio is also able to help illiterate people know where they are and how to navigate to their destination, and helped them define their destination more effectively (Medhi et al, 2007b).

In order to help illiterate people with difficulties arising from keyword-driven web search engines, Tijust devised pictograms that are more quickly interpreted than text. The interpretation of even simple picture symbols can offer visual representation of information instead of text for illiterate people (Tijust, 2007). For example, Bhattacharya designed an Igwana system based on the symbol tree to help provide illiterate people with more opportunities to be independent. The symbol tree is a lineal and weighted graph where the node is a pictogram with a special meaning that is represented by attached text tags. The symbol tree is composed of the text tags from symbol nodes to content items

(Belhe, 2012). The key aspect of the symbol tree design is mapping the symbol fragment to a corresponding picture fragment, such as in the example (Bhattacharya, 2012) shown below:

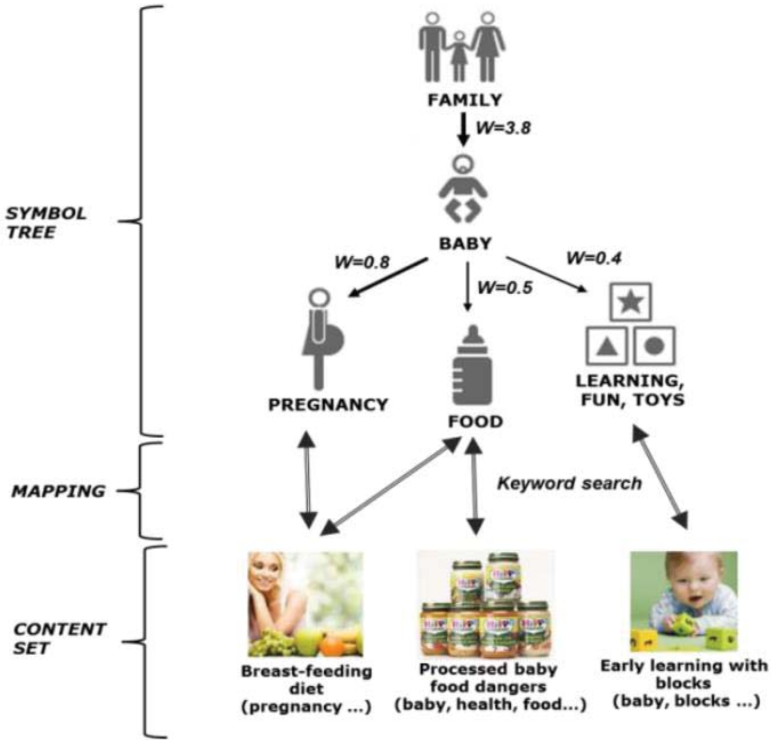

FIGURE-1: STRUCTURE OF SYMBOL FRAGMENT

As Figure 2 shows, the arrow on this graph is a path between two nodes (e.g. between ‘family’ and ‘child’). Every arrow shows a positive value of weight. The weight shows the degree of strength of relation between the family symbol and the child symbol. The add-on function in the Igwana interface is able to show the contents of the path through the symbol tree which is passed to it. The “Add-on” function is shown in Figure 2 below:

FIGURE-2: IGWANA INTERFACE

The Igwana interface is a text-free interface with symbol cues for illiterate users that is "ejaculated" by representing a real ontology. In order to replace the text using symbols successfully, understanding the users' subjective experience is the vital foundation for symbol design (Bhattacharya, 2012).

Many non-native speakers differ from illiterate people by having good independent living skills, and are able to read and use text-interfaces in their own language. Compared with native speakers, non-native speakers have a much lower reading skill. Non-native speakers can only know the main content in their reading while native speakers always focus on the detailed contents. As a result, non-native speakers are unable to know a text-based interface comprehensively or use the text-based interface well (Sheorey, 2001; Montrul, 2011). For example, in order to let the second language speakers practice conversational skills, Wik and his group developed a Deal interface to set various scenarios letting non-native speakers deal with the dialogues. The visual representations of this interface include video, audio, static drawings and photographs. Non-native speakers were able to obtain information though these visual representations to deal with various events (Wik, 2007). Non-native speakers needed text-free interfaces with the support of various visual representations.

2.2.2 Maps play an Important Part in our Daily Lives

Maps can be used to represent human activities, cultural patterns and economic exchanges, and indeed to construct worlds of the imagination (Bertin et al, 2011). Map design aims to provide input to mental worlds-maps as cognitive devices. Cognitive map-design research has the goal of understanding human cognition in order to improve the design and use of maps. Maps are used for spatial information delivery in the form of graphics and they allow users to acquire knowledge of space through viewing images on the map. Map data is stored in a spatial database and used for delivering various types of spatial information based on location, time, and the profile of end users (Hinze, 2003). Maps have simulation functions and symbolic models as the real world and maps not only illustrate the characters of spatial structure but also show the changes of time-series to allow people to make decisions in improving geography (Vermote et al., 2008; Oleinick, 2004). Maps are able to hold large amounts of spatial information (Koperski, 1995; Sheikholeslami et al., 1998). Maps are important tools for our daily life and use visual representations of real surface features like streets, rivers, and mountains intuitively. Users can discover their position, define their destination and plan how to reach their destination using this platform. One of the main functions of maps is way-finding (Hallpike et al., 1986; Passini, 1996; Golledge, 1999; Schmid, F, 2010).

2.2.2.1 Cartographic Symbol Construction

To understand and improve map functions, cartographers need to understand the effects of design decisions on the minds of map users (Montello, 2002). Map production and use should be understood as a single process of communicating cartographic information. The cartographic process incorporates the idea of map communication as symbolic, thereby pointing to the role of semiotics (the study of signs and symbols) and linguistics in cartographic communication. Symbols also have culture-specificity, the use by artists of globes and maps as emblems with their own specific symbolism. As a politically laden sign the globe or orb has frequently symbolized sovereignty over the world. Cartographic communication at a symbolic level can reinforce that exercise through map knowledge (Harley, 2009). This is a problem involving symbolism, which relies upon figurative analogies (Bertin et al, 2011). The cartographic communication model also incorporates other theories that are not inherently cognitive but formal, such as those of structural linguistics. The mere fact that for centuries maps have been projected as “scientific” images and are still placed by philosophers and semioticians in that category makes this task more difficult. In any symbolism study it is only through context that meaning and influence can properly be unraveled. Such contexts are defined as the circumstances in which maps were made and used. For example, in early America, when many different agencies made maps and created their own symbology to convey critical information, the exchange and quick interpretation of important information was made difficult by the lack of a common symbology.

Map symbols can be thought of as a material object that is being represented by something immaterial; a token or sign. Replicative or abstract are two categories of symbols applied in maps. Replicative symbols are designed to look like the feature they represent. These symbols do not need to have any direct connection to what they identify, but they may be representational (eg. in hazard mapping of a severe weather area, people may see the outline of a tornado that replicates the cloud pattern seen when a tornado has formed). However, abstract symbols generally take the form of a geometric shape. This type of symbol has no relationship to the form of the object it symbolizes (e.g. a hospital can be represented on a map as a letter H, or perhaps a circle or box with or without an H inside). A range of map symbology schemes have been used and were developed by international organizations, individual, local and private agencies. However, there are no specific standards to indicate what symbol is appropriate to present a given feature (Dymon, 2003).

In early years, map symbol design was based on the name of the object (e.g. a hospital can be represented on a map as a letter H; a river can be represented on a map as a letter R) (Harley, 1989). However, for illiterate people who can't read the word and recognize the letter, designers started to consider using symbols with physical characteristics to allow illiterate people to image the entity. Therefore, symbols with many different characteristics appeared (XIE, 2006; Lee et al, 2014), and these symbols always contained the area feature and colour so that illiterate people have enough information to determine what they represent. However, accompanied by the development of map technology, when map interfaces require many symbols, methods to simplify the symbols to make them smaller and more clear have been considered. New symbols composed of only points and lines have been designed (Nianxue, 2003, Weiwei, 2006). However, it is not clear whether such simplified symbols also can be understood by illiterate people or not. We explore this question in this thesis.

2.2.2.2 Ontology

Ontologies provide structures of geographic feature types to reflect people's conceptualisations (like Figure 3 below), and a number of geospatial ontologies have been developed to help people to interact with geographic data. That geographic feature types and the linkages between them have been described in a number of geospatial ontologies, and could be used to identify more extensive sets of features that could be included on a text-free map. Symbols are used to represent landmarks, and ontologies can be used to identify the landmarks that may be important and releveant for inclusion on a text-free map (Hu et al, 2013).

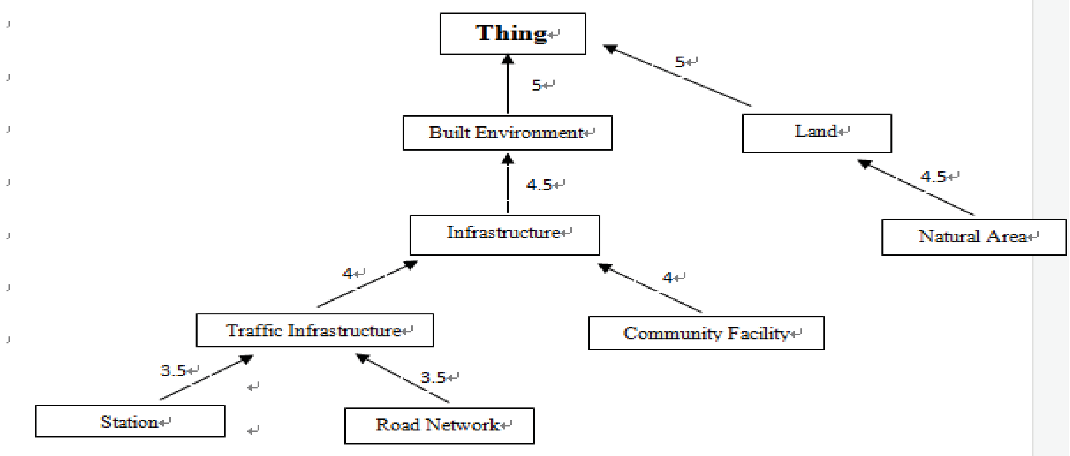

FIGURE 3 AB EXAMPLE ONTOLOGY

2.2.3 Wayfinding for Illiterate People

The most popular way to help illiterate people and non-local-language speakers is designing universal signs. Signs are helpful for wayfinding, and provide effective wayfinding systems for illiterate people and non-local-language speakers in unfamiliar environments. Many people from different cultural and linguistic backgrounds are also able to find their way in a new environment based on universal signs (Lee, 2014). For example, Figure 4 below shows the signs for different departments of hospital, CM04 is the ward, CM05 is department of surgery, FA10 is the internal medicine, illiterate people and non-local-language speakers are able to find each department in hospital based on these signs (Nicol, 2007).

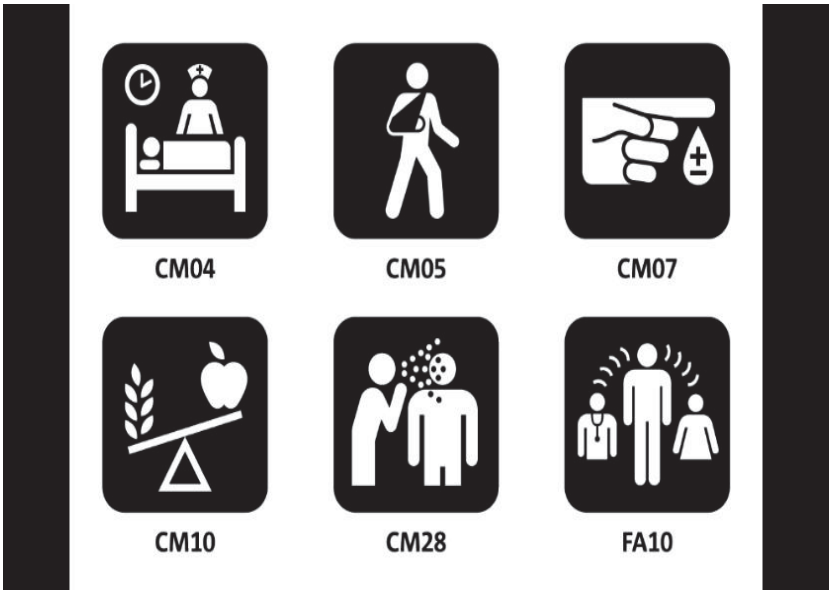

FIGURE 4: SIGNS FOR HOSPITAL

Another way to help illiterate people and non-local-language speakers is deigning text-free map (Medhi, 2006), which rely heavily on landmarks. Text-free maps try to use more symbols to replace the texts to deliver the GIS information. For example, in Figure 5 below, symbols represent landmarks, lines represent routes (various colours represent different traffic lines), photography represents important landmarks, a specific icon represents the orientation (at the left top). For illiterate people and non-local-language speakers, text-free map interfaces can help them find their way in a small area with the simple terrain (Medhi, 2006; Medhi, 2007a; Bergen, 2012).

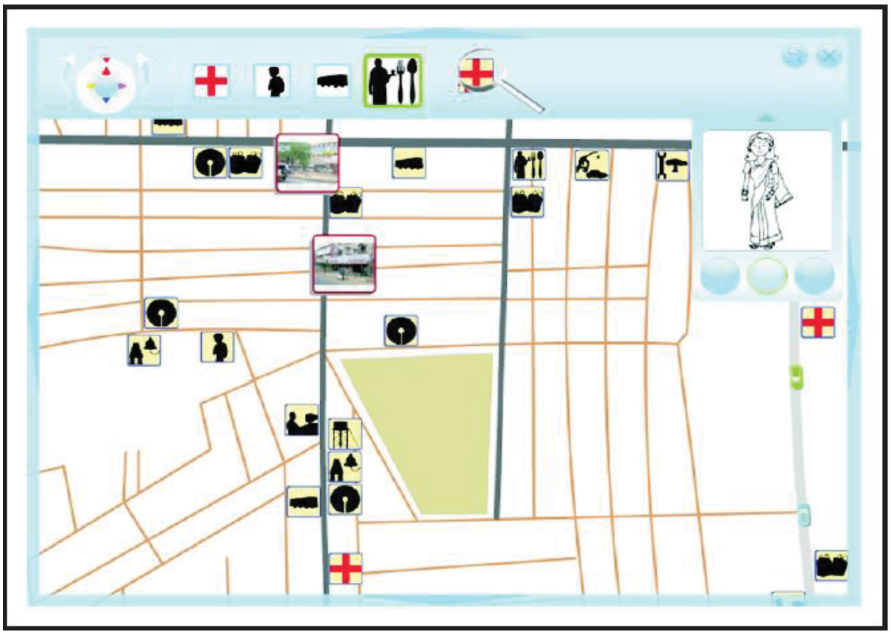

FIGURE 5: TEXT-FREE MAPS

However, three main elements that are important in helping people find their way include environmental communication (understanding of environment), architecture (which delineates spatial organization) (connection and orientation of different positions) and destination zones (positions of environment) (Muhlhausen, 2006). Both universal signs and currently text-free maps all have big shortcomings. Universal signs lack environmental communication and architecture that delineates spatial organization, which means that illiterate people can only find current or nearby places rather than a detailed path to the destination, and it is possible that not every sign can be understood because of cultural factors (Morais, 2001). Although text-free maps have effective architectural wayfinding clues (e.g. roads and building layouts), their development lags far behind that of text map (e.g. text-free maps have no any mature products like Google map widely used accepted by people). The main problems of text-free maps symbols are that they are not universal (many of them can't be recognized), the paths are too Simple, and there are no dynamic functions for easy use (Medhi 2006; Matise, 2007). There is no specific text-free category within new technology to replace the text for illiterate people and non-local-language speakers (e.g. audio or symbol functions to replace the text, positioning and navigation). Also text-free map interfaces have not been well evaluated for illiterate people and non-local-language speakers to determine whether text-free maps are really necessary for them and if so, which kind of text-free map is most suitable.

2.3 Theory on How People Conceptualize Space for Way-Finding

In this section we review the theory behind wayfinding and conceptual models of space, as a foundation for the design of text-free maps. Maps do not present the world directly, but present the world by providing a representation that is a version of the model held in human minds (Montello, 2002). Only by maintaining linked, relational conceptions of space and geography can we approach a full understanding of the inter-relationships between them. This inter-relationship involves relational assemblies linking technological networks, space and place, and the space and place-based users (and non-users) of such networks. Such linkages are so intimate that defining space and place separately from technological networks soon becomes as impossible as does defining geographic technology separately from space and place (Graham, 1998). Therefore, to conceptualize space is to understand its structure, which is the foundation of map design (Graham, 1998; Kitto et al, 2013).

2.3.1 How people Conceptualize Space

Geographical information systems (GIS) are computer programs for spatial information processing. All information displayed in the form of maps is based on location in space (Kvamme, 1999). People like to conceptualize information space through user motion from physical space to information space. Our world is composed of physical and information space.

The three phenomena of Spatial Interaction are defined as people-to-people, people-to-space, and space-to-space (Huang et al., 2002; Huttenlocher et al., 2004). Space is composed of physical and information components. Physical space means how people move from one point to another point. However, all symbols, all dynamic functions (e.g. scale size, navigation, and location services) and data included in maps are based on information space.

Interactions between people and information space may generate a successful space conceptualization for mapping (Graham, 1998; Maglio, 1999). How people conceptualize space is the foundation for better designs for GIS to allow people to use such systems more easily (Couclelis, 1992). Many early researchers have tried to build different models of how people conceptualize space. The cognition of space focuses on the distance, orientation, movement and location of objects in space rather than the environment itself (Siegel 1981). This framework illustrates the manipulability related to the ability of moving objects in space. Locomotion is related to travelling through and learning space, while size is related to how to constrain spatial cognition and experience. Geographic space is created by people's spatial cognition and experience, which is decided by manipulability, locomotion and size of space.

Moreover, defining space categories from a geographic perspective can offer people a better understanding of spatial behavior and improve the interaction with space for humans. Therefore, it is necessary to develop navigational tools to track multiple small objects for enhancing the efficiency of interaction with space (Freund, 2001). In addition, different spatial scales should have influence on the design of spatial communication systems. Both linguistic and non-linguistic information are concerned about creating effective user-interfaces, such as maps and personal navigation systems (Montello, 1993).

2.3.2 Way-finding is based on Space Conceptualization

Way-finding includes all the ways in which people navigate from place to place in physical space, which is the process of people-to-space interaction (Huang et al., 2002). Way-finding design is based on the settings of spatial organization, the circulation system and graphic information. The layout of landmarks and routes both define wayfinding problems (Passini, 1996). The conceptualization of five city elements influences the success of way-finding. These are Node, Path, District, Edge and Landmark (Lynch, 1960).

All models of conceptualizations are set by the spatial notions: axial lines and isovists. Axial lines are for connecting the spatial settings (the fewest and longest lines on the map), while isovists are the volume of space visible from a given spatial point in space. Therefore, axial lines and isovists both influence the success of a layout of the five city elements (Dalton, 2003). Way-finding is about how people conceptualize space in their brain, with five city elements prominent in the space conceptualization. Landmarks represent people's mental representations of the features (e.g. bus stations, restaurants and universities). Paths tell users the direction and how to arrive at destinations (McNaughton et al., 2006). Nodes illustrate the connection of traffic lines. Districts are used for identifying the extended area around intersections. These five elements make up the complete mental map together (Lynch, 1960; Al-Kodmany, 2001).

Landmarks are identifiable objects acting as reference points for people to recognize objects in the environment. The process of way-finding is based on environmental and mental images, and these images are created by immediate sensation and past memory (Lynch, 1960). Landmarks play an important role in distance and direction estimating for way-finding. Tversky found that cognitive maps are used to help us recognizea particular map or environment. The main reason for problems in way-finding is landmark, which are the most important way to organize spatial information in the cognitive maps. People usually estimate both distance and direction based on landmarks and their mental representation of the environment is also based on landmarks (Tversky, 1992).

Choosing correct paths will lead to accurate way-finding. Users usually respond positively to warm-toned lines. Red lines can be used to show important paths in maps to help people find their destination. Warm-toned lines represent paths that may allow users to view the relative routes more clearly (Darken, 1996; Hartley et al., 2003). McNaughton illustrates the process of path integration in mapping. He showed how neurological mechanisms affect path integration for cognitive algorithm maps. The experiment involved setting a mouse onto a piece of paper with lines of different colors: red, orange, green, black and grey. The mouse was observed in terms of the route it took. Results illustrated that the mouse mainly moved along the red and orange lines. The encoding in the hippocampus leads to the awareness of cognition of the path integration (McNaughton et al, 2006).

Landmark identification is used to define all candidates for geographic objects in a certain region that may serve as a landmark shown on a map. Two approaches for identifying landmarks are computing salience and data mining salience. Computing salience concerns measuring the "Attractiveness" based on visual, semantic, and structural attractiveness. An object with high attractiveness could be a candidate to be a landmark. Landmark identification is used to define which objects need to be drawn on a map within a certain area. For example if at an intersection, the surrounding buildings are a café, a bank and a large shopping centre, space limitations may mean the designer needs to consider which building is suitable to be shown on the map to represent this intersection. The corresponding measuring method is a route algorithm (for calculating routes to landmarks) based on the distance, orientation and salience (Richter, 2014). Some people have a poor sense of direction (SOD) which results in them losing their direction when travelling. The prototype interface offers some main landmarks (e.g. airports and power plant) to let people associate objects. Visual, semantic and structural landmarks are three main landmark categories (Quesnot, 2015).

2.3.3 The Factors that affect people's Spatial Conceptualizations

The following explores the factors that affect people's conceptualizations of space and identifies possible ways to represent information. The environment plays an important role in the social development of humans. Young people these days have a restricted spatial range (Carver et al., 2013) because they do not have as much experience with local environments since they usually move about using vehicles. Research was conducted to try to discover factors that affect young peoples' (9 - 19 years of age) independence and to conceive risks in their processing of moving around a city. Depeau found that distance is the most important factor affecting people's spatial cognition in an environment, since they often ask for places for shopping and eating along the way. Another factor is travelling time. Long distance travelling means an increased risk of following the wrong route. Routes should be considered carefully since dangerous routes may bring about increased risk for young people. Environmental spatial characteristics may help people to enhance their awareness of independence and conceive risks in way-finding (Depeau, 2001).

There are two traditional ways of conceptualizing space: the regional approach and the space as a container approach. The regional approach means showing the various regions and physical complexity (Andrews, 2003). Space as a container means setting the space as a co-ordinate which allows different phenomena to be distributed (Hartshorne, 1958). Place is not just a static “background”, but is embued with meaning for individuals. Society’s conceptualization of the environment is shaped by places and space. Geographic proximity is able to shape experience (Valentine, 2001; Silverstein, 2006).

In 1999, Maglio also ran qualitative research on discovering how people conceptualize the information space of the World Wide Web. The empirical study illustrated that people rely on knowledge of information space (landmarks, routes and survey knowledge) and conceptualize space based on organizational principles and elements: paths, landmarks, districts, nodes, and edges. This phenomenon led to map navigation, an important GIS function for supporting the ability to search for a specific place, planning a route or moving between two points successfully. The experiment session aimed to test how people think about the web with natural settings and users’ actions on the web. A total of 24 students of the University of California (Santa Cruz campus) were selected as participants (13 males and 11 females, all native English Speakers). Twelve people in each group were experts and beginner web users. Each participant was required to use a specified website and complete a questionnaire about their user experience and how long they used this website. The data showed the beginners preferred to pay more attention to the physical elements domain (e.g. keyboard and mouse) than experienced users. Beginners were more likely than experts to regard the web as a container. The final results illustrated that people expressed the experience according to the user motion from physical space to information space. Due to the consistency of conceptualizing information space being very high, people may have an appropriate metaphorical and spatial understanding of the information space. Further study will center on the conceptual differences between real and information space to enhance the interactions of information space (Maglio, 1999).
The web can be conceptualised as a container that stores and displays spatial conceptualizations. Services containers meet all specifications for the Web container already mentioned and provides, support and management of Web services.
Web stores and shows Space Conceptualizations in three ways
• Communication module to build communication of Space Conceptualization
• Processing module to process ingoing and outgoing spatial data
• Service module to store and invoke the requested Web service. (Mohamed et al, 2011; Mustafa,2009)

2.3.4 Mental/Cognitive Maps

The aim of cognitive map-design is understanding of human cognition in order to improve the quality of the designed map, in order that it might more closely reflect the maps individuals hold in their heads. Cognitive maps are signed digraphs, combining spatial memory and spatial representation (Montello, 2002). In cognitive maps, nodes are variable concepts and edges are causal connections.

These cognitive models of space are composed of geometric data (Frank 1992) based on mathematical points from pinpoint space which is static and cannot reflect useful concepts about geographic space for people. Cognitive maps mainly indicate routes, paths and environmental relationships and every position in a cognitive map is characterized as varying from a narrow variety to a broader variety (Tolman, 1948; Montello, 2002). For example, Figure 6 below shows a person's cognitive map of the environment surrounding his home and landmarks were shown through his favourite shapes. Cognitive maps can be regarded as a foundation for final map study and design (Montello, 2002). Firstly, symbols of cognitive maps represent the landmarks for the individual and are not the specific symbols perceived by the public. Secondly, the scope of cognitive maps has boundedness, and most cognitive maps are only able to show a small area, and can't contain a country or the world. Thirdly, cognitive maps only show the environmental relationships for each position while each position in cognitive map is not precise. Last but not least, people can't quickly obtain their position through a cognitive map (Zahra, 2005; Papageorgiou, 2011). Therefore, it is not sufficient to create maps that include only the contents of a cognitive map, but the design must consider aspects to address the shortcomings of cognitive maps, including the use of broadly understood symbols, pan and zoom functions to allow access to more landmarks, and function to allow people to obtain their current position.

FIGURE 6: EXAMPLE OF COGNITIVE MAP

2.4 Online Maps to Reflect the Mental Maps held by Users

2.4.1 Online Map Technology is Developing Rapidly

In order to convert people's mental maps (conceptualizations of space) into real space, during the last 20 years, mapping technology has evolved rapidly and the facilities offered by mature online mapping software applications have helped people learn how to use maps (Fisher, et al., 2007; Hunsberger, et al., 2015). Evidence of this is shown in the large amount of use of online maps. For example, individual web servers had already reached 700,000 maps accesses in 1997 (Peterson, 1997), and the Earth Viewer site created over 18,755,588 maps between 1994 and 1997 (Peterson, 1997; Radke, 2000). More recently, Google Maps, Yahoo Maps, and OpenStreetMap have all developed into mature and popular online map applications. As the most popular online mapping software, Google Maps was used by 71.5 million users and Google Earth by 22.7 million users at the end of 2007 (Wall Street Journal 2007). More than 50,000 new websites based on Google Maps have been created and 43% of mashups apply the Google Maps API (Tran, 2007; Svennerberg, 2010)

Compared with traditional paper maps, online maps provide many dynamic features for people to save time in travel planning and they enhance the efficiency of travelling to a high degree. For example the Search Bar feature is used for searching places, the Route Planning feature illustrates how to arrive at a destination, the Positioning feature is used to determine a user's current position immediately, and the Navigation feature gives turn-by-turn instructions on how to get to a destination. There is no disagreement that traditional maps will be replaced by online maps gradually. As Peterson said: "traditional paper maps are static maps that just present a single view while Internet maps are dynamic applications that allow users to adjust the scale or otherwise alter the view. The Internet must develop rapidly in the future" (Peterson, 1997; Brown, 2001; Steiniger, 2013).

2.4.2 Online Map and symbols

Successful way-finding is determined by suitable planning of these five city elements. However, Landmarks are the most important elements (Grierson, 2009; Richter, 2014; Kamil & Cheng, 2001). Richter used a landmark level structure to illustrate how landmarks represent each location. He defined landmarks using a hierarchy of hypernyms based on an ontology. Level 0 is Landmarks, Level 1 is Position, Level 2 is Points, Level 3 is Location, Level 4 is Objects and Physical Objects, Level 5 is Physical Entities. The computing processes for landmarks include landmark identification and landmark integration respectively (Etienne, Maure, & Séguinot, 1996). In addition to offering people conveniences in daily life, another important reason for the dramatic increase in the usage of online maps in recent years is the corresponding database technology providing a secure and complete database that is improved upon constantly. Collected data can be easily retrieved through online mapping applications instead of formatting data transformations. The resulting data can be updated and refreshed quickly and complex data manipulation can be extracted easily through SQL scripts (Goetz, 2012; Hu, 2013).

2.4.2.1 Symbols for Landmarks

One of methods used to develop early cartographic map symbols involved intensive study of photographs in a large portion of Northern Ontario (Dean, 1956; Leung, 2002). The lack of standardized symbology on maps seriously hinders information sharing during important emergency cases (Dymon, 2003).

However, different people have various opinions on certain symbols (especially illiterate people) that can lead users to misunderstand some map features and fail to navigate accurately. Therefore, it is necessary for designers to investigate users' demands for symbol designs on maps (Williams, 1958; Leung, 2002; Handcock, 2004). The size of a symbol has a significant effect on recognition and the time required for searching for specific landmarks on maps (Handcock, 2004). It is easy for specialized map users to interpret the meanings of map symbols accurately, while many symbols may lead to misunderstandings for general map users (Handcock, 2004).

Handcock investigated the degree of familiarity by different age groups with various symbol types. A total of 40 safety symbols and 4 categories (hazard alerting (19), mandatory action (7), prohibition (7), and information symbols (7) were used). The findings illustrated the comprehension rates for the two age groups were both lower than 85%. The accuracy rate of younger adults was much better than that of older adults. Survey results also suggested that the symbol designer should not assume that certain symbols are easily understood by others, since they frequently use them in a specific context.

The different scales of color screens may affect the results of screen visual evaluations for interfaces (Handcock, 2004). For online map designs, the colored screens used for scales of values will affect peoples' judgement of space. Especially for light colors like yellow, steps will also follow the curve of the grey spectrum. In order to solve the common problem with selecting screens to show suitable scales of values, Williams conducted research to determine what scale of each color screen should give the visual steps from white to all colors. The test used a black screen as the reference color, comparing it with red, orange, blue, yellow, green and brown. Both triangular-patterned dot screens and line screens showed the colored screens did not behave in the same way as the black screens and different patterns of colors may affect the results of screen visual evaluation (Williams, 1958). For better map designs, larger symbols performed better than medium-sized symbols as the larger symbols were easier to understand than medium symbols. Black symbols were also better accepted than the symbols with other colors of the same size (Morrison, 1995)

2.4.2.2 Location Based Services (LBS)

Location-based services are an important set of software-level services that support the use of online map interfaces by which controlling the display of geographic features based on location data. They offer a service to identify a location, as well as object tracking to let people find and arrive at their destinations easily (Steenstra,2004, Li, 2006). In short, location Based Services (LBS) assists users to perform way-finding (Raubal, 2004; Li, 2006). A simulated LBS application with multi-mode information is thought to be more efficient in helping individuals to complete way-finding (Li, 2006). For example, when a driver can look for a nearby restaurant during his or her travels, the GPS sensor of a navigation system would obtain his or her current location automatically. The whole LBS system includes a location information source, a wireless network and the corresponding location servers (Gruteser, 2003). The main working principle is that when users send a request to a LBS (e.g. clicking the "Location" button in Google Maps), the service obtains the users' current location information immediately from the location server which acts as a proxy (Gruteser, 2003; Brush, 2010). LBS is a great tool to help illiterate and non-local-language speaking people to identify a location, combined with object tracking to let people find and arrive at their destinations easily without reading the text, LBS development is in the context of LBS-P. The corresponding procedure is shown below:

1. Users send position data (request) to a service provider.
2. The service provider replies to the request according to the received position data and delivers it to the user through the server.
3. The user receives a reply message.

LBS providers are similar to web servers that log requested URLs and source IP addresses of the requesters (Gruteser, 2003; Kido, 2005). Ubiquity, congestion, and uniformity are three main characters for anonymous LBSs (Kido, 2005). Normally location-based services rely on intermittent location tracking and trace logs of GPS data (Benseman, 2011).

The LBS-P (Location Based Service Platform) is able to support the data transmission process of LBS to make online map services work effectively (Zhao, 2008; Wang, 2010). The LBS development is in the context of the LBS-P. Wang used Byte-Map Data to run experiments to prove the LBS-P Service (a LBS Platform, consisting of data mechanisms, data transmission modules and GIS service modules) can support online map services well. LBS-P mainly supports Map Rending Processing and Data Loading Processing in the online map designing processes. The aim of the experiment was to test whether LBS-P can help LBS transfer a large volume of data. Firstly, the original map of this experiment was in the GML format which contained 7 layers (the data size of Admin Areas was 1,649,435 bytes and that of landmarks was 2,401,979 bytes). Secondly, the performance of LBS-P Mobile was tested which included the volume of transferred data, the speed of data loading, the speed of data transmission and the display time. Finally, based on the test results of the last part, the operation performance for LBS-P Mobile was tested by examining moving left, and zooming in and out at various scales. The results of this experiment illustrated that the majority of processing time was the data transfer without the LBS-P (Wang, 2010).

It must be questioned how accurate a location based service needs to be to provide useful information. It is difficult to determine the minimum accuracy requirements for LBS but more accurate information is more useful (Gruteser, 2003). To enhance the accuracy of the GPS trace and to reduce the costs for transmission and storage of trajectories for Intelligent Transportation Systems (ITS), Steinmann and his study group ran a test based on the Hidden Markov Model (HMM), a map-matching algorithm measuring Noise and Sparseness which combines spatial, temporal and topological aspects of machine learning. The main theory of this test was that all candidate paths are evaluated based on their likelihoods after a trajectory point is generated. Previous solutions are altered to consider new data, and the end solution is defined as the highest joint likelihood of the last trajectory. The main method is a fixed sliding window (FSW). Firstly, some road segments were defined, with each one having an emission probability for overserving the GPS point. A higher likelihood point was assigned to the segment, and finally every transition probability for discovering the maximum likelihood path was calculated. The results illustrated that the map-matching accuracy of rural areas was significantly more accurate than that of urban areas. FSW shows consistently higher accuracy and output delays. Hence, FSW is a suitable way to solve problems that involve the accuracy of GPS traces and to reduce the costs for transmission and storage of trajectories (Steinmann, 2005).

2.5 Usability

Usability is a vital element to measure the quality of a product, which is a multidimensional construct that can be evaluated from many aspects, including whether the interface is functionally correct, efficient to use, easy to learn, easy to remember, and pleasing (Molich et al., 1999; Jeng, 2005). Usability is the most important principle, encompassing learnability, efficiency and effectiveness of a product (Albert 2013). Efficiency represents the accuracy and how quickly goals can be achieved in testing. Effectiveness represents the accuracy and completeness of specified goals achieved in particular environments. Satisfaction shows the degree of comfort and acceptability of the working system (Molich et al., 1999, Albert 2013; Lin, 2013). Usability testing is based on business goals and context, user needs and product content. Emotion and affect emphasizes the degree of happiness of using products (e.g. decision-making and subjective wellbeing). Relative measuring standards include subjective and positive attitudes of product use. The affect of an interface is based on antecedents (e.g. willingness-to-pay) and consequences (e.g. money spent on products). Experiments in usability involved checking the dynamics, the degree of complexity, and how the product is situated and temporally-bounded (Hassenzahl, 2006).

In addition, usability does not exist in any absolute sense, but only can be defined in particular contexts. It means that there is no absolute measure for usability. If the usability of an artefact is defined by the context in which that artefact is used, measures of usability must of necessity be defined by that context too. Despite this, there is a need for broad general measures which can be used to compare usability across a range of contexts. The System Usability Scale (SUS) is a reliable, low-cost usability scale that can be used for global assessments of systems usability. SUS is a Likert scale. It is often assumed that a Likert scale is simply one based on forced choice questions, where a statement is made and the respondent then indicates the degree of agreement or disagreement with the statement on a 5 (or 7) point scale. However, the construction of a Likert scale is somewhat more subtle than this. The approach for calculating the corresponding scores for SUS to measure the usability is defined by previous study (Brooke, 1996; Borsci, 2009; Bangor et al., 2009; Kortum, 2013). Another popular way for usability testing is Software Usability Measurement Inventory (SUMI) which provides a valid and reliable method of measuring users' perception of the usability (an objective way of assessing user satisfaction with software). SUMI evaluation combines Affect (user's emotional feeling of interacting with product), Helpfulness (user's opinions that the software communicates in a helpful way) and Control (users feels that he and not the product, setting the pace). However, SUMI has a significant drawback that the accuracy of the findings is limited (this can be solved by adding a small number of open question to the SUMI questionnaire) (Brooke, 1996; Arh, 2008)

2.6 Summary

There are still many illiterate people in the world, and these people are mainly distributed throughout South and West Asia, Sub-Saharan Africa, and the Arab States. Some developed countries also face problems of growing illiteracy (Speaking Books, 2013). Illiterate people cannot read text and may have a low level understanding of how to use electronic devices (Fingeret, 1983; Cooter, 2006; Benseman, 2011). In New Zealand, the majority of illiterate people are adults and they may have few opportunities to use computers (Benseman, 2011). Illiterate people have a high probability of having health problems. It can be difficult for illiterate people to be independent and enjoy an optimal quality of life without reading and writing skills (Nejati, 2008).

Text free interfaces are interfaces with minimal or no text that use other components like images and audio to assist illiterate users. Text is not the exclusive method of information representation. Audio in interfaces is the most widely used feature for delivering information to illiterate people. Currently, universal signs and text-free maps are two main methods to help illiterate people and non-local-language speakers to find the way around. Universal signs point to current or nearby landmarks, and the development of text-free map technology lags far behind that of text-maps and there is no specific text-free category within new technology to replace the text for illiterate people and non-local-language speakers (e.g. audio or symbol functions to replaces the text, positioning and navigation). Therefore, we need to evaluate which kind of text-free map is most suitable for illiterate people and non-local-language speakers.

The principles of text-free map design need to consider cognitive maps. Cognitive maps mainly indicate routes, paths and environmental relationships (Tolman, 1948; Montello, 2002). However, symbols used on cognitive maps to represent landmarks are not the generalized symbols that are broadly understood by the public. The scope of cognitive maps has boundedness, and cognitive maps are only able to show limited areas. Cognitive maps only show the environmental relationships for each position and those positions may not be precise. Therefore, cognitive maps leave many gaps in providing a template for wayfinding functionality that could be used to develop a text-free map for illiterate users.

Compared with traditional paper maps, online maps can provide many dynamic features for people to save time in travel planning and they enhance the efficiency of travelling to a high degree, but this functionality is not currently available to illiterate users. In this research, we investigate the range of functionality that may be required for text-free maps.

Usability is a vital element to measure the quality of product, which is multidimensional construct that can be evaluated from many aspects, functionally correct, efficient to use, easy to learn, easy to remember, and pleasing (Molich et al., 1999; Jeng, 2005). The corresponding principle includes learnability, efficiency and effectiveness of using the product will be the foundation for text-free map evaluation experiments design in this research.

3. Research Procedure

3.1 Introduction

This Section describes the methodology of this research. The approach consists of four parts: two surveys to define suitable symbols for the text free maps and features to be included in the design; the design of a set of web maps and a usability test (100 respondents) of the designed map evaluation. The green part in Figure 7 below shows the methodology, and the numbers refer to chapter numbers.

3.2 Detailed Research Procedure

In this project, the maps use data from OpenStreetMap (a popular online map) (Haklay, 2008) with the main map development tool being OpenLayers (Steiniger, 2010). A total of 5 web maps were required for comparison purposes (2 text maps & 3 text-free maps: text with symbol only, text with audio only, text-free with symbol only, text-free with audio only and text-free with symbol & audio). The reason for only choosing symbol and audio as visual representations is based on the results of previous study that audio is the most widely used feature for delivering information to illiterate people and map interface only composed with the simple static drawings (e.g. symbols, lines, no photograph or animation).

The two main parts of methodology includes text-free map design and usability evaluation of designed maps, before map design there are two surveys should be running as the foundation. Survey one illustrates how we select the symbol type for text-free map design. After the symbol type is decided, different map features mean different map types, survey two decides which map features will put in text-free maps. When symbol type and map features are all decided, we should design the text-free maps for evaluation (survey one and two both feed into map design). Finally evaluate the usability of designed maps to dis cover which kind of text-free map is the best for illiterate people and non-local-language speakers.

The generating process of text-free map runs in the ESRI ArcGIS Environment. The orange box illustrates the findings of the literature review and the green boxes in Figure 7 show the steps in the methodology.

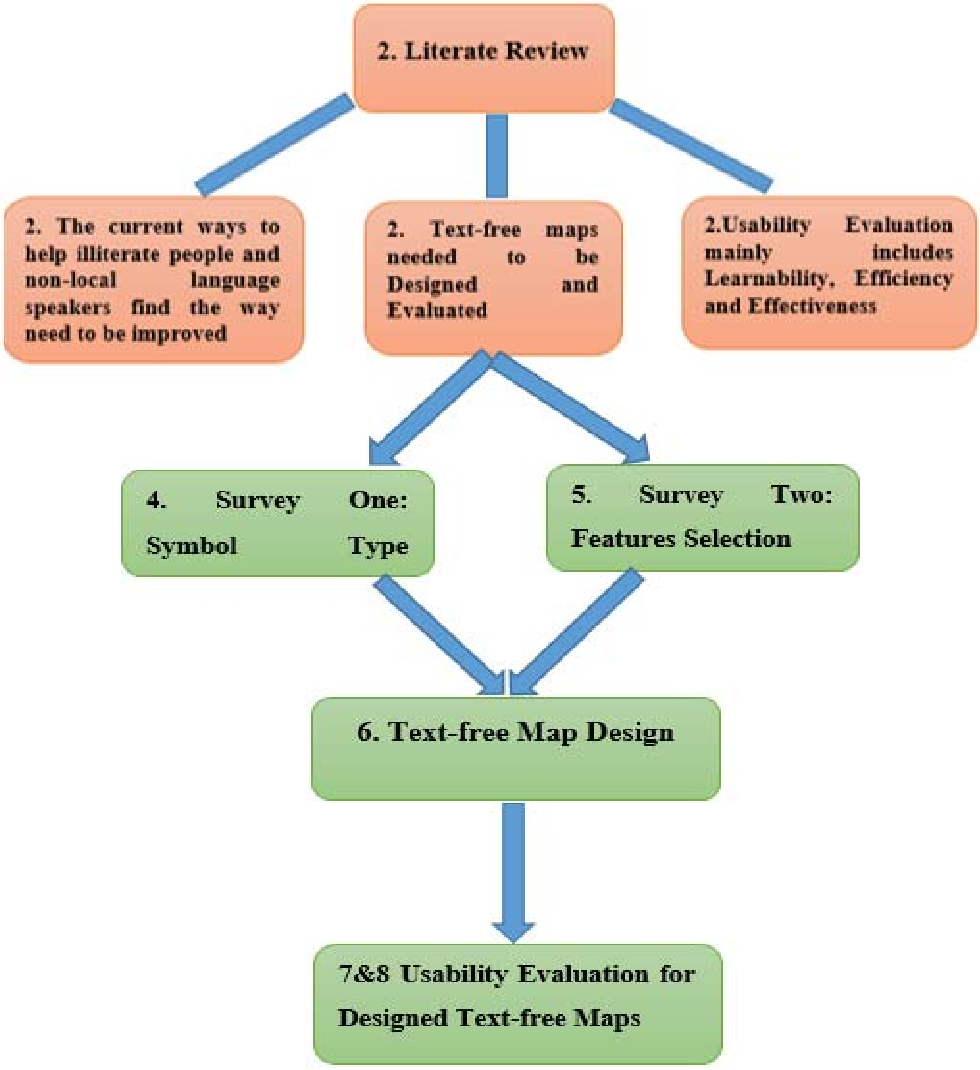

FIGURE-7: MODEL OF RESEARCH PRODUCE

3.4 Summary

This chapter indicates the broad research process, and detailed methodology is presented in the Chapters discussing each of the surveys.

4 Survey One – Symbol Type Selection

4.1 Introduction

This survey is the first step of methodology to define the symbol type for future map design.

4.1 Methodology

Survey one is intended to select the most suitable symbol type required for use in the online map interface. The three candidate symbol types are simple symbol, complex symbol and photograph. For testing, 38 common landmarks were selected that are consistently mentioned in articles about landmarks (Vinson, 1999; Raubal, 2013). The simple symbols have already existed online and were reviewed and used directly since they appeared to offer a clear and meaningful symbol. All complex symbols were designed by extending the simple symbols (more details than simple symbols) with additional detail added in Photoshop CS5. All the symbols are compressed to ensure their size remains the same as they would when they appear on a map. All three symbol types for the selected landmarks are shown in Appendix A

TABLE 1: LANDMARK COLLECTION

1 University	2 Gas Station	3 Museum	4 Middle & High School	5 Primary School	6 Zoo
7 Bank	8 Cinema	9 Hospital	10 Gym	11 Swimming Pool	12 Farm
13 Stadium	14 Restaurant	15 Sea	16 River	17 Park	18 Amusement Park
19 Highway	20 Bus Station	21 Railway Station	22 Railway	23 Street	24 Road
25 Avenue	26 Hotel	27 Bach	28 Island	29 Harbour	30 Pharmacy
31 Marked Buildings	32 Court	33 Mountain	34 Shopping	35 Viaduct	36 Game Hall
37 Bridge	38 Community Hall				

50 participants took part in the survey, made up as follows:

- 19 Illiterate People
- 24 Non-English Speakers
- 17 Native English Speakers.

The purpose of this classification is to compare the difference in interpretation of the symbols between illiterate people and literate people, and to determine whether there are differences across languages. Most illiterate people in the survey originate from China and the South Island of New Zealand (most of participants in the South Island of NZ are refugees), the non-English Speakers are coming from Chinese, with the majority of native English speakers being New Zealanders. Participants were selected non-randomly through personal contacts. The non-randomly selected participants provide a good cross-section of society and since our surveys gather information about the usability of online map applications, random selection was not thought to be essential.

This survey required participants to select the landmark that best matched each symbol and to select the symbol type preference overall. The first part required each participant to finish three tables, matching 20 randomly selected symbols with the best landmark from the set of 38. The second part required them to view all of the symbols (the order is simple symbol – complex symbol – photography (the reason for this order is we wanted to progressively increase complexity to see whether this improved the interpretability)) and answer some questions about their views of each symbol type. The complete questionnaire is shown in Appendix B.

4.3 Results

The final selected symbol type was decided by the accuracy of symbol-landmark matching and the participants favoured symbol type. Accuracy is calculated by the number of correctly matched landmarks divided by the total number of all selected symbols (20) across all participants. For example, for illiterate people with simple symbols, the number of all correctly matched landmarks was 228 and the number of all selected symbols is 20*19 = 380, so the accuracy was 228/300 = 60%. The participants favoured symbol type is generated from the answers of the question “Which symbol types do you like best?

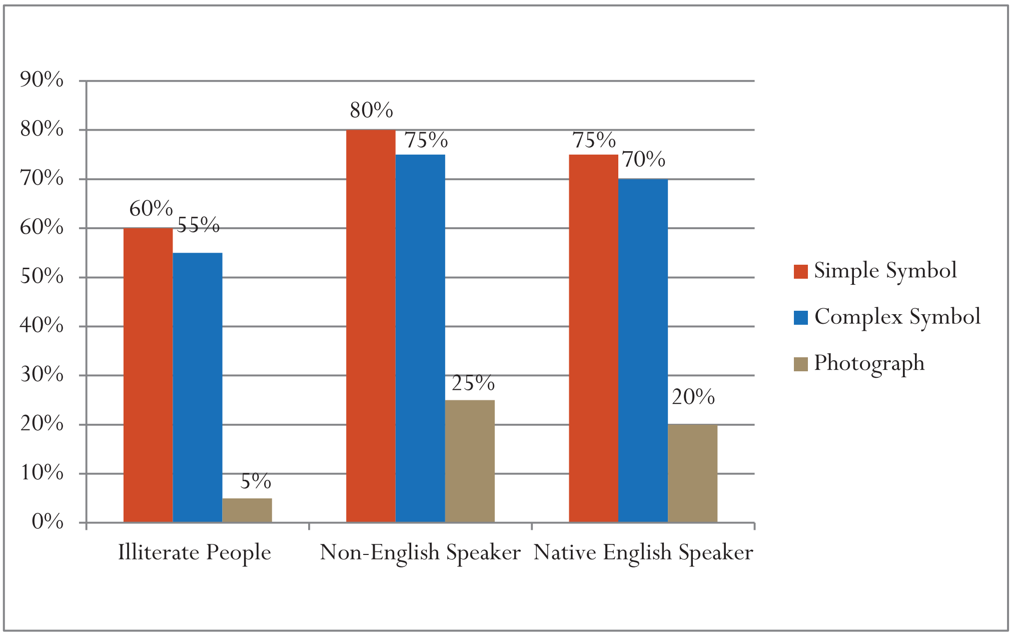

FIGURE-8: ACCURACY OF SYMBOL MATCH

Figure 8 above illustrates the comparison of accuracy on symbol-landmark matching among Illiterate people, non-English Speakers and Native English Speakers. The accuracy of both simple and complex symbols is much higher than the photographs (matching accuracy of each symbol type is approximately 70% while that of photography is only 20%). In terms of simple symbols and complex symbols, the bar chart indicates the close accuracy for both of them in each group (Illiterate people: 60% & 55%; Non-English Speakers: 80% & 75%; Native English Speakers: 75% & 70%). In addition, the accuracy achieved by Illiterate People is lower than that of Non-English Speakers and Native English Speakers for all symbol types.

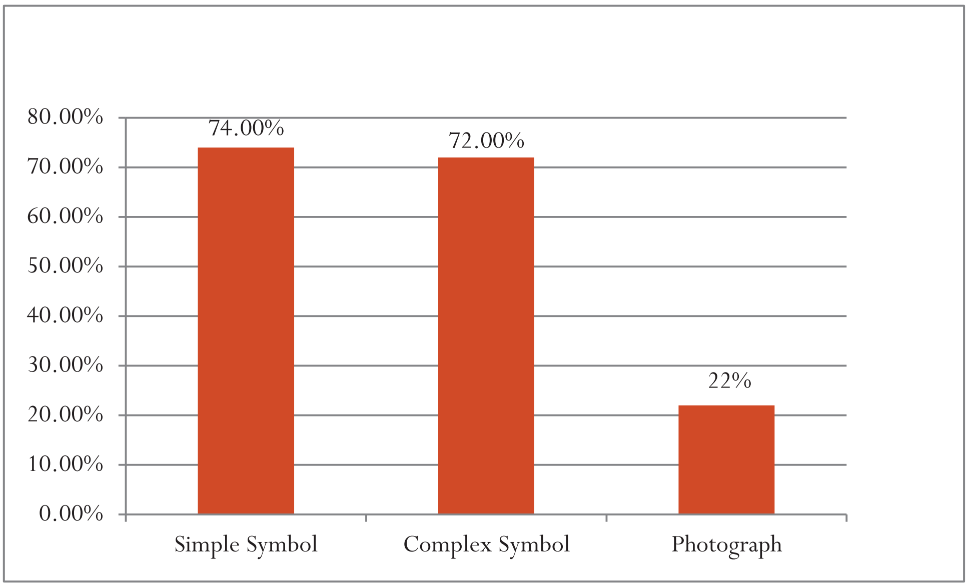

FIGURE-9: ACCURACY OF SYMBOL MATCH FOR DIFFERENT LANDMARKS

Figure 9 demonstrates a comparison of the overall accuracy of symbol-landmark matching for each symbol type across all participant groups. Simple symbol and complex symbol both illustrate a high accuracy rate (74% and 72%) while photographs show a much lower accuracy in symbol-landmark matching.

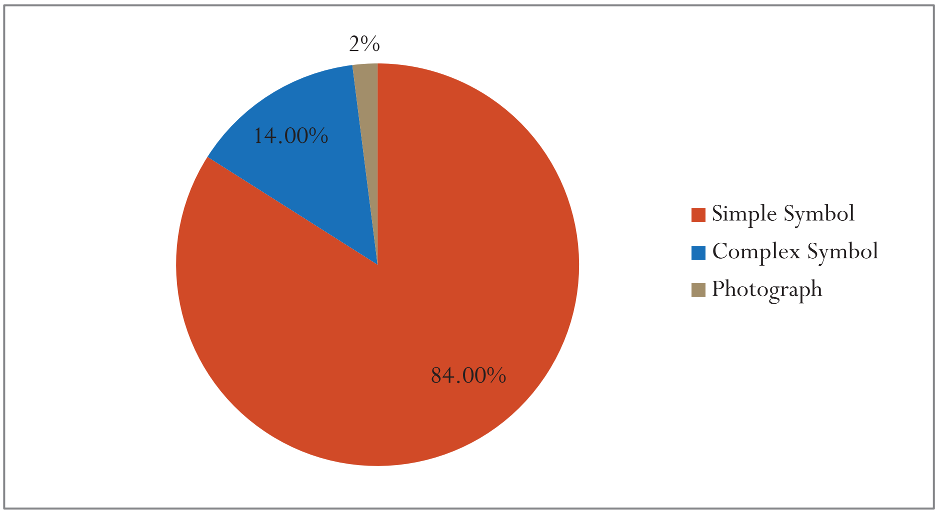

FIGURE-10: APPROVAL RATING OF EACH SYMBOL TYPE

Figure_10 shows that the majority of participants support the simple type of symbol (84%) while the complex symbol, that had only slightly lower accuracy, has a much smaller approval rating (14%). The main reason was that most participants thought that the meaning of the symbol is decided by the symbol type (if they couldn't recognize the meaning of the simple symbol then they also couldn't determine the meaning of the corresponding complex symbol). In most instances in which simple and corresponding complex symbols can be recognized simultaneously, simple symbol is a better choice since the size of symbols in a map makes complex symbols harder to see clearly. Photographs had little support from participants, even though they provide a more realistic depiction of the landmark, since the content was hard to see clearly at the appropriate size for representation on a map. It addition, the time-taken on simple symbols was the least of these three types. Table 2 shows the time spent on each symbol type.

TABLE-2: TIME-TAKEN ON SYMBOL-LANDMARK MATCH

Symbol Type/ Time	Average	Maximum	Minimum
Simple Symbol	14:38min	36:01min	4:57min
Complex Symbol	16:05min	29:10min	4:14min
Photograph	27:10min	46:17min	9:22min

Therefore, when feedback is combined with the time participants spent on this survey and the accuracy, simple symbols are the final choices for use in the text free web maps created for this research. It is worth mentioning that it was more difficult for illiterate people to recognize all types of symbols. This phenomenon suggests that illiterate people not only can't read the text, but also have a low level of recognition of symbols generally.

4.4 Summary

Different map types have the same symbols, suitable map symbols are vital for illiterate people and non-local-language speakers to recognize. Finally, simple symbol is selected and suitable map features (another important foundation for text-free map design) needed to be selected in next chapter.

5. Survey Two — Map Feature Selection

TABLE-3: FEATURES COMPARISON

Features	Function	Google Map	Open Street Map	Yahoo Map	Baidu Map
Search Bar	Search for place name	Y	Y	Y	Y
Zoom in or not?	Change the size of view	Y	Y	Y	Y
Positioning	Obtain user's current location from GPS (available in online map interface and mobile device)	Y	Y	Y	Y
Navigation	Tell users how to get to a destination	Y	N	N	N
Satellite View	A new view "Satellite"	Y	N	N	N
History Records	Record place names searched in the past	Y	Y	N	N
Distance Display	Display the distance between two landmarks	Y	N	Y	Y
Traffic Option	Select different traffic type: Bus, Car or Foot	Y	N	Y	Y
Show the picture of place when the symbol is clicked	When users click the symbol, the photographic of the place is shown	Y	N	Y	Y
Audio Notice	When the user clicks the symbol, the Place Name is spoken audibly by the system	Y	N	Y	N
Favorite	Store users' favorite places	Y	N	N	N
Add favorite location	Add any places which lost in the map	Y	N	Y	Y

5.1 Introduction

The second survey explores the importance of different online map features to inform the design of the text free maps, which is the second step of the methodology. It includes an analysis of the features of four currently popular online maps: Google Maps, OpenStreetMap, Yahoo Maps and Baidu Maps (Haklay, 2008; Lin, 2009; Hsu, 2013) and a survey of 10 regular GIS users to gather suggestions about potential map features. It was a qualitative study because we were interested in getting in depth views and reasons for suitable text-free map features from a set of regular GIS users.

5.2 Methodology

The four currently popular online maps (Google Map, Open Street Map, Yahoo Map and Baidu Map) that were studied contain a range of features (Ciepłuch, 2010), as shown in Table-3, The results show Google Map is the most comprehensive online map as it has the most complete functions (11 features in Google Maps in total, 8 features in Yahoo Map, 7 features in Baidu Maps and only 6 features in Open Street Map). “Search Bar”, “Zoom in or not” and “Position” are the three main features on all four online maps.

10 regular GIS (Geographic Information System users took part in this survey to provide advice about which features were most appropriate for inclusion on a text-free map. 4 of them were located in New Zealand while the remainder originated from China. 7 of them were PhD students studying GIS, 2 of them were professors working in the GIS area, and 1 worked for a GIS company as an online map features analyst. All of them are regular GIS users and all experienced users of online maps). The participants were recruited through personal relationships and the selection was non-random. The survey was distributed by email in the form of a Microsoft Word document.

Based on the analysis of the features for current popular online maps, we defined 9 potential features of text-free online maps and used a survey to allow experts to evaluate each feature (the complete questionnaire is shown in Appendix C):

TABLE-4: POTENTIAL FEATURES

Potential Features
Search Bar
Pan and Zoom
Position
Satellite View
History Records
Show the picture of place when click symbol
Audio Notice
Favourite
Add location

5.3 Results

The 9 Pie Charts below illustrate the results regarding each specific potential feature with the analysis under each chart discussing the reasons provided by participants for their selections.

5.3.1 Search Bar

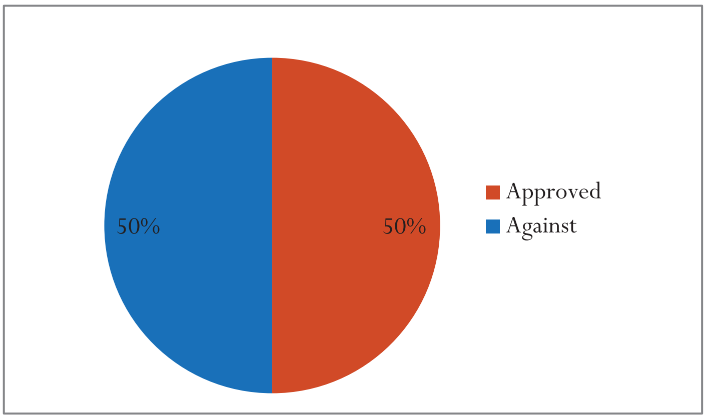

FIGURE-11: APPROVED RATING FOR SEARCH BAR

TABLE 5: OPINIONS ON SEARCH BAR

Half of participants support the Search Bar	
Opinions for Approved	**Opinions for Against**
Place searching is the most basic function in every online map for users. Search bar is necessary	Text search bar is of no use for illiterate people because they can't input the words into text search bar.
In text-free map, although the text search bar is of no use, symbol search bar and audio search bar can provide illiterate people with the ability to search symbols through visual recognition and verbally.	Search by symbol or audio (Search by Symbol & Audio means searching the place name through its corresponding symbols & voice) may cost illiterate people too much time. For example, when searching by symbols a specific symbol can represent different places in one category (e.g. the symbol of "Bay" can represent both "Browns Bay" and "Long Bay"), which will require users to run another naked-eye observation to find a specific place after they finish using the symbol search bar.

5.3.2 Satellite View

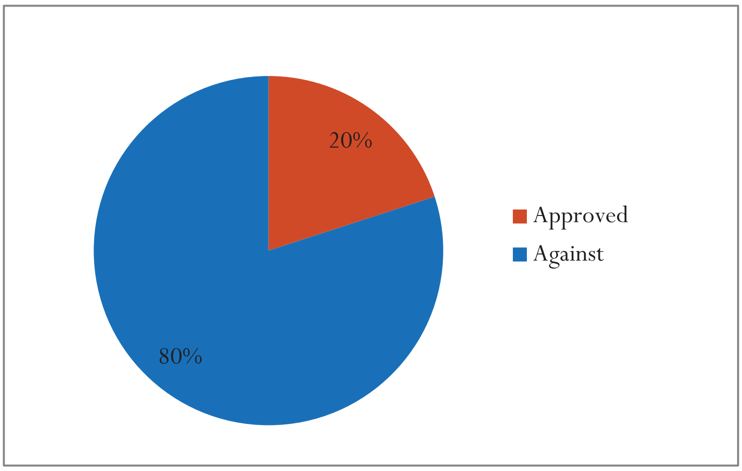

FIGURE 12: APPROVED RATING FOR SATELLITE VIEW

TABLE 6: OPINIONS ON SATELLITE VIEW

Most participants were against inclusion of the "Satellite View" (80%)	
Opinions for Approved	**Opinions for Against**
2 GIS experts think the Satellite View offers users a new view for observing the geography (especially the distribution of the towns and terrain where change will be shown more clearly).	Compared with the "Street View", Satellite View has many limitations. It offers a totally different view of map, which is just for observation but is unpractical. For illiterate people, just "Street View" for them to visit is enough.

5.3.3 History Records

All participants oppose the "History Records" Function
History records show what searches users have utilized in the past for text search only. For Illiterate people, the symbol search can only represent one specific category of landmarks.

TABLE 7: OPINIONS ON HISTORY RECORDS

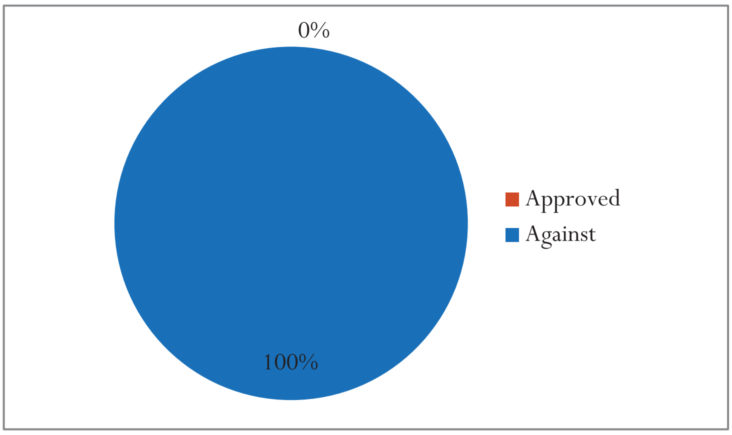

FIGURE 13: APPROVED RATING FOR HISTORY RECORDS

5.3.4 Pan and Zoom

All participants approved the "Pan and Zoom" Function
Pan and Zoom is the most function for the online map

TABLE 8: OPINIONS ON PAN AND ZOOM

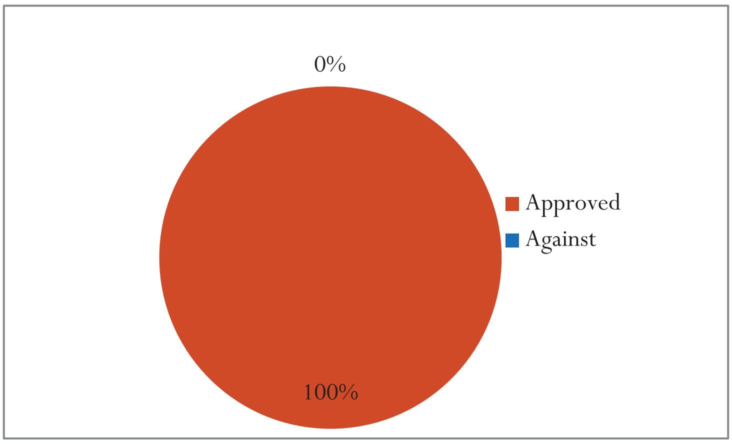

FIGURE 14: APPROVED RATING FOR PAN AND ZOOM

5.3.5 Positioning

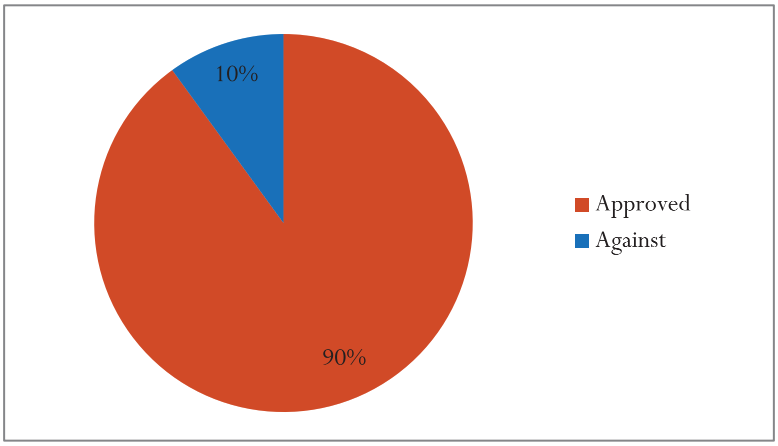

FIGURE 15: APPROVED RATING FOR POSITIONING

Table 9: Opinions on Positioning

Most participants support the "Positioning" function	
Opinions for Approved	**Opinions for Against**
Users are able to know their current location, making it easier for people that may have lost their way (for Illiterate people, this feature is vital).	The single GIS expert thinks it would be difficult for illiterate people to use the "positioning" function. Illiterate people have no previous online map use experience, this feature is too difficult for them to understand.
Only users know their current location. This will enable them to check how to reach their destination.	

5.3.6 Audio Notice

All Participants think "Audio Notice" is important
Opinions for Approved
Illiterate people can't read the text but are able to listen to audio. In instances where there is no notice of text, the "Audio Notice" is necessary to help Illiterate people understand the meaning of the relevant symbol.

Table 10: Opinions on audio notice

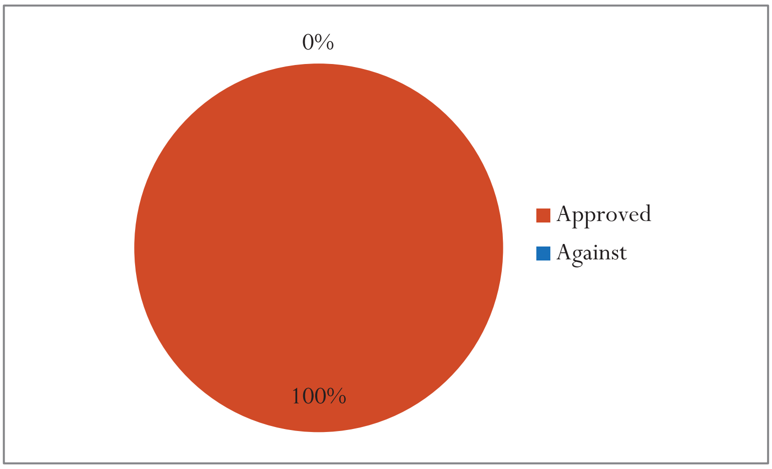

Figure 16: Approved Rating for audio notice

5.3.7 Show the Picture when the Click Symbol

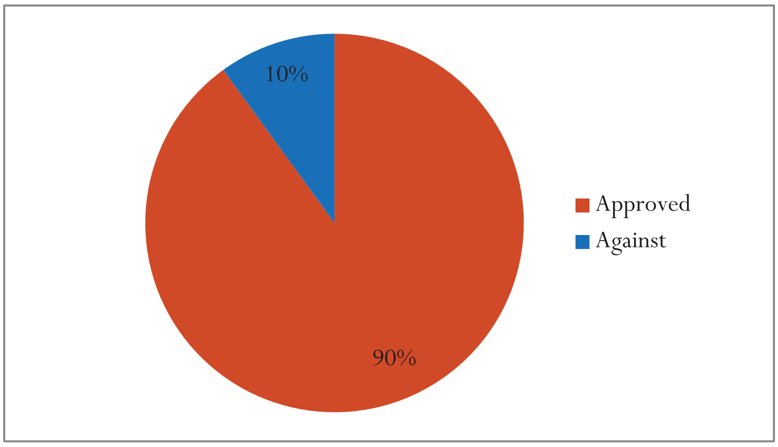

FIGURE 17: APPROVED RATING FOR SHOWING THE PICTURE ON SYMBOL CLICK

TABLE 11: OPINIONS ON SHOWING THE PICTURE ON SYMBOL CLICK

Most participants think "Show the Picture when Click Symbol" is necessary	
Opinions for Approved	**Opinions for Against**
This function brings users a more visual understanding of each specific location.	This picture only illustrates a small part of real place, which just tells users what this place is but not a comprehensive explanation of this place.
For Illiterate people, the symbol shows a general concept of a specific place or location. The real picture has the ability to replace the text to help them locate a specific place.	

5.3.8 Add Location

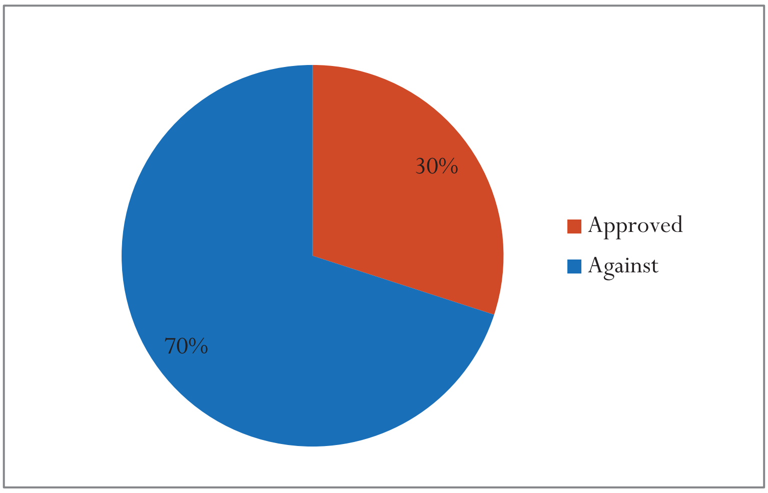

FIGURE 18: ADD LOCATION

TABLE 12: OPINIONS ON ADD LOCATION

Most participants against the "Add Location"	
Opinions for Approved	**Opinions for Against**
This feature allows users to add their own favorite location into the map allowing easier access to this location next time.	A specific symbol can represent different places in one category, which requires users to run another naked-eye observation to find the specific location when they access the added location.
In a text-free map, users can add corresponding symbols of their favorite location for visiting.	Add new location is an extra feature in traditional online maps Regardless of the symbol or audio, the efficiency of this feature is not good.

5.3.9 Favourite

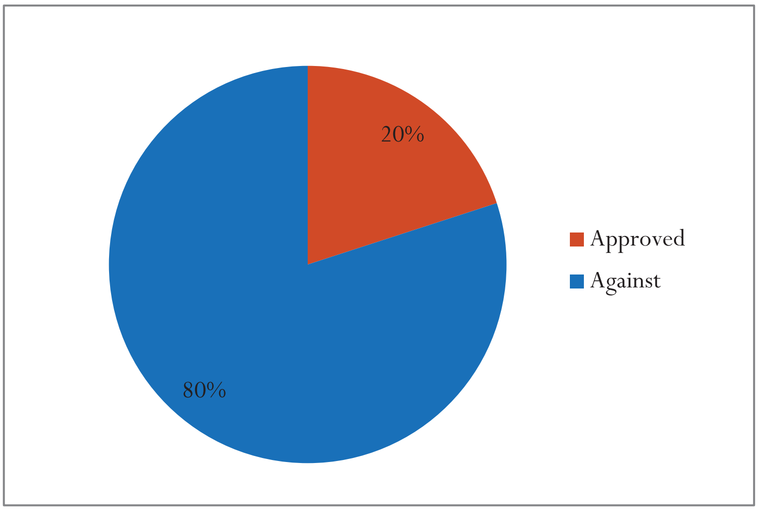

FIGURE 19: APPROVED RATING FOR FAVORITE

Most participants think "Favorite" is not useful	
Opinions for Approved	**Opinions for Against**
This feature lets users collect favorite locations they have previously searched for and can access those collected locations easily next time (directly open the locations in Favorite instead of seeking for them in the Search Bar). For Illiterate people, they add the corresponding symbols of their favorite location into Favorite.	This feature is not suitable for a text-free map. A specific symbol can represent different places in one category, which requires users to run another naked-eye observation for finding the specific location.

TABLE 13: OPINIONS ON FAVORITE

The results of the survey indicate that the Search Bar, Positioning, Pan and Zoom are all important features for text-free online maps. Audio Notice for place name and Show the Real Picture when the Symbol is clicked are necessary for Non-English Speakers and Illiterate people. In addition, the Symbol Search Bar and Audio Search Bar are also vital for non-English Speakers and illiterate people to search for places. Thus the final map features that we have selected for inclusion on the text free maps are shown in Table-13:

TABLE 14: FEATURES FOR TEXT-FREE MAP

Features for Text-free map
Zoom in or zoom out
Pan
Positioning
Symbol Search Bar
Audio Search Bar
Audio Notice
Show the real picture when click symbol

5.4 Summary

This survey has identified the map features that will be included on the different kinds of maps (e.g. text-free map with audio-only has no symbol search bar while text-free map with symbol-only has no audio search bar). Following the two surveys to establish the best symbol type and to identify appropriate map features to include, the maps were designed and created.

6. Web Map Design

6.1 Introduction

This is the key step in methodology, after the symbol type and map feature were defined, map design is imperative for illiterate people. The research questions require us to compare the distinctions between text maps and text-free maps, and to determine whether text-free maps are more suitable for illiterate people and non-native-language speakers or not. Text map interfaces and text-free map interfaces are therefore two of the two main dimensions by which we vary the design. Moreover, combined with the previous study, symbol and audio are two alternative methods of information representation instead of text. Thus maps using symbol and audio also need to be designed in order to determine which kind of text-free map interface is the best. Therefore, we design 5 maps for comparison (a total of 5 maps, text with symbol and audio is redundant since it is the same as text-free with symbol and audio for illiterate people):

1. text with symbols;
2. text with audio;
3. text-free with symbol only;
4. text-free with audio only;
5. text-free with symbol and audio;

6.2 Web Map Design Produce

The presence or absence of text is the unique distinguisher between corresponding text maps and text-free maps (besides text, other designs are all the same between text and text-free maps). Each map category has a corresponding search bar. For example, map 2 (text with audio) has a text search bar and an audio search bar while map 5 (text-free with symbol and audio) has both a symbol search bar and an audio search bar. Openlayers 3 is the main development environment for the online map applications. OpenLayers 3 is a JavaScript library package designed for client to develop Web GIS, Prototype.js modules have been applied into the OpenLayers 3 framework for object oriented development.. According to previous research on how people conceptualize space for way-finding, our design for all of the maps is centred around landmarks represented by appropriate symbols. The data source for our online map applications is OpenStreetMap. The process of creating the text online map interface is shown below in Figure 20, and the process for the text-free map is shown in Figure 20. The only difference between these two processes is that the tile map from OpenStreetMap can be used in the text map directly whereas the text was cut first before the tile map for the text-free map was generated. For text-free map design, the process of cutting the text from OpenStreetMap includes four steps which is shown in Figure 21.

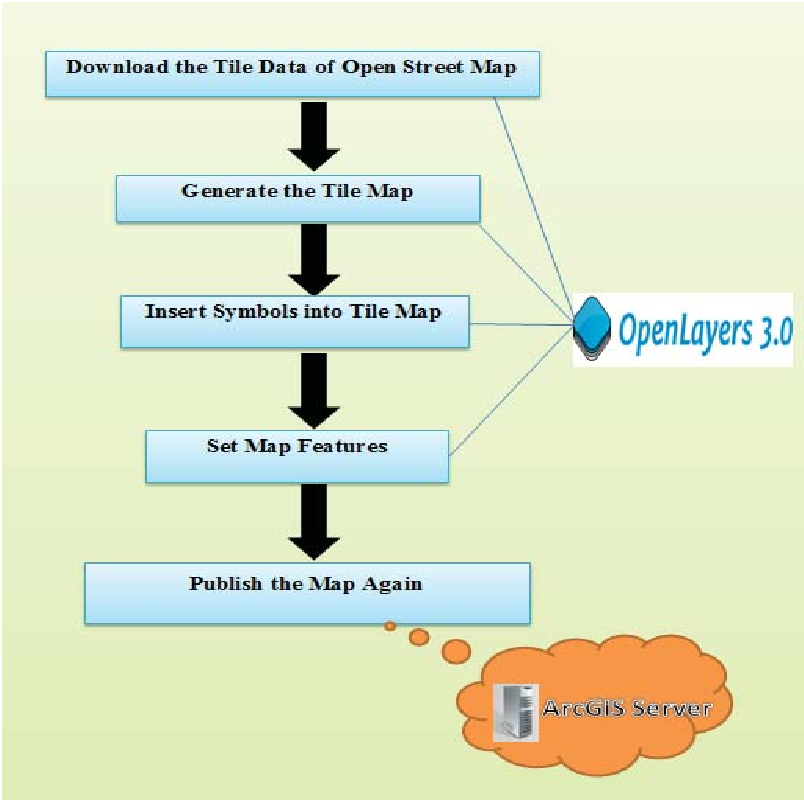

FIGURE 20: TEXT MAP DESIGN PROCESS

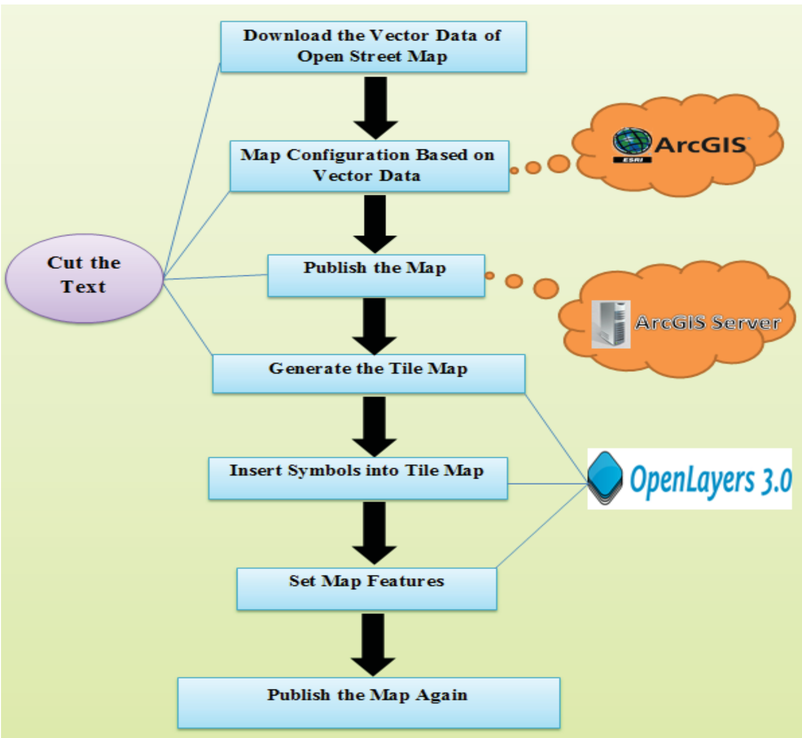

FIGURE 21: TEXT-FREE MAP DESIGN PROCESS

6.3 Obtain the online OpenStreetMap as the tile Map

The first step in the creation of the online map interface is to load a tile map from OpenStreetMap as the background for adding the features. This is the most important and basic step since all subsequent steps will run in the tile map. The tile map is shown below:

FIGURE 22: TILE MAP

6.4 Insert the Symbols for Landmarks (Including showing Images & Audio)

This feature means inserting the symbols into the map and adding the corresponding function that shows the images and reads the place name when users click the symbols. In order to make sure the symbols can represent the meaning of landmarks well (users can know the meaning of landmarks through symbols easily), all 16 symbols for the map interfaces were selected from easily recognized simple symbols (based on the results of survey one, 60% illiterate people could match the simple symbols and landmarks accurately and those simple symbols which were correctly matched by illiterate people were also correctly matched by native English speakers and non-English speakers, so the 16 symbols came from the correctly matched symbols for all three groups). The main areas for inserting symbols are Albany, Auckland and Auckland City Centre in New Zealand, which were used as test areas in the usability testing. Massey University, Sky Tower and Albany Bus Station are important landmarks for inserting symbols. We found the accurate geographical location (geographical coordinates) of these landmarks and then inserted the symbols into the corresponding geographical location:

- Find the Name, Longitude and Latitude for each point of landmark from Google Map (e.g. Sky Tower (174.7624, -36.848169), Massey University (174.703408, -36.733737)).

- Collect and save the Name, Longitude and Latitude of each point of landmark in the JSON format.
- Setting ID and longitude and latitude for each point of landmark, using the Function (ol.Feature) to read the POI JSON (ivJson) and generate the position of symbols, then adding the symbols to the corresponding position of the Vector layers (ol.layer.Vector).

To show the corresponding Picture or Audio for each symbol, we define a click event on the target symbol, then set the “Feature Function” to inform the displayed elements on symbols (only showing “Picture”, only showing “Audio” or showing both “Picture &Audio”). Finally, we display the elements through HTML5, which supports Firefox, Chrome, Safari, Opera and many more Browsers. The performance of “img” and “ivg” has been improved (Anthes ,2012; Chen et al., 2013). All images were downloaded from the Internet and the Audio uses the audio function from Google API. The inserted symbols are shown below. The code and explanation for this code is shown in Appendix D.

FIGURE 23: SYMBOL INSERT

6.5 Pan and Zoom

As the basic function of map, the range of the Pan is set from Bottom to Center of interface, Zoom is four times amplification for the center [-10997148, 4569099]. Examples of Pan and Zoom are shown below. The relevant code is shown in Appendix E.

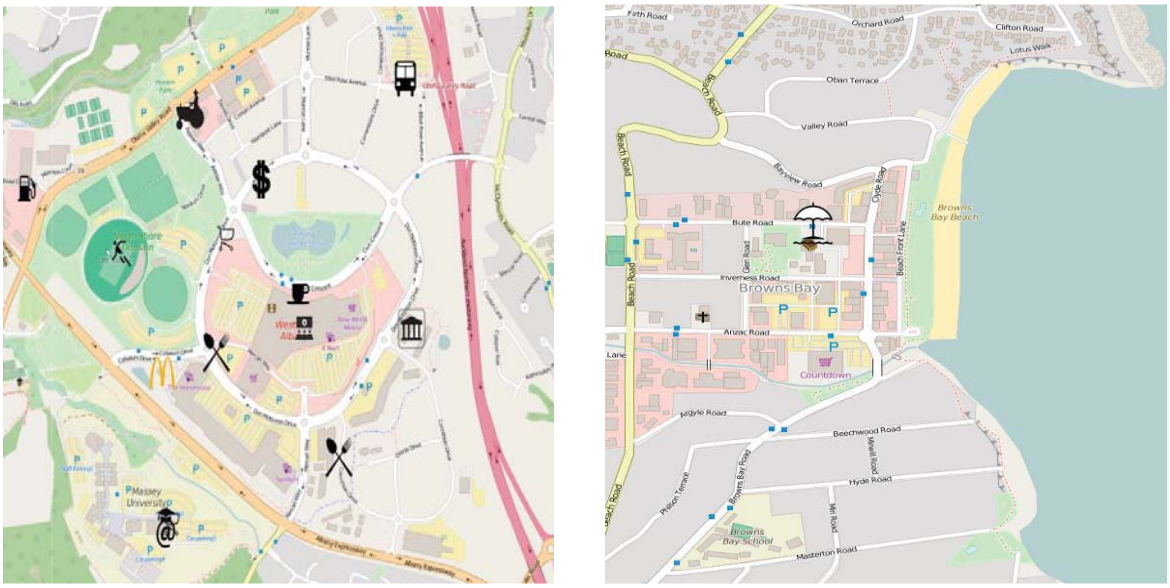

FIGURE-24: FROM ALBANY SHOPPING CENTER TO ALBANY BROWNS BAY (PAN)

FIGURE 25: FROM NEW ZEALAND TO NORTH ISLAND OF NEW ZEALAND

6.6 Obtain Current Location

HTML5 provides a Location Based Service (Geolocation API) letting users share their location in the web map application using GPS data (Global Positioning System). Once users send a request to obtain their current position, the browser will determine the coordinates, along with other parameters and return the location information to the user. The process involves detecting whether the browser supports the Geolocation API of HTML5 or not, creating a "Click Event" on the "Geolocate" button, and creating a function to recognize the current longitude and latitude to return the location information to the users. The example is shown below and the blue point is the user's current location. Such as Figure 26, we were near the Sky Tower of Auckland. The code and explanation for this step is shown in Appendix F.

FIGURE 26: EXAMPLE OF OBTAIN CURRENT LOCATION

6.7 Search Bar

The online maps have different combinations of the "Text Search Bar", "Voice Search Bar" and "Symbol Search Bar". The Layout is shown below:

FIGURE-27: LAYOUT OF SEARCH BAR

Text Search Bar

The text search bar is in English for all groups. Search by text function judges whether the key assignments of landmark name stored in IvJSON is consistent with the content in the search bar. "Consistent" means the searched landmark of POI has been found, then extracts the longitude and latitude of the landmark and builds the geometric object of the point of landmark, finally setting the geometric object as the central point and showing the point of the corresponding landmark. This is achieved by creating an Input Box, defining a "Click Event" in the "JS" and using the SearchFeatureFromName(name) function to handle this Event. This then searches the corresponding "value" stored in JSON.   The example of searching for Browns Bay is shown below. Relevant code is shown in the Appendix G.

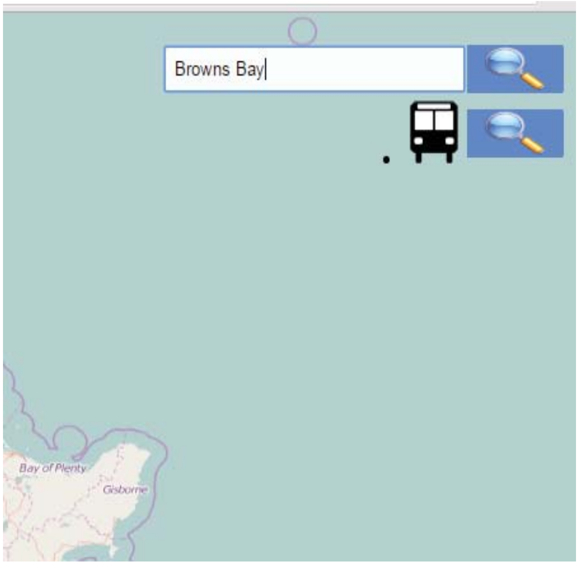

FIGURE 29: INPUT TEXT

FIGURE 28: FIND LOCATION

Audio Search Bar

Search by voice is implemented using the Speech Recognition Engine − Google Web Speech API. The operation converts audio into text in the "Text Box", duplicating the same job as the "Text Search Bar". The voice recognition process is only available in Google Chrome. All audio data is delivered in English only. The example of searching for "Albany Bus Station" is shown below (the level of information is contained in the audio is specific map text "Albany Bus Station"). Relevant code and explanation is shown in the Appendix G.

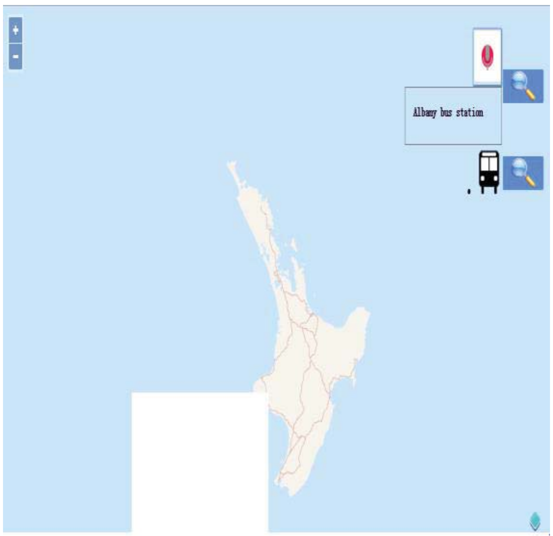

FIGURE 30: FIND LOCATION

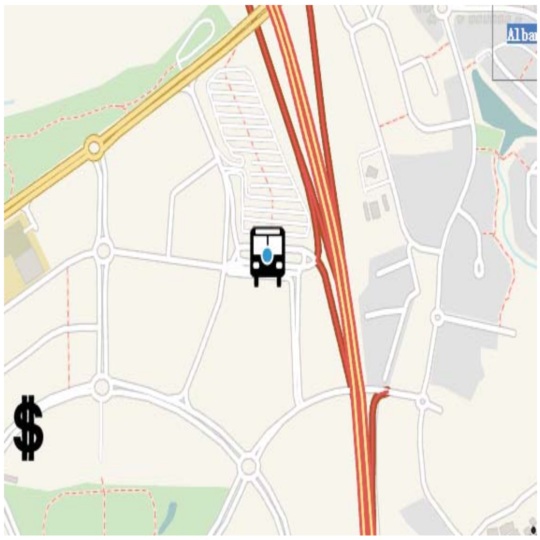

FIGURE 31: INPUT VOICE

Symbol Search Bar

We wanted to find a way to allow users to search for objects without relying on audio. We developed a method to allow illiterate people and Non-English Speakers to search for places without just depending on the place name using symbols. While this does not allow them to find specific places, it does allow them to find specific types of places. This is achieved by defining an "IconTab" similar to a table for storing information regarding the symbol. This then sets the ID for each symbol, inserts the relevant ID, name and icon (symbol) into the "IconTab" and sets a "Click Event". When clicking a specific icon in the IconTab, the corresponding symbol in the map will replace that icon while the IconTab remains hidden. One problem that was encountered is that there are two beach symbols in the map (one is browns bay, one is mission bay), the symbol search should find all beaches if the beach symbol is selected, and this is a problem that will be addressed in the future. The example of searching "Massey University" is shown below. Relevant code is shown in Appendix G.

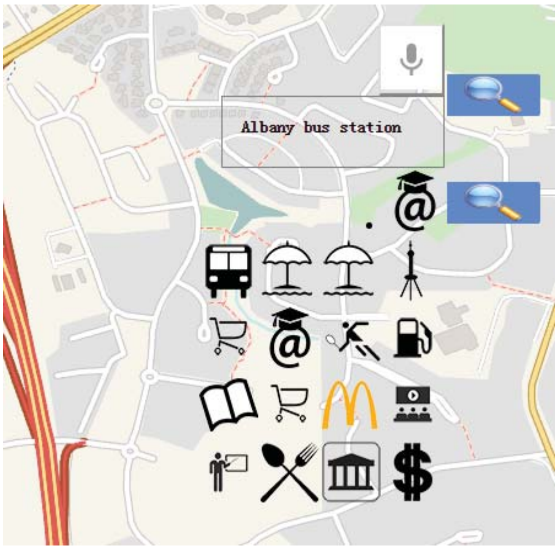

FIGURE 33: SELECT ICON

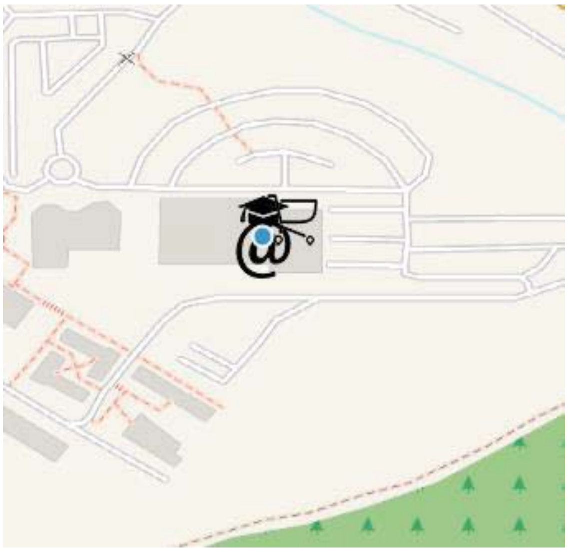

FIGURE 32: FIND LOCATION

6.6 Cut the Text

In OpenStreetMap, text is in the form of an image. "Text" and "picture" all belong to the same layer. Hence it is impossible to remove text by deleting the layer of text. The text-free map was thus configured in the ArcGIS environment based on the OpenStreetMap. Firstly, we downloaded all vector data (without downloading the vector data of text) from OpenStreetMap and ran the symbol settings of each Point, Line and Face according to the scale of OpenStreetMap. Secondly, the scale data was saved as an MXD file in the ArcGIS. This scale data was then converted into the tile data (tile data includes Road, Traffic lines and other map elements). Thirdly, using the API function "ol.source.TileArcGISRest" of ArcGIS, tile data was added to the layer, inserting the POI and setting the distinguishability of the interface. Finally all features were added using the same method as for the text map. The text-free map configuration step is shown below, and in more detail in Appendix H

FIGURE 34: ALL DOWNLOADED VECTOR DATA

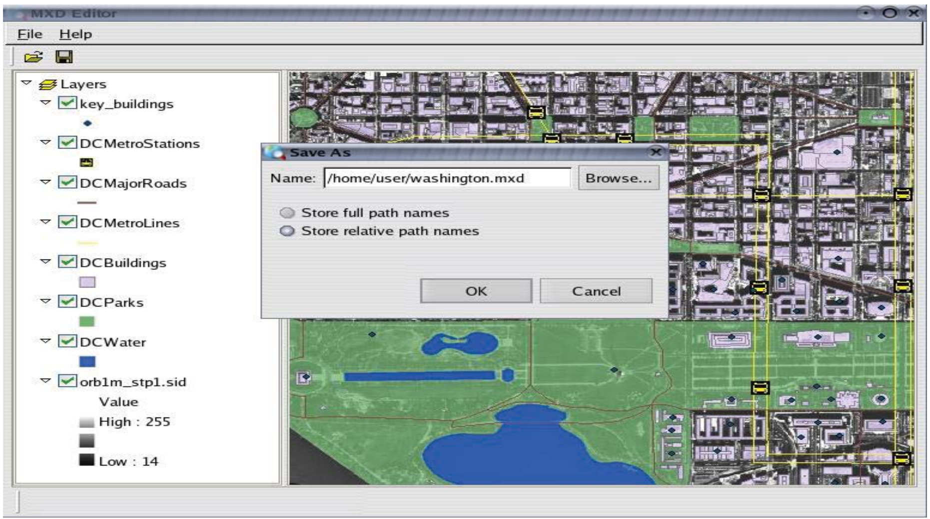

FIGURE 35: TEXT-FREE MAP CONFIGURATION

6.8 Map Publish

The 5 kinds of online maps designed are published through ArcGIS Server. The map was published through ArcCatalog. After the IIS was configured, we chose the “Manager GIS Services” and input the “Host Name”, then published the “MXD” file to the ArcGIS Server, finally selecting the corresponding service (Mapping and KML). The screen dumps are shown in Appendix I

6.9 Summary

This Chapter has described the design and implementation of the map, based on the results of the first two surveys. In the next chapter we will evaluate all of the created maps for illiterate people and non-local-language speakers, alongside native English speakers for comparison.

7. Usability Study Methodology

7.1 Introduction

The usability evaluation for designed maps is for deciding whether the text-free map is necessary or not and which text-free map is most suitable for illiterate people. Following the design of the map interfaces, an experiment was conducted using qualitative and quantitative data to answer the research questions posed in the Chapter 1.

7.2 Sample

A total of 90 participants were selected to take part in the experiment. They were divided into 3 groups: Illiterate people, Non-English Speakers and Native English Speakers (30 participants for each group). The illiterate group only contains non-native English speaking people. Members of this group can understand simple English words and use simple English sentences. All members of non-English speaking group are literate. Participants were non-randomly selected through personal contacts, in order to establish the required number in each group. It was difficult to recruit the illiterate people group since many illiterate people are sensitive about their illiteracy and do not openly describe themselves as illiterate. We recruited them by establishing a relationship of trust through regular interactions at bays club (many illiterate people stay in bays club for drinking and playing pool), and after such a relationship was established, they were willing to assist with the survey. All people who took part in the symbol type selection also participated in the usability testing. We do not anticipate any bias resulting from this as the usability test of map interface requires use of the web map and is mainly influenced by participants' level of English and experience of using map interfaces, while the symbol study was an abstract investigation of the symbol sets independent of a map.

Research questions were aimed at comparing the difference of map use among each group, and the sample size of each group was determined so that 6 participants from each of the three participant groups completed the survey using one of the 5 map types. This allowed us to identify differences both across participant groups and across map types. Although it would have been ideal to have more than 6 participants in each of the sub-groups, this was impractical given the time constraints.

The native English speakers group acted as a control group (based on English Text) to show the differences in map use between users who can read text and users who can't, and to determine whether text free maps can also provide a functional alternative for literate (avoiding the need for separate maps for the different user groups). Moreover, the research questions aimed to discover whether the illiterate people and non-English speakers benefited from the text-free map interface, bearing in mind that while non-English Speakers may not be able to read some of the text (for example, labels on map interface functions), they are more likely to have general reading ability and experience with electronic devices in a textual environment. However, even if both groups can't read words, the illiterate group may also be less able to read maps.

7.3 Experimental Design

The experimental design tests the learnability, efficiency and effectiveness for all features of the 5 map applications (Pan and Zoom, Positioning, Three Search Bars and Click Event on Symbols) and aims to determine the degree of satisfaction (from "Strongly Disagree" to "Strongly Agree") with each kind of online map. The three main sections of the questionnaire include: completing the given tasks to test each map feature, filling in the System Usability Scale (SUS) form to illustrate the satisfaction of their evaluated map and answering some questions about text-free map improvements. Participants were asked to:

1. Completed the following 5 tasks:
   a. Find the shortest route between two given landmarks (Text map interface)
   b. Find the corresponding symbols of three given landmarks (Text feature: three search bars)
   c. Get your current location (Test feature: Positioning).
   d. Find three given symbols through using the "Pan and Zoom" (Test feature: Pan and Zoom).
   e. Determine the place name of three given symbols.
2. Complete the System Usability Scale (SUS) form.
3. Answer some open-ended questions about their experience using the online map. The full questionnaire is show in Appendix J. Participants were recorded and timed while they were completing the survey.

Each part of the map is required to be tested more than once to allow for verification of the learnability, efficiency and effectiveness of the map (e.g. Using Pan and Zoom; finding three specific symbols which means that "Pan and Zoom" are being tested three times) (Jeng, 2005; Joo, 2011). The evaluation of Learnability and Efficiency of maps is based on the time taken to complete tasks. The Learnability test is for discovering the capability of users to learn how to use the online maps. Each feature needs to be tested three times. The time taken for the first testing of finishing the task can be measured as "Learnability" (e.g. when testing the learnability of "Pan and Zoom", if participants finish finding the first symbol through the "Pan and Zoom" quickly, which indicates that the learnability of "Pan and Zoom" functions is effective) (Joo, 2011). The efficiency is used to measure the ability of participants to use the map well without time waste. The speed for finishing the second and third testing for the same task can be measured as the "Efficiency" (Jeng, 2005). The effectiveness measures the ability to create a desired result (utility). Effectiveness is measured by identifying whether the participants can finish the task accurately or not (Joo, 2011)). In addition, in order to learn something about participants for more comprehensive results analysis, a total of 6 pre-questions are designed to determine their age range, their occupation, the frequency of using maps and online maps and their level of English. The detailed questionnaire is shown in Appendix J (The Chinese version (Appendix O) of questionnaire was designed as there are 28 Chinese included in the 30 Non-English Speakers group. A further 2 Non-English Speakers come from Japan and Korea and the questionnaire was read out to them), and the questionnaire was read out to the participants in the illiterate people group. The corresponding Data Collection (Task Recording) is shown in Appendix N.

The experiment took place in Albany, Auckland, New Zealand. All participants were required to finish the consent form before the experiment started to ensure willingness to take part in the experiment. The content of the consent form was read out to the illiterate people, and a Chinese version was provided to non-English Chinese speakers. In order to ensure all maps were evaluated by all groups of participants (illiterate people, non-English Speakers, Native English Speakers), each group was divided into five sub-groups and each sub-group was required to evaluate one kind of maps. Each participate has their own ID (1 ~ 90) and is randomly allocated into a small group:

TABLE 15: ALLOCATION FOR PARTICIPANTS TO EVALUATE ONLINE MAPS

Group A (Illiterate People)		**Group B (Non-English Speakers)**		**Group C (Native English Speakers)**	
Participant No	**Map Category**	**Participant No**	**Map Category**	**Participant No**	**Map Category**
1~ 6	Text with Symbol Only	1~ 6	Text with Symbol Only	1~ 6	Text with Symbol Only
7~ 12	Text with Audio Only	7~ 12	Text with Audio Only	7~ 12	Text with Audio Only
13~ 18	Text-free with Symbol Only	13~ 18	Text-free with Symbol Only	13~ 18	Text-free with Symbol Only
19~24	Text-free with Audio Only	19~24	Text-free with Audio Only	19~24	Text-free with Audio Only
25~30	Text-free with Symbol and Audio	25~30	Text-free with Symbol and Audio	25~30	Text-free with Symbol and Audio

7.4 Ethics

To ensure this research was executed with the highest ethical standards, the entire survey process was approved through the ethical principles of Massey University. This requires that research procedures be appropriate to the participants. Researchers have a responsibility to recognize their own cultural location and to inform themselves of and take steps necessary to respect the social and cultural sensitivity of all participants. Meeting language preferences of participants in the provision of information was particularly important (Massey University, 2016) for our survey, as was ensuring that illiterate participants were fully informed. The study followed the Massey University Code Of Ethical Conduct.

7.5 Pilot Study

In order to make sure the online map interface worked well before the map evaluation and to evaluate the data collection instruments, we ran a small scale preliminary test to evaluate feasibility, time, cost and adverse events for the usability study and to predict an appropriate sample size and confirm design of the final experiment. This was aimed at avoiding time and financial costs and identifying any issues in the final usability study (Goodman et al., 1998; Pitman et al., 2002). The 3 participants of a pilot study were recruited through personal contact. All could speak good English and were proficient with electronic devices.

7.6 Summary

This Chapter has described the methodology and experimential design for the usability study that was conducted to compare the 5 map interfaces and their use by different groups of respondents. The following Chapter presents the results for the study.

8. Results

8.1 Introduction

All data analysis is based on the task performance of different groups of participants on the same map and the task performance of participants in the same participant group on different kinds of map.

8.2 Pre-Question Analysis

This section analyzes the answers to pre-questions. The age-brackets of the illiterate people are distributed from 15~55, while non-English speakers are mainly from 15~35. The illiterate people participant group has more middle aged people. We think middle aged people also can work well as young people which will not affect the results. Among the three participant groups, all native English speakers could speak English well, almost all Non-English speakers were unable to speak any English (29 of them could not speak English and only one could speak poor English). Most illiterate people thought they were able to speak poor English (27) and a few of them could speak general English (3). Regarding previous map use experience, all native English Speakers and Non-English Speakers have used maps before while nearly half of the illiterate people have not used maps previously (12). We consider it likely that the frequency of previous map use will affect the task performance, and therefore we investigate the effect of use in the next Section (see Section 9.2). Most non-English speakers use maps very frequently. Regarding their previous online map use experience, most illiterate people have no previous online map user experience (only two of them have used online maps). The amount of native English Speakers who used online maps frequently is generally the same as native English speakers, with 2 native English Speakers that have not used the online maps before. The two bar-charts below show participants' previous map and online map user experience.

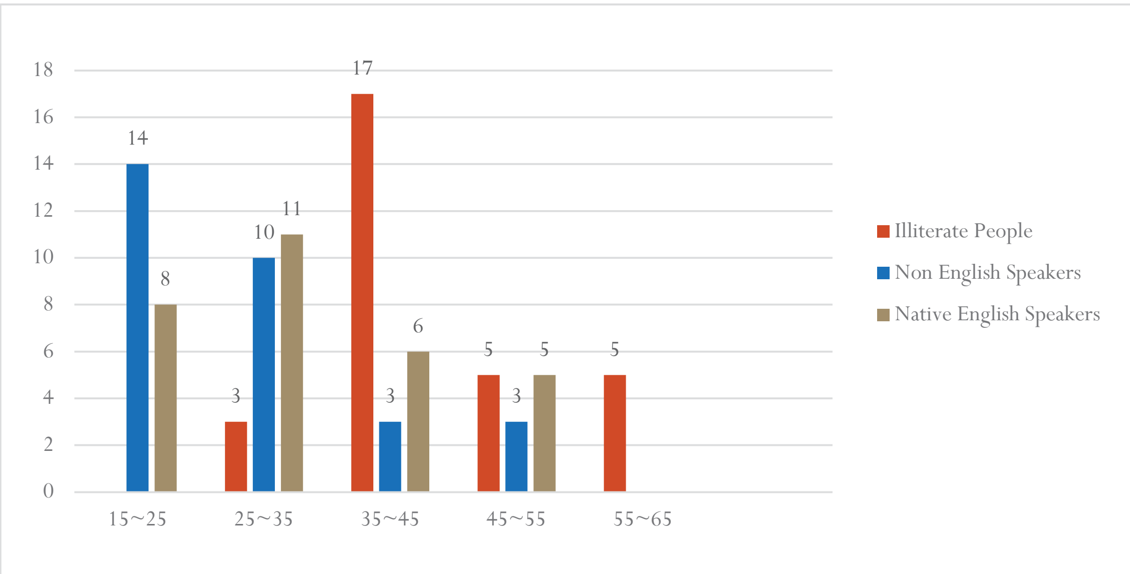

FIGURE 36: AGE-BRACKET FOR EACH GROUP

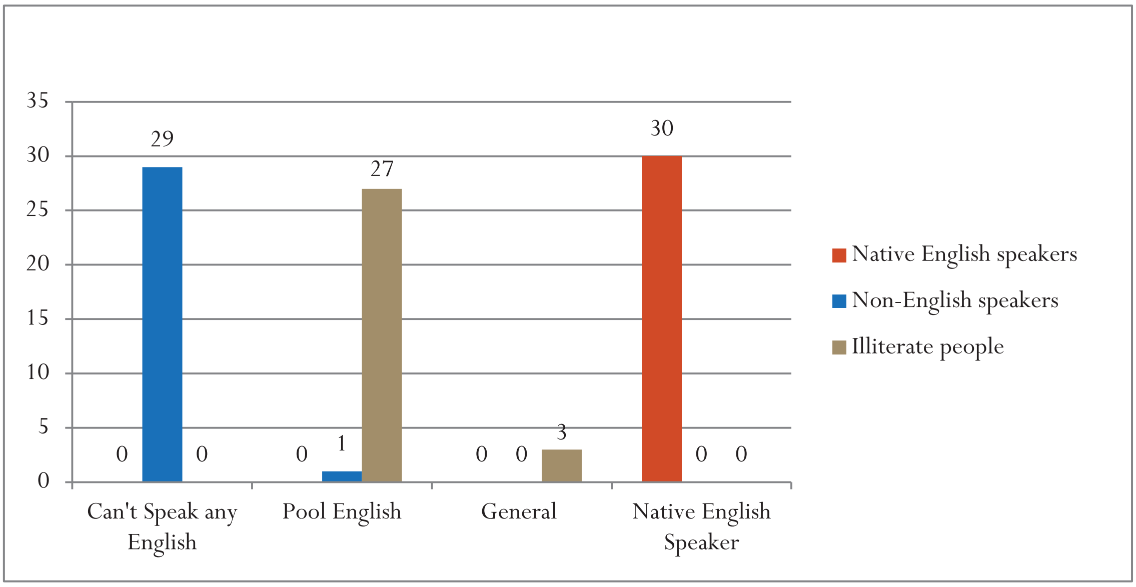

Figure 37: English Speaking level for each Group

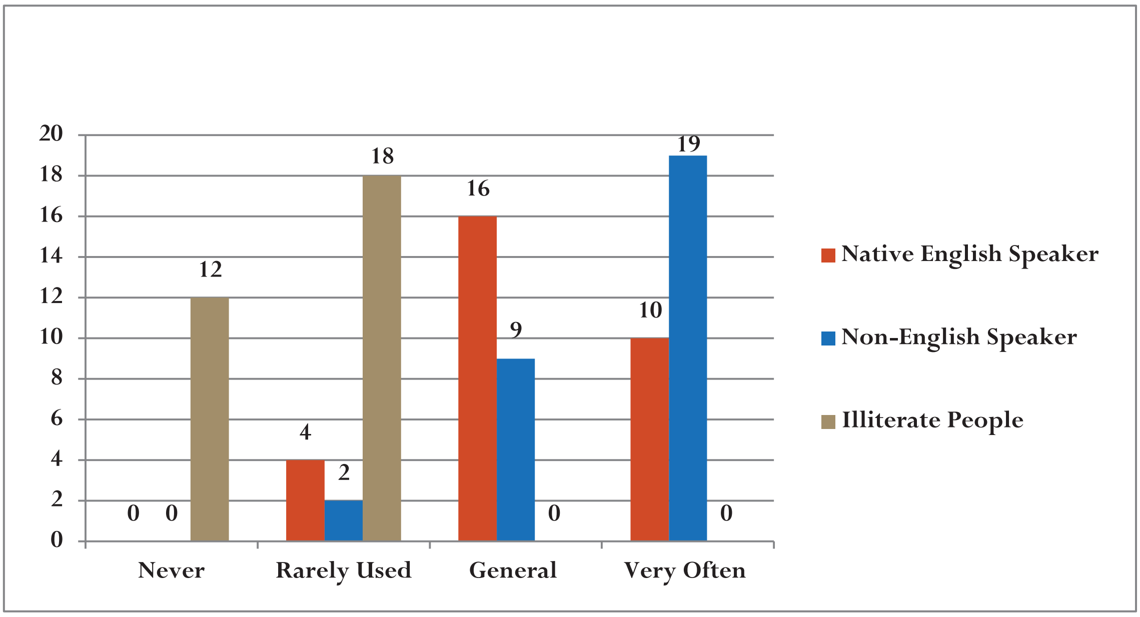

Figure 38: Previous Map Use Experience

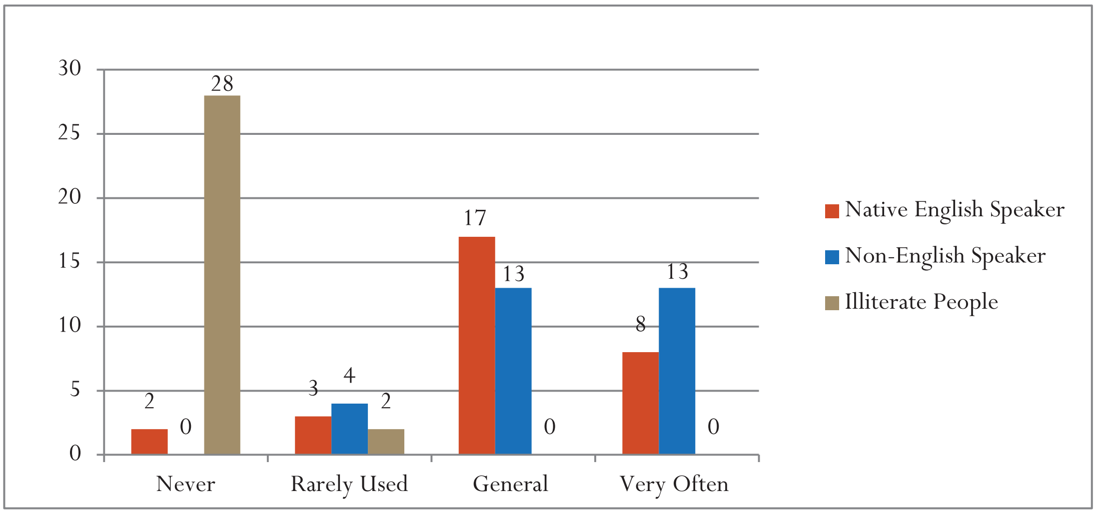

FIGURE 39: PREVIOUS ONLINE MAP USE EXPERIENCE

8.3 Time-Taken Analysis

8.3.1 Time-taken analysis for Different Groups

The data used in this section demonstrates the task performance for different kinds of participants on the same map and task. Figure-40, below, compares the average time-taken in all tasks for each group (the unit of time is converted into a numerical value). In general, Illiterate people were always slowest and the Native English Speakers were fastest in finishing all tasks. This is due primarily to the fact that Illiterate people spent most of their time in learning map features while Native English Speakers spent least time in learning the features. The biggest difference in time taken between Native English Speakers and Non-English Speakers occurred on the text map with audio-only (17.38mins & 36.18mins). Native English Speakers and Non-English Speakers spent almost the same time on the text-free map with symbol-only (28.11mins & 28.45mins). The text map with symbol-only cost all of the three groups least time and the smallest difference in the time-taken between Illiterate people and other groups is shown in "text map with symbol and audio". Time-taken means the time spent by participants from the starting of the first task to the end of the last task. .

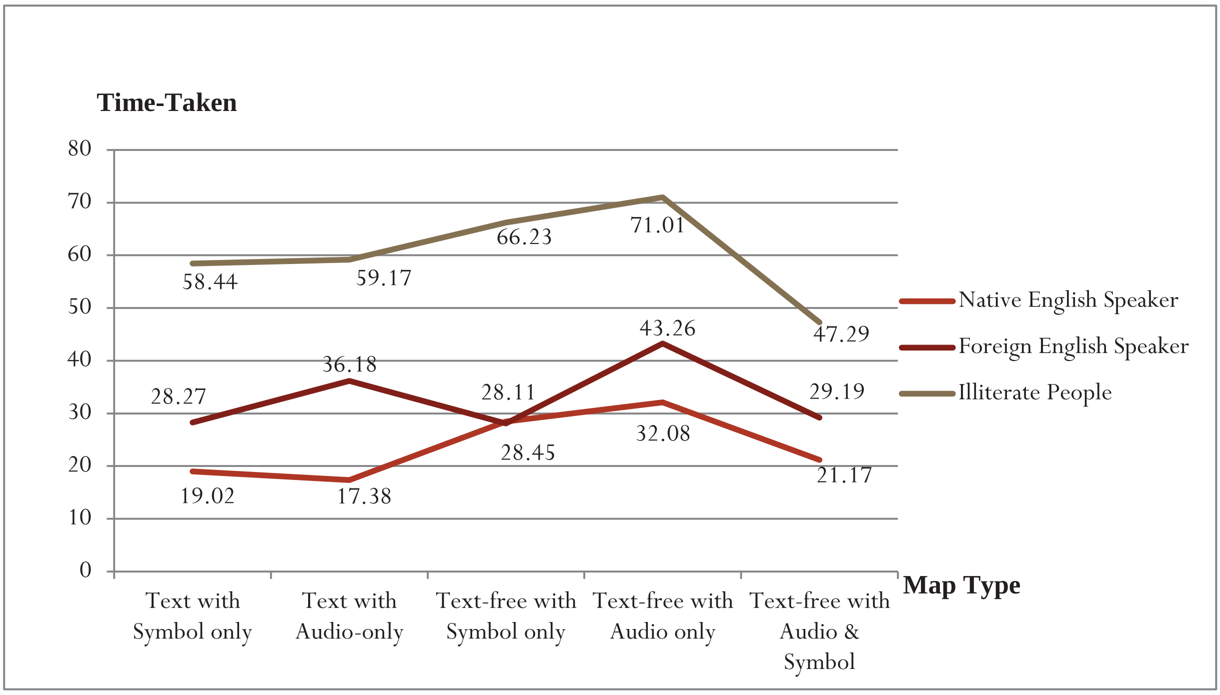

FIGURE-40: AVERAGE TIME-TAKEN FOR EACH GROUP

The time-taken analysis for some specific tasks for different groups is also useful to examine. The tasks Find a shortest route between two landmarks (from "Massey University" to "Albany Bus Station") and define two landmarks on the way is a comprehensive test of map use, which shows the distinctions based on different previous map experience. Another task "Find three landmarks: Massey University, Albany Bus Station and Sky Tower" is also representative since the two new features "Symbol Search Bar" and "Audio Search Bar" were frequently used to replace the text-based search function. They are both designed for non-English speakers and illiterate people. Native English Speakers spent the least time (4.17mins) on the task "Find the shortest way and define two landmarks on the way" while Illiterate people spent the most time on it (28.37mins). However, Non-English Speakers spent the least time on "Symbol Search Bar" and the overall time-taken on "Symbol Search Bar" of these three groups are close. Zero seconds for non-English speakers for Audio Search Bar means no non-English speaker used the Audio Search Bar.

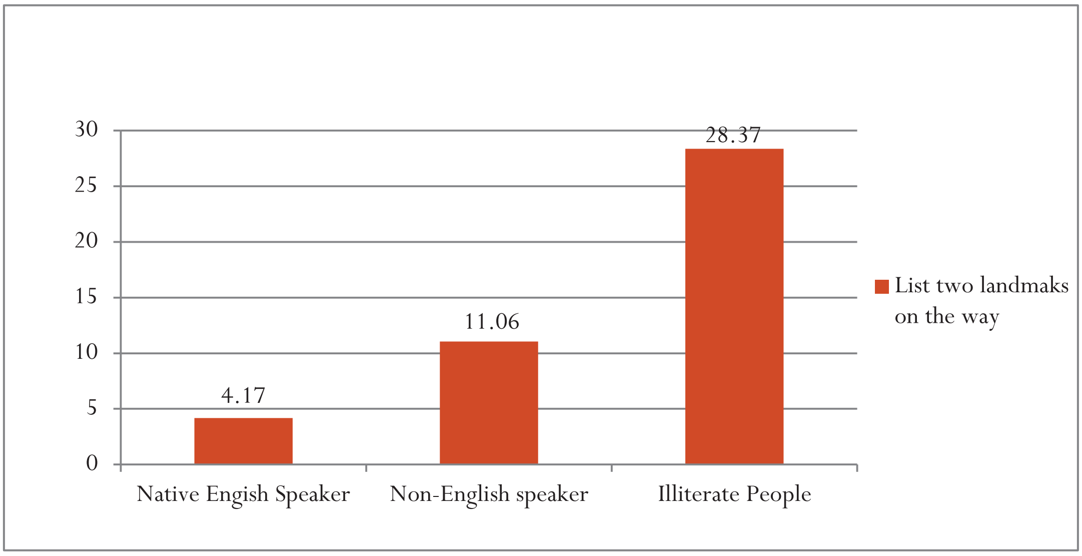

FIGURE 41: TIME TAKEN ON TASK FIND A SHORTEST ROUTE BETWEEN TWO LANDMARKS

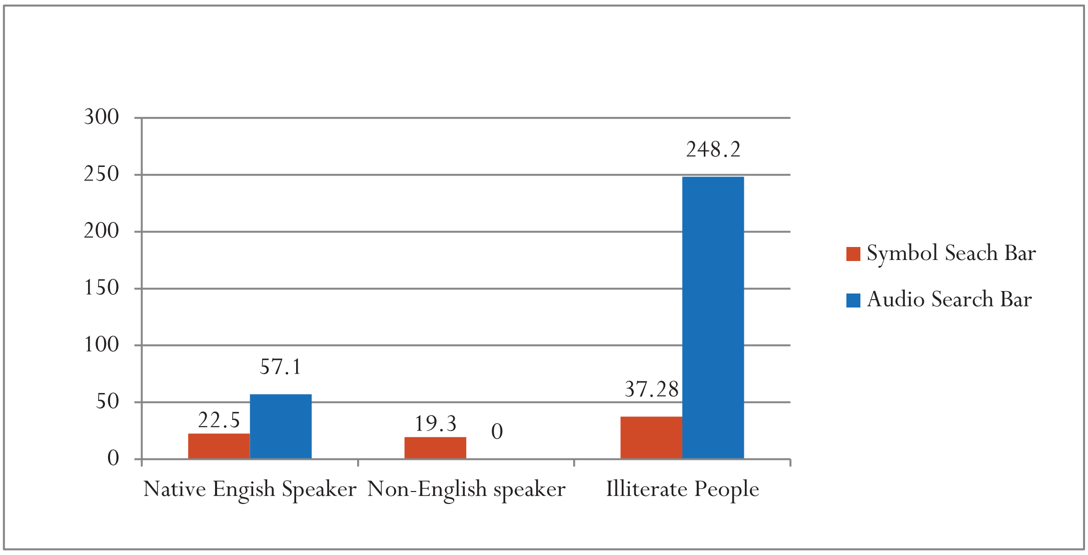

FIGURE 42: TIME-TAKEN ON TASK "FIND THREE GIVEN LANDMARKS"

8.3.2 Time-taken Analysis for Map Types

The data for this section is used to compare the task performance of participants in the same category on different kinds of map. Table-14 also compares the time taken on different kinds of maps. In general, for Native English Speakers, the mean time-taken on the text-free map is much more than the text map (text map with audio-only takes the least time (17:38mins) while "text-free map with audio-only" takes the most (32.08mins). For Non- English Speakers, the mean time-taken on the map with symbols is much less than that on the map without symbols (audio-only). The text-free map with symbols and audio takes the least time (25:19mins) while the text-free map with audio only takes the most time (43:26mins). However, entirely different from the other two groups, Illiterate people spent the least time on the text-free map with symbol and audio while they spent a similar time on the other four kinds of maps.

8.3.3 Significance Difference Testing for Time-Taken

Tables 15 indicate the statistical significance of the differences between different user groups and map types (Lysholm, 1982; Tryon, 2001; America et al., 2006). We used the ANOVA method for calculating the significance, which is for analysis of variance attained and is based on whether the observed p-value of is less than the significance level. The main approach is to subsample the data; that is, use only some of the data in order to reduce the temporal resolution (Bandura, 1989). For example, the surface temperature shows a strong day-to-day correlation. If the temperature measurements were separated by one month, the autocorrelation would be much smaller and perhaps we could assume that the data are independent. The highlighted cells are those for which the difference is statistically significant at the 0.01 level. The detailed processing for calculating the significance is shown in Appendix K:

TABLE 16: SIGNIFICANCE DIFFERENCE FOR TIME-TAKEN

Text with Symbol-Only			
Source of Variation	**F**	**P-value**	**F crit**
Native English Speakers and Illiterate People	23894.12	2.68E-16	4.182964
Non- English Speakers and Illiterate People	177.656	6.78E-14	4.182964
Native English Speakers and Non- English Speakers	15.32622	0.000504	4.182964
Text with Audio-Only			
Source of Variation	**F**	**P-value**	**F crit**
Native English Speakers and Illiterate People	27869.12	1.21E-16	4.182964
Non- English Speakers and Illiterate People	78.656	9.54E-9	4.182964

Native English Speakers and Non- English Speakers	57.477	5.43E-8	4.182964
Text-free with Symbol-Only			
Source of Variation	**F**	**P-value**	**F crit**
Native English Speakers and Illiterate People	21976.12	2.89E-16	4.182964
Non-English Speakers and Illiterate People	98.35	4.23E-15	4.182964
Native English Speakers and Non- English Speakers	0.036458	0.85333	4.182964
Text-free with Audio-Only			
Source of Variation	**F**	**P-value**	**F crit**
Native English Speakers and Illiterate People	19787.12	9.21E-15	4.182964
Non- English Speakers and Illiterate People	98.35	9.71E-13	4.182964
Native English Speakers and Non- English Speakers	40.01	0.000023	4.182964
Text-free with Symbol & Audio			
Source of Variation	**F**	**P-value**	**F crit**
Native English Speakers and Illiterate People	112.23	7.21E-10	4.182964
Non- English Speakers and Illiterate People	70.7667	6.71E-8	4.182964
Native English Speakers and Non- English Speakers	5.45	0.032946	4.182964

* "**F**" value is the variance of two groups, "**F crit**" is the Threshold of "**F**" Under the appropriate level of significance, **P-value** is the Probability of Significance Difference under corresponding "F- value"

The data of Table-15 illustrates that the differences in time-taken are significant at a level of 0.01 in nearly all cases. Only in Text-free map with Symbol Only there is no Significant Difference between Native English Speaker and non-English Speaker (F (0.036458) < F (4.182964); P-value (0.85333) > 0.005). It is worth mentioning that the native English speakers and non-English speakers have a significant difference for time-taken on “text-free map with symbol and audio” (F (5.45) > F (4.182964); 0.001 < P-value (0.0032496) < 0.005).

8.4 Usability Test

The System Usability Scale (SUS) is a simple Likert scale and shares a comprehensive method to measure subjective assessments of the usability of interfaces. The approach for calculating the corresponding scores for SUS to measure the usability is defined by previous study (Brooke, 1996; Borsci, 2009; Bangor et al., 2009; Kortum, 2013). Different groups have various ideas regarding the usability of the map. For the text map with symbol-only and audio-only, the average SUS scores of Native English Speakers is larger than 70, and that of the text map of audio only is 82.5. By contrast, besides the text-free map with symbol and audio, the average SUS score of Illiterate people is much smaller than that of Native English Speakers and non-English Speakers. However, the SUS score for Illiterate people shows a significant increase in the text-free map with symbol and audio compared with the other four kinds of maps (from approximate 30 to 57.5). The SUS score between Native English Speakers and Non- English Speakers in text-free with symbol only is close (65 and 67.5).

The average SUS score of each kind of maps is shown in Table-16, the detailed arithmetic for calculating the SUS is shown in Appendix L:

TABLE 17: SUS SCORES FOR DIFFERENT PARTICIPANTS

	Average Scores on each Map		
Participants Category/ Map Type	**Native English Speakers**	**Non-English Speakers**	**Illiterate People**
Text with Symbol Only	77.5(>70)	65	35
Text with Audio Only	82.5(>70)	45	22.5
Text-free with Symbol Only	65	67.5	37.5
Text-free with Audio Only	60	37.5	25
Text-free with Symbol and Audio	67.5	60	57.5

8.4.1 Significance Testing for Difference in SUS Score

This section explores the difference between participant groups and their views of the usability of each kind of map. The main method used is to compare the significance of the difference between the SUS scores of different kinds of maps. The comparison is mainly focused on the text map with symbol-only and text-free map with symbol-only, text map with audio-only and text-free map with audio-only and three kinds of text-free maps. The statistical significant of the difference in SUS for compared maps is listed in Table-17, Table-18 and Table-19 and the detailed SUS scores for each map are listed in Appendix M. The highlighted row is the only one that has a significance difference. Corresponding measuring methods are shown in Appendix M.

TABLE 18: SIGNIFICANT DIFFERENCE OF SUS SCORE – NATIVE ENGLISH SPEAKERS

Native English Speakers			
Text with Symbol-only & Text-free with Symbol-only	**F**	**P-value**	**F crit**
	7.352941	**0.053447**	**6.607891**
Text with Audio-only & Text-free with Audio-only	**F**	**P-value**	**F crit**
	45	**0.001114**	**6.607891**
Text-free with Symbol-only & Text-free with Symbol and Audio	**F**	**P-value**	**F crit**
	0.251509	**0.637311**	**6.607891**
Text-free with Audio-only & Text-free with Symbol and Audio	**F**	**P-value**	**F crit**
	1.956522	**0.220754**	**6.607891**

TABLE 19: SIGNIFICANT DIFFERENCE OF SUS SCORE – NON- ENGLISH SPEAKERS

Non-English Speakers			
Text with Symbol-only & Text-free with Symbol-only	**F**	**P-value**	**F crit**
	0.9375	**0.377391**	**6.607891**
Text with Audio-only & Text-free with Audio-only	**F**	**P-value**	**F crit**
	3.648649	**0.114365**	**6.607891**
Text-free with Symbol-only & Text-free with Symbol and Audio	**F**	**P-value**	**F crit**
	2.410714	**0.181214**	**6.607891**
Text-free with Audio-only & Text-free with Symbol and Audio	**F**	**P-value**	**F crit**
	86.78571	**0.00024**	**6.607891**

TABLE 20: SIGNIFICANT DIFFERENCE OF SUS SCORE – ILLITERATE PEOPLE

Illiterate People			
Text with Symbol-only &	**F**	**P-value**	**F crit**

Text-free with Symbol-only	**5.136986**	**0.072758**	**6.607891**
Text with Audio-only & Text-free with Audio-only	**F**	**P-value**	**F crit**
	5.95	**0.061482**	**6.607891**
Text-free with Symbol-only & Text-free with Symbol and Audio	**F**	**P-value**	**F crit**
	23.52	**0.004675**	**6.607891**
Text-free with Audio-only & Text-free with Symbol and Audio	**F**	**P-value**	**F crit**
	68.51351	**0.00042**	**6.607891**

For native English speakers, there is no significant difference of SUS Scores between "text map with symbol-only" and "text-free map with symbol-only" (F (7.352941)> F (6.607891), P-value (0.0053) > 0.005)), whereas the difference of SUS Scores between "text map with audio-only" and "text-free map with audio-only" is significant. For non-English speakers, the significant differences of SUS Scores only exist in "text-free map with audio-only" and "text-free map with symbol and audio". However, in terms of Illiterate people, significant differences only exist between "text-free map with symbol-only" and other text-free maps. Both have a significant difference of SUS scores compared with "text-free map with symbol and audio" respectively.

8.5 Evaluation for Map Features

We also evaluated the map features that were included on the online maps: Positioning, Pan and Zoom, Symbols, Text Search Bar, Symbol Search Bar and Audio Search Bar. Each feature is evaluated based on its learnability, effectiveness and efficiency. The time-taken on each feature is the determining factor.

8.5.1 Positioning

The operation of using Positioning is too simple, which only requires click the button "Geolocate Me" and the interface will show the user's current location. Therefore, this feature is only measured by effectiveness, which means that whether the user was able to find their current position successfully or not.

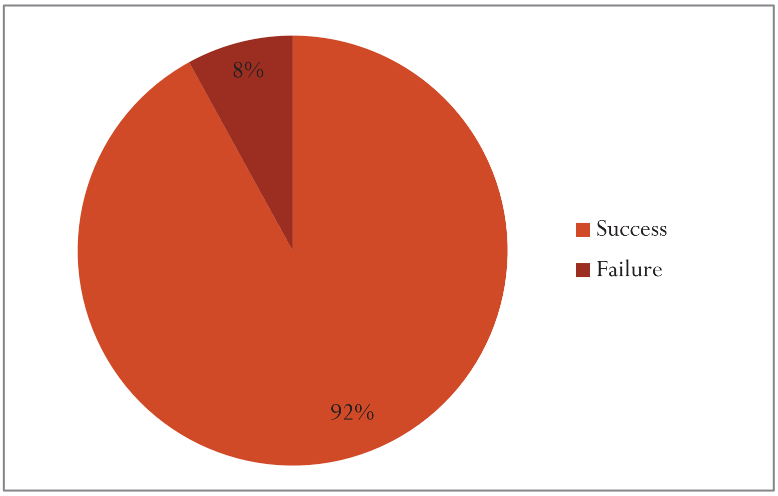

FIGURE 43: THE RATE OF SUCCESS IN USING FEATURE "POSITIONING"

A total of 83 (92%) participants finished the "Positioning Testing" with only 7 (8%) of participants being unable to find their current location.

8.5.2 Pan and Zoom

The Pan and Zoom functions are tested with a task that requires the user to find three specific symbols (Bank, Cinema and Library). The time-taken for the first symbol is used to measure the learnability of these functions. The time-taken for the second and third symbol is used to measure the efficiency of these functions.

TABLE 21: TIME-TAKEN FOR FINDING SYMBOLS

Participants / Symbols	First Symbol	Second Symbol	Third Symbol
Native English Speakers	10:07sec	5:46 sec	6:03sec
Non- English Speakers	8:53sec	4sec	6:26sec
Illiterate People	21:27sec	14:06sec	13:57sec

TABLE 22: SIGNIFICANT DIFFERENCE ON TIME-TAKEN

First Symbol & Second Symbol	**F**	**P-value**	**F crit**
	103.9268	1.13E-16	3.946876
First Symbol & Third Symbol	**F**	**P-value**	**F crit**
	95.48	7.78E-14	3.946876

Table-20 shows that the overall time-taken on finding the second and third symbol is much less than the first symbol. Table-21 shows that the difference between the time-taken on first symbol searching with both second and third symbol searching is statistically significant (no comparison of the second and third symbol since the time-taken of third symbol is more than the second symbol, only if both of them have statistically significant with first symbol means this function has a good efficiency). In short, participants are much quicker at finding the second and third symbols compared with the first symbol. In addition, 81 (90%) people successfully found all three symbols.

TABLE 23: THE CASE OF FINDING SECOND AND THIRD SYMBOL BY USING PAN AND ZOOM

Find 3 symbols successfully	81
Find 2 symbols successfully	8

Therefore, "Pan and Zoom" has a good learnability since literate people only spent less than 10 seconds in finding the first symbol, the efficiency of "Pan and Zoom" is also good based on the time-taken of the second and third landmark both have the Significant Difference with the first landmark, 90% people are able to find all three symbols successfully suggest this feature has a good effectiveness.

8.5.3 Text Search Bar

19 participants attempted to use the text-search bar to find a specific landmark, 7 non-English speakers and 10 illiterate people were not willing to try this feature. (36 people have chances to use this feature in total since there are two maps have text (text map with symbol-only and text map with audio-only) and each one needs to be evaluated by 18 participants (6 for each group)). Participants were made up of:

- 12 Native English Speakers
- 5 Non-English Speakers
- 2 Illiterate people.

Learnability & Effectiveness

TABLE 24: THE CASE OF FIRST LANDMARK SEARCH BY "TEXT SEARCH BAR"

First Landmark Searching	
Did not Attempt	17
Success	15
Unsuccessful	4
Mean time-taken on success	15.07sec

Of those who used the text search bar, all of the 12 native English speakers who evaluated maps that included the text search bar were successful in using it to finding the first landmark. Only 2 non-English speakers who evaluated maps that included the text search bar succeed to find the Text Search Bar and only 1 illiterate person was successful in finding the first landmark.

TABLE 25: THE DISTRIBUTION OF GROUPS FOR FINDING THE FIRST LANDMARK SUCCESSFULLY

Participants' Success and Time-taken in finding first landmark successfully			
Number & Mean Time-Taken / Participants	**Native English Speakers**	**Non- English Speakers**	**Illiterate People**
Number	12	2	1
Mean Time-Taken	14.29sec	16.23sec	28.28sec

Of those 19 participants who attempted to use the text search bar, 15 participants found the first landmark (Massey University) successfully while only 2 participants failed in using the Text Search Bar. These 15 successful participants were made up of 12 Native English Speakers, 2 Non- English Speakers and 1 Illiterate Person. While the majority of the illiterate group have negligible literacy, one of the group members had used the computers before. Although he couldn't read text, he knew how to find each letter on the keyboard and how to input letters one by one in to the search bar. Whilst this took a longer amount of time, he was successful in his search.

Efficiency Test

Of those 15 people who were successful in finding the first landmark (Massey University) all chose to use the "Text Search Bar" to find the second landmark (Sky Tower) and the third landmark (Albany Bus Station). Table-25 shows the high success rate of the second and third landmark through using the text search bar (100% for each, the mean time-taken on third landmark is a little bit longer since the word "Albany Bus Station" is longer to type). Figure-44 indicates the time-taken on all three landmarks for all three groups with the difference of time-taken between first landmark and two latter landmarks being significant. Table-26 illustrates the Significant Difference on time-taken for searching all three landmarks by using Text Search Bar. It indicates that the speed of searching the latter two landmarks is much faster than the first one.

TABLE 26: THE SUCCESS RATE OF SECOND AND THIRD LANDMARK SEARCHING

Second Landmark Search	
Did not Attempt	0
Successful	15
Unsuccessful	0
Mean time-taken	10.27sec
Third Landmark Search	
Successful	15
Unsuccessful	0
Mean time-taken	11.21sec

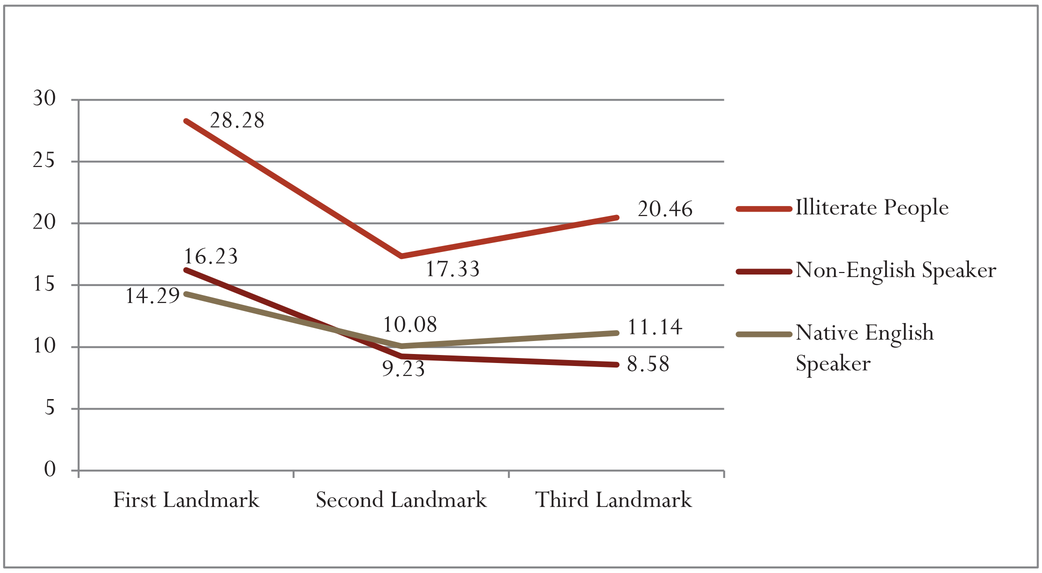

FIGURE 44: TIME TAKEN ON ALL THREE LANDMARKS OF EACH GROUP

TABLE 27: SIGNIFICANT DIFFERENCE ON TIME-TAKEN FOR SEARCHING THREE LANDMARKS

Significant Difference on Time-Taken			
First Landmark & Second Landmark	**F**	**P-value**	**F crit**
	52.70914	1.91E-06	4.493998
First Landmark & Third Landmark	**F**	**P-value**	**F crit**
	46.59812	4.78E-06	4.493998

8.5.4 Audio Search Bar

Learnability & Effectiveness

The Audio Search Bar works based on the voice recognition, users needs to click the Audio Search Bar and say the place name loudly to Audio Search Bar, then the voice recognition system will convert the voice into the text and shown in the Audio Search Bar. After checking the content of text can match the content of voice, users can click the “Search” button and the destination will be found. The screen dumps are shown in Chapter 6.5.

A total of 32 participants attempted to use the Audio Search Bar to search the first landmark (Massey University), which includes 14 Native English Speakers, 2 non-English Speakers and 16 Illiterate People. However, there are still 22 participants were not willing to attempt this feature for the first landmark (54 people have chances to use this feature in total since there are three maps have text (text map with audio-only and text-free map with audio-only and text-free map with symbol and audio) and each one needs to be evaluated by 18 participants (6 for each group))

TABLE 28: THE CASE OF FIRST LANDMARK SEARCH BY "AUDIO SEARCH BAR"

First Landmark Search	
Did Not Attempt	22
Success	19
Unsuccessful	13
Mean time-taken on success	34.57sec

TABLE 29: TIME TAKEN ON ALL THREE LANDMARKS OF EACH GROUP

Different Participants finding First Landmark Successfully		
Number & Mean Time-Taken / Participants	**Native English Speakers**	**Illiterate People**
Number	14	5
Mean Time-Taken	30.02sec	49.47sec

Table-27 and Table-28 both illustrate 59.4% of participants successfully finished the first landmark searching through the audio bar. Those successful participants contain 14 native English speakers and 5 illiterate people. While 32 native English speakers and illiterate people attempted to use the audio search bar function, the poor performance of the voice recognition function (Google API), particularly with people who do not use standard pronunciation and emphasis, has resulted in lower effectiveness of audio search than that of text search. Illiterate people spent more time on this feature since their pronunciation was not as well as native English speakers so that many times their voice can't be recognized. Compare with Symbol Search Bar, participants spent much more time on the first landmark and the success rate of the first landmark shows a dramatically decreases, which suggests the learnability and effectiveness of Audio Search Bar is not good.

Efficiency Test

As the audio search bar was difficult to learn, only 13 of the 19 participants who used it to find the first landmark when on to use it for the second landmark (Sky Tower). 9 participants chose to use the Audio Search Bar to search to the third landmark (Albany Bus Station).

Table-29 shows the general success rate of second and third landmark using the text search bar (76.9% for second landmark and 77.8% for third landmark). Figure-45 indicates the time-taken on all three landmarks, for the two groups who used it. Table-30 shows significance difference on time-taken only exists between the first landmark and third landmark. The speed of the latter two landmarks have no obviously improvement compared with the first one, which indicates the efficiency of Audio Search Bar is general.

TABLE 30: THE CASE OF SEARCHING THE SECOND AND THIRD LANDMARKS

Second Landmark Searching	
Did not Attempt	6
Successful	10
Unsuccessful	3
Mean time-taken on success	37.29sec
Third Landmark Searching	
Did not Attempt	4
Successful	7
Unsuccessful	2
Mean time-taken on success	29.56sec

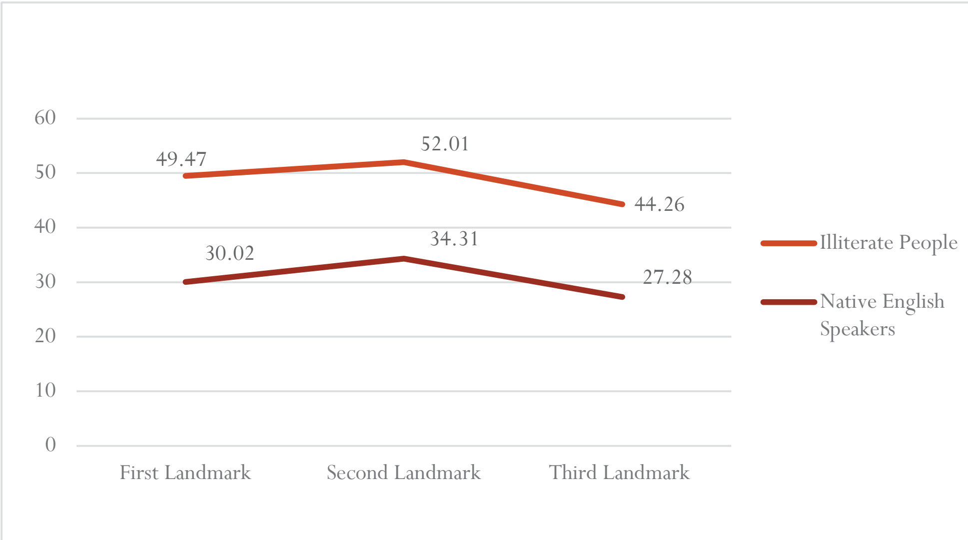

FIGURE 45: TIME TAKEN ON ALL THREE LANDMARKS OF EACH GROUP

TABLE 31: SIGNIFICANT DIFFERENCE ON TIME-TAKEN FOR SEARCHING THREE LANDMARKS

Significant Difference on Time-Taken			
First Landmark & Second Landmark	**F**	**P-value**	**F crit**
	4.662481	0.059137	5.117355
First Landmark & Third Landmark	**F**	**P-value**	**F crit**
	66.95686	0.000179	5.987378

8.5.5 Symbol Search Bar

Learnability & Effectiveness

40 participants attempted to use the Symbol Search Bar to search for the first landmark (Massey University) while 14 did not try to use it (54 people have chances to use this feature in total since there are three maps have text (text map with symbol-only and text-free map with symbol-only and text-free map with symbol and audio) and each one needs to be evaluated by 18 participants (6 for each group)).

This group contained:

- 5 Native English Speakers
- 23 Non- English Speakers
- 12 Illiterate people

TABLE 32: THE CASE OF FIRST LANDMARK SEARCH BY "AUDIO SEARCH BAR"

First Landmark Searching	
Did not Attempt	14
Successful	32
Unsuccessful	8
Mean time-taken to successfully perform the function	6:53sec

TABLE 33: TIME TAKEN ON ALL THREE LANDMARKS OF EACH GROUP

Different Participants in finding the first landmark successfully			
Number & Mean Time-Taken / Participants	**Native English Speakers**	**Non- English Speakers**	**Illiterate People**
Number	5	22	5
Mean Time-Taken	4:22sec	6:46sec	9:01sec

Table-31 and Table-32 demonstrate that 32 (80%) people were able to find the first landmark successfully, with only one Non- English Speaker and two Illiterate people that could not finish this task. The mean time-taken for finding the first landmark is only 6.53 sec. Therefore, users could find the first landmark quickly suggests that Symbol Search Bar has a good learnability and 80% users could find the first landmark successfully also indicate that the effectiveness of Symbol Search Bar is good.

Efficiency Test

29 of the 32 successful people, chose to use the Symbol Search Bar to search for the second landmark (Sky Tower) and 23 also used it for the third landmark (Albany Bus Station).

TABLE 34: THE CASE OF SEARCHING THE SECOND AND THIRD LANDMARKS

Second Landmark Searching	
Did not Attempt	3
Successful	25
Unsuccessful	4
Mean time-taken on success	7:48sec
Third Landmark Searching	
Successful	23
Unsuccessful	0
Mean time-taken on success	6:28sec

Table-33 shows the success rate of the second and third landmark search by using the symbol search bar (86.2% and 100% respectively). Figure-46 indicates the time-taken on all three landmarks, each group shows the different speed on second and third landmark, native English speaks and non-English speakers are all fast. The difference of time-taken between first landmark and two latter landmarks is not statistically significant since these three landmarks were all searched quickly. It suggests that the efficiency of Symbol Search Bar is good.

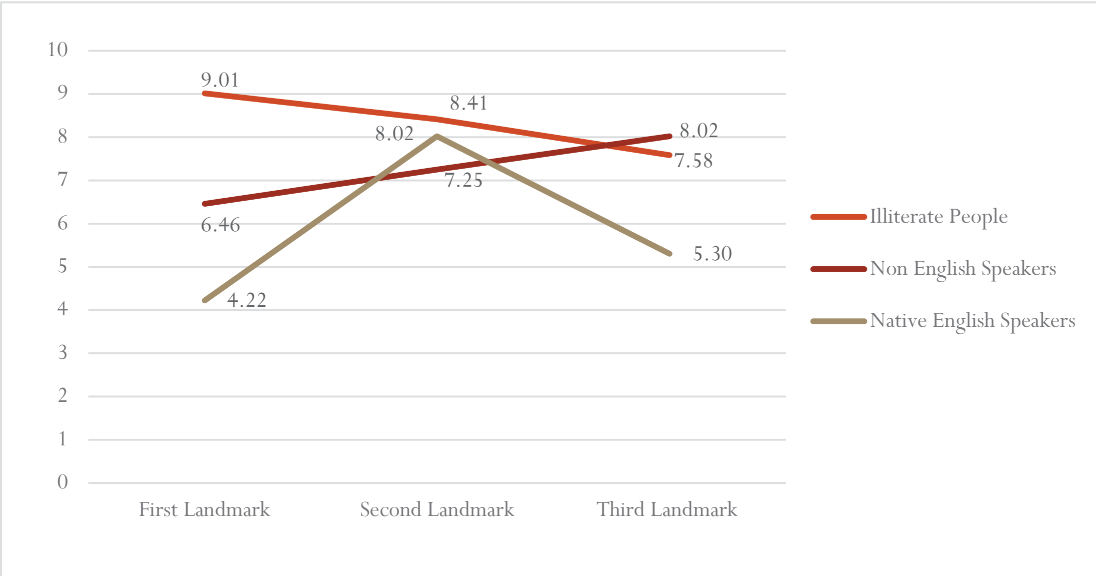

FIGURE 46: TIME TAKEN ON ALL THREE LANDMARKS OF EACH GROUP

TABLE 35: SIGNIFICANT DIFFERENCE ON TIME-TAKEN FOR SEARCHING THREE LANDMARKS

Significant Difference on Time-Taken			
First Landmark & Second Landmark	**F**	**P-value**	**F crit**
	7.087039	0.013378	4.241699
First Landmark & Third Landmark	**F**	**P-value**	**F crit**
	0.007917	0.929871	4.279344

8.6 Other Analysis

The analysis in this section is based on the fourth part of the questionnaire (See Appendix J) where participants express their views about the interfaces in response to open-ended questions.

8.6.1 Evaluation of Layout

1. **Do you like the interface layout of the map? (Yes/No) Any suggestions about the layout improvement?**

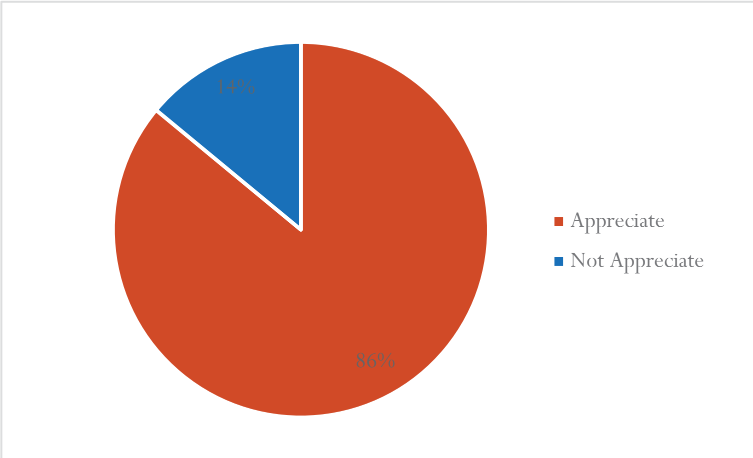

FIGURE 47: APPRECIATE RATE OF LAYOUT

77 (86%) participants liked the appearance of the online map interface while 13 (14%) participants did not appreciate the layout of the map they used (the data is based on responses to the open question "Do you like the layout of your map? (Yes/No)). Among those 13 participants, 8 thought that the Search bar should be put at the left top of the interface since the Search Bar currently popular online maps are at the left top, 6 thought that the traffic lines were not enough, 6 thought that the size of the symbols was too big and 3 didn't like the color settings of the interface.

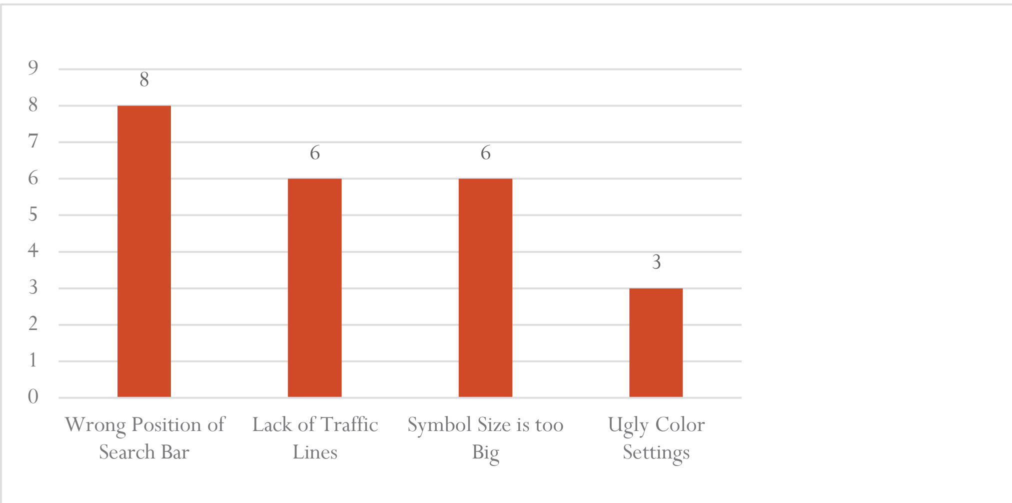

FIGURE 48: MAIN PROBLEMS OF LAYOUT

8.6.2 The Difficult Features

2. Which part is the most difficult in learning to use this web map?

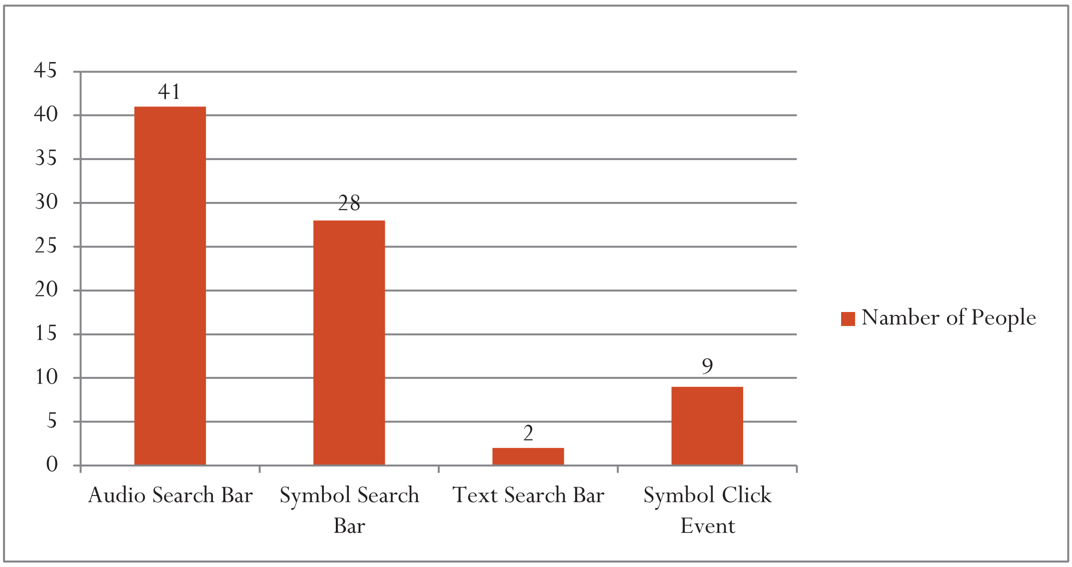

FIGURE 49: MAIN DIFFICULT FEATURES

A total of 41 participants think the Audio Search Bar is the most difficult feature (equal number in each group have the opportunity to use the search bar, 6 for each group). These participants include:

- 10 Native English Speakers
- 18 Non-English Speakers
- 13 illiterate people.

28 people think the Symbol Search Bar is the most difficult (9 Native English Speakers, 7 Non-English Speakers and 12 Illiterate people) while only 2 people chose the Text Search Bar (all Non-English Speakers). The illiterate people did not specify text search as the most difficult feature mainly because they didn't try to use is). In addition, there are 9 people that think the "Symbol Click" is the most difficult feature (1 Non-English Speaker and 8 Illiterate people). Those people thought there was nothing happened when they tried to click symbols for many times.

8.6.3 The Meaning of Symbols

Do you think it is easy to understand the meaning of the symbols? If not, which symbols need to be changed?

Like Figure-50 and Figrure-51, only 24 (26.7%), participants thought that all of the symbols were easy to understand (63 participants thought the Symbol of "Albany Primary School" was not meaningful, 58 participants chose the "Community Hall" while 26 of them chose the "Cinema", and another 11 participants selected other symbols). All misunderstood symbols were shown in Appendix A.

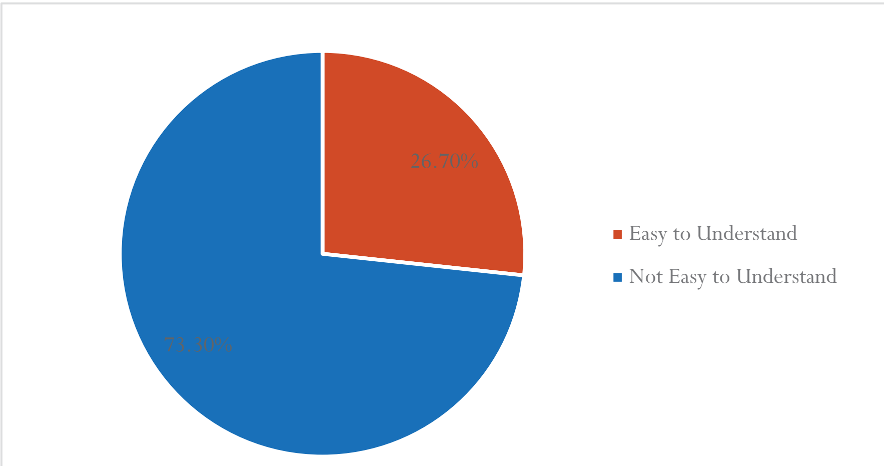

FIGURE 50: THE RATE OF UNDERSTOOD SYMBOLS

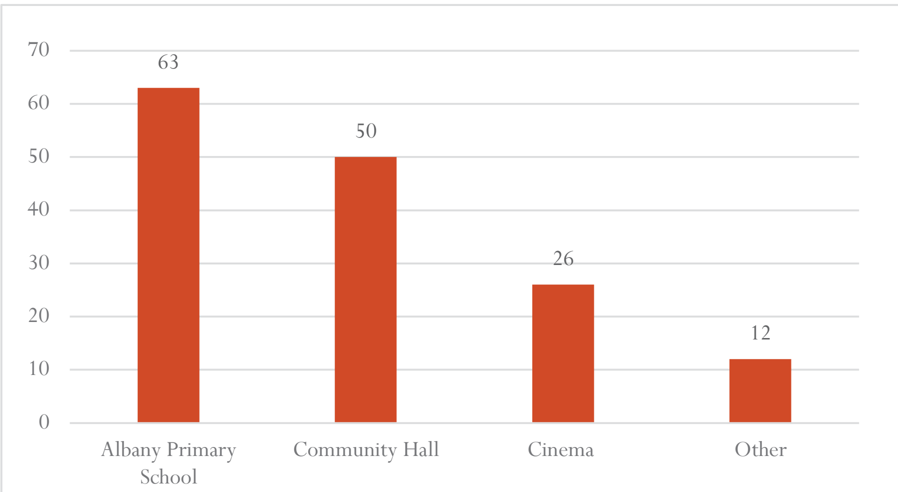

FIGURE 51: MAIN MISUNDERSTOOD SYMBOLS

8.7 Summary

Illiterate people spent most time on finishing all tasks among three groups, and they showed the highest SUS score (most satisfaction) with the text-free map with symbol and audio of all of the tested web map interfaces. No matter the time-taken or SUS scores, there is no significant difference between text maps and text-free maps of non-English-speakers. Most participants think the layout of the interface should be improved and that the audio search bar is the least effective and efficient feature used.

9. Discussion

9.1 Introduction

This Chapter discusses how the results relate back to the research gaps and the original research questions. Section 9.2 talks about the first research question about the differences between using the online map interface for literate and illiterate people. Section 9.3 answers research questions 2 and 3 regarding whether the text-free map interface is useful for illiterate people and which kind of text-free map is the best type; and research question 4 and 5 are discussed together in Sections 9.3 and section 9.4.

9.2 Difference among each kind of Participant

The data of mean time-taken between participants illustrates that the native English Speakers spent the least time completing all of the tasks while Illiterate people spent the most time finishing all of the tasks. Moreover, the large difference in the time-taken to finish all tasks among different these two participant groups shows that it is much more difficult for Illiterate people to use the online map interface compared with literate people and English speaking people.

For native English speakers and non-English speakers there exists a large difference in mean time-taken for both "text map with audio-only and "text-free map with audio only". This suggests that the text and audio are the two main elements that affect the online map interface use between these two groups. The root cause is that Non-English Speakers are unable to read the text and speak English (both Text and Audio Search are based on English-only), and is not surprising.

The difference in time-taken between non-English speakers and illiterate people on all kinds of text-free maps suggests that non-English speakers have more previous map experience than illiterate people, or that they are better able to understand mapping concepts, perhaps as a result of skills they have learnt through language learning (Brown, 2007). Furthermore, combined with the average SUS scores for each group, the result validates that illiterate people are unable to use the online map interface as well as literate people. This may be due to illiterate people have no previous map or online map use experience and language is also a big barrier for them (pre-questions has talked about these).

To address the issue of whether frequency of previous map use biases the results, we consider the survey respondents who identified the "rarely use" frequency of previous map use, as this is the only use category that contains members of all three participant groups (there were no illiterate people in the frequent use group, and no native-English speakers in the never use group). Looking only at the 'rarely use' category, the mean time-taken on finishing all tasks of illiterate people is 67.13mins while native English speaker is 31.43mins and non-English speaker is 37.22mins. Moreover, the average successful rate of finishing the tasks for native English speakers is 66% (each person can finish more than three tasks successfully), for non-English speakers is 57% (each person can finish nearly three tasks successfully), for illiterate people is only 26% (each person can finish only one or two tasks successfully). These two aspects illustrate that it is much hard for illiterate people to use the online map interface, regardless of frequency of previous map use.

9.3 Comparison amongst different Online Map Interfaces

The mean time-taken data for different online map interfaces indicates which is the most suitable online map interface for participant groups. For native English speakers, the time-taken on text maps is significantly less than that of text-free maps, and there is a small significant difference between different types of text free maps For non-English speakers, the biggest difference is shown between “Map with Audio” and “Map without Audio” (both Text maps and Text-free maps), regardless of whether the maps include text or not.   The Audio functions are provided in English only. Moreover, a statistically significant difference in time-taken only exists between “text-free map with audio-only” and “text free map with symbol and audio” for non-English speakers, and not for other participant groups. The difficulty with the audio function may be due to unusual pronunciation, which is not detected by the voice recognition system that we used (non-English speakers can say little English and they didn’t know the sounds that go with English letters). For Illiterate people, the least time was spent on the “text map with symbol and audio” and there was a statistically significant difference between “text-free map with symbol-only and text-free map with audio only” and “text-free map with symbol and audio” respectively. Overall, the most suitable online map interface for Native English Speakers is “text map”, the most suitable online map interface for non-English speakers is “text map with symbol” and the best online map interface for Illiterate people is “text-free map with symbol and audio”.

Therefore, text-free maps are required to be created to support Illiterate people, and they should provide comprehensive text-free maps (include both symbol and audio), but they are not the best maps for other participant groups.

9.4 Discussion of Individual Map Features

9.4.1 Positioning

The operation of “Positioning” is too simple to measure its “learnability” and “efficiency”. 92% of participants were able to finish this task meaning the feature “Positioning” is an effective feature.

9.4.2 Pan and Zoom

Native English speakers and non-English speakers both found the first symbol fast (less than 10.00 sec), which indicates the learnability of “Pan and Zoom” is good generally. 81(90%) of participants could find all three symbols through “Pan and Zoom” and a further 8 (9%) participants were able to find two symbols, indicating that the “effectiveness” of “Pan and Zoom” is good. In addition, the time-taken on finding the second and third landmark both dramatically declines compared with the first symbol, which also means “Pan and Zoom” shows good efficiency.

9.4.3 Text Search Bar

15 (88.2%) participants finished the first landmark search, 15 (100%) participants finished the second landmark search and 15 (100%) participants finished the third landmark search indicating that the “Text Search Bar” has good “effectiveness”. Considering the users were required to input the correct word with the correct format into the text bar, the speed of finishing the search of the first landmark is fast (14.29’” for native English Speakers, 16.25”’ for non-English Speaker and 28.28”’ for Illiterate people) and the learnability is good. Furthermore, the time-taken for the two latter landmarks search sharply decreases, which shows the “Text Search Bar” shows good efficiency.

9.4.4 Audio Search Bar

Only 19 (59.4%) participants finished the first landmark searching, 10 (76.9) participants finished the second landmark search and 77.8% participants finished the third landmark search. From this we can determine that the “effectiveness” of the Audio Search Bar is not good. The mean time-taken on first landmark searching reaches at 34.57”’ meaning the Audio Search Bar is not easy to learn to use. We postulate that this is related to the poor performance of the voice recognition system that was used, particularly for people using atypical pronunciation and emphasis.

9.4.5 Symbol Search Bar

32 (80%) participants completed the first landmark search, 25 (86.2%) participants completed the second landmark search and 23 (100%) participants completed the third landmark search indicating that the “Symbol Search Bar” has good effectiveness. The mean time-taken on the first landmark is only 6.53’” meaning it has good learnability. The mean time-taken on the latter two landmarks is almost the same as the first one (“7.48” for the second landmark and “6.28” for the third landmark) because it is so simple that they are performing well at the start.

9.5 Research Question Validation

In this section, we go back to the Research Questions posed in section 1.4 and answer them in the light of the results from the usability testing.

1. What are the differences between using the online map interface for literate and illiterate people?

   It is much more difficult for illiterate people to use the online map compared with the literate people, they have the low ability to learn the features and use them effectively.

2. Is it necessary to develop a text-free online map interface for illiterate people?

   Yes, it is. Illiterate people spent least time (Time-taken) and feel best (SUS Scores) when using the “text-free map with symbol and audio”, which suggests they really need the text-free online map that includes symbol and audio.

3. Which kind of text-free map is most suitable for illiterate people?
   The text-free map with symbol and audio is the most suitable category for illiterate people since they showed the best performance when using it (mentioned in research question 2).

4. Is a text-free map easily and effectively used by non-local-language speakers, over a text map?
   No. There is no large difference of task performance between text map and text-free maps for non-local-language speakers, which does not indicate that the text-free map is beneficial for non-local-language speakers. For non-local-language, the audio function with local language and more static drawings are important aspects

5. How do text-free maps of different types compare to textual maps for literate, local-language speaking people?
   Text maps are much more suitable for literate people who speak the language in which the map is published (in this case, English). The task performance of native English speakers on text-free maps was much worse than that of text maps based on the time they spent to finish all tasks, and their SUS scores. Thus it will not be feasible to develop a single online map that would suit all three of the user groups tested.

9.6 Research Limitations

In this Section, we discuss the limitations of the research and their possible consequences.

9.6.1 Lack of Illiterate People

One of the limitations of this research wass the difficulty in finding illiterate people, as they are relatively scarce in New Zealand and those who are illiterate are often unwilling to admit this. While we were able to find 30 illiterate people, it was a difficult task. This means that the sample for testing in the experimental session is limited in size, so more detailed analysis of subgroups (e.g. different levels of previous use of maps, different ages), could not be considered.

9.6.2 Different Previous Map Use Experience

The level of previous map use between different groups is also a limitation. Two participants at the same group may illustrate entirely different performance because of the different previous online map use experience.

This limitation may impact the accuracy of the research question 1~3. Firstly, for measuring the different performance between literate and illiterate groups, literate people who have no previous online map use experience may have worse task performance than illiterate people, but the latter are far more likely to have had previous map experience. Secondly, for non-local-language speakers and illiterate people, bad task performance related to lack of previous map use experience may suggest that text-free map interfaces are not useful, when poor results may actually be related to lack of experience.

9.6.3 Low Quality of Voice Recognition System

Another limitation was the Voice Recognition System used. The results suggest that the voice function is necessary for illiterate people, but many times the voice of illiterate people could not be recognized by the software. The Voice Recognition System should be improved.

Low Voice Recognition functionality may cause more participants to fail in use of the Audio Search Bar, when in fact it may be a useful function if better able to recognize speech.

9.7 Summary

This section indicates how this research fill the research gaps identified in Chapters 1 and 2. Illiterate people were worst at using online map interfaces, but their performance was significantly improved with text-free interfaces over text-interfaces. While non-local-language speakers did not benefit from text-free maps, text-free map with symbol and audio was the most suitable category for illiterate people. In addition, three main research limitations may affect the research results, which needed to be improved in future work.

10. Conclusion and Future Work

In conclusion, we have shown the results of the evaluation of different online text-free map interfaces for Native English speakers, Illiterate people and Non-English Speakers. This research indicates that Illiterate people and Non-English Speakers all strongly prefer text-free map interfaces over text-based interfaces and that text-free online map interfaces are necessary for these sectors. The design and comparison looked at the five categories of online map interface:

- text with symbol-only
- text with audio-only
- text-free with symbol-only
- text-free with audio-only
- text-free with symbol and audio.

A simple set of symbols was identified in the first survey (Symbol Match Game) as the best symbol type for text-free interface in comparison to two alternative sets (complex symbols and photographs). All three sets of symbols were designed during the course of the research.

A set of features that are appropriate for inclusion on a text-free map was selected through the second survey, identifying search bar, Positioning, Pan and Zoom and Audio Notice functions as most important. Two alternative types of search function were designed in addition to the standard text search, in order to cater for non-English speaking and illiterate users: audio search and symbol search.

The five online map types were comprehensively evaluated using a task-based experiment during which time-taken and success rates were recorded, usability testing with the System Usability Scale (SUS) and open-ended questions. Scores on task performance illustrated that Illiterate people experience greater difficulty in using all online map interfaces compared with Literate people. We anticpated that this is due to their low educational level and low experience with map use and with electronic items use. It is necessary for Illiterate people to have access to text-free online maps in order to fully participate in society, and text-free maps with both symbol and audio is the best kind of text-free map for Illiterate people. This differs from non-English people in that there is no significant distinction in the task performance of that group between text-based map interfaces and text-free map interfaces, but their performance in audio functions was impaired. It is suggested that non-local-language speakers don't really need the text-free maps and the main reason for this is that text-based maps and text-free maps have the same features so that the cases of non-English speakers using these features are similar. Additional features need to be added to the text-free maps to replace the text compared with text-based maps for non-local-language speakers. Results also indicate that Illiterate people are the most important and significant beneficiaries of this research. Currently there are at least 30 Illiterate people who participated in my research that have been benefited from this research, and it is suggested that the illiterate people around the world could have chances to own their the text-free online map interface to find the places what they want through symbol or audio, obtain their current location and learn more landmarks in the future.

The results of learnability, effectiveness and efficiency tests for map features indicate that both layout and functionality of the online maps that were created all require improvement. According to the findings of this research, participants consider maps using a single language is not sufficient, whereas maps with multiple languages would allow more International users access; the accuracy of voice recognition is not sufficient to allow for successful place searching and the meaning of some symbols is not easy to understand.

Future work will focus on:

- finding a wider range of illiterate people from different parts of the world;
- finding and comparing participants who have the same background (e.g. the same experience of previous online map using);
- how to design the effective Text Search Bar for showing the non-local languages;
- how to improve the Voice Recognition System for Voice Search Bar;
- designing a function to display the distance and directions between a landmark and the user's current location and
- investigating Illiterate people's cognition of symbols in more depth.

11. Reference

Al-Kodmany, K. (2001). Supporting imageability on the World Wide Web: Lynch's five elements of the city in community planning. Environment and Planning B, 28(6), 805-832.

Al-Rowais, N., Al-Faris, E., Mohammad, A. G., Al-Rukban, M., & Abdulghani, H. M. (2010). Traditional healers in Riyadh region: reasons and health problems for seeking their advice. A household survey. The Journal of Alternative and Complementary Medicine, 16(2), 199-204.

Arh T, Blažič BJ. A case study of usability testing–the SUMI evaluation approach of the EducaNext Portal. WSEAS transactions on information science and applications. 2008 Feb 1;5(2):175-81.

Bandura A, Wood R. Effect of perceived controllability and performance standards on self-regulation of complex decision making. Journal of personality and social psychology. 1989 May;56(5):805.

Bangor, A., Kortum, P., & Miller, J. (2009). Determining what individual SUS scores mean: Adding an adjective rating scale. Journal of usability studies, 4(3), 114-123.

Belhe, S., Paulzagade, C., Deshmukh, A., Jetley, S., & Mehrotra, K. (2012, December). Hindi handwritten word recognition using HMM and symbol tree. In Proceeding of the workshop on Document Analysis and Recognition (pp. 9-14). ACM.

Benseman, J. (2011). Understanding the needs of adult literacy, language and numeracy learners with very low skills: Insights from the research. Journal of Adult Learning in Aotearoa New Zealand, 39(1), 7-18.

Berthold J, Dieterle M, Loogen R. Implementing parallel Google map-reduce in Eden. InEuropean Conference on Parallel Processing 2009 Aug 25 (pp. 990-1002). Springer Berlin Heidelberg.

Bertin J, Dodge M, Kitchin R, Perkins C. General theory, from semiology of graphics. The map reader. 2011 Apr 6:8-16.

Bergen B, Chan Lau TT. Writing direction affects how people map space onto time. Frontiers in psychology. 2012 Apr 10;3:109.

Bhattacharya, S., & Feldman, L. (2012, November). Igwana: a text-free search interface. In Proceedings of the 24th Australian Computer-Human Interaction Conference (pp. 34-37). ACM.

Borsci, S., Federici, S., & Lauriola, M. (2009). On the dimensionality of the System Usability Scale: a test of alternative measurement models. Cognitive Processing, 10(3), 193-197.

Brown, A., Emmer, N., & van den Worm, J. (2001). Cartographic design and production in the Internet era: The example of tourist web maps. The Cartographic Journal, 38(1), 61-72.

Brush, A. J., Krumm, J., & Scott, J. (2010, September). Exploring end user preferences for location obfuscation, location-based services, and the value of location. In Proceedings of the 12th ACM international conference on Ubiquitous computing (pp. 95-104). ACM.

Brooke J. SUS-A quick and dirty usability scale. Usability evaluation in industry. 1996 Sep;189(194):4-7.

Chen, E. Y., Tan, C. M., Kou, Y., Duan, Q., Wang, Z., Meirelles, G. V., & Ma'ayan, A. (2013). Enrichr: interactive and collaborative HTML5 gene list enrichment analysis tool. BMC bioinformatics, 14(1), 128. Retrieved from http://bmcbioinformatics.biomedcentral.com/articles/10.1186/1471-2105-14-128

Ciepłuch, B., Jacob, R., Mooney, P., & Winstanley, A. (2010, July). Comparison of the accuracy of OpenStreetMap for Ireland with Google Maps and Bing Maps. In Proceedings of the Ninth International Symposium on Spatial Accuracy Assessment in Natural Resuorces and Enviromental Sciences 20-23rd July 2010 (p. 337). University of Leicester.

Cockburn, A., Looser, J., & Savage, J. (2003). Around the world in seconds with speed-dependent automatic zooming.
Cooter, K. S. (2006). When mama can't read: Counteracting intergenerational illiteracy. The Reading Teacher, 59(7), 698-702.

Dalton, R., & Bafna, S. (2003). The syntactical image of the city: a reciprocal definition of spatial elements and spatial syntaxes.

Darken, R. P., & Sibert, J. L. (1996, April). Wayfinding strategies and behaviors in large virtual worlds. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 142-149). ACM.

Dean, W. G. (1956). GLACIAL FEATURES OF THE HEARST-COCHRANE MAP-SHEET AREA: An Aerial Photograph Reconnaissance. The Canadian Geographer/Le Géographe canadien, 2(8), 35-45.

Del Bimbo, A., Dini, F., Lisanti, G., & Pernici, F. (2010). Exploiting distinctive visual landmark maps in pan–tilt–zoom camera networks. Computer Vision and Image Understanding, 114(6), 611-623.

Elmeroth, E. (2003). From refugee camp to solitary confinement: Illiterate adults learn Swedish as a second language. Scandinavian Journal of Educational Research, 47(4), 431-449.

Etienne, A. S., Maurer, R., & Séguinot, V. (1996). Path integration in mammals and its interaction with visual landmarks. The Journal of Experimental Biology, 199(1), 201-209.

Findlater, L., Balakrishnan, R., & Toyama, K. (2009, April). Comparing semiliterate and illiterate users' ability to transition from audio+ text to text-only interaction. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1751-1760). ACM.

Fingeret, A. (1983). Social network: A new perspective on independence and illiterate adults. Adult education quarterly, 33(3), 133-146.

Fisher, M., Bordini, R. H., Hirsch, B., & Torroni, P. (2007). Computational logics and agents: a road map of current technologies and future trends. Computational Intelligence, 23(1), 61-91.

Foo, P., Warren, W. H., Duchon, A., & Tarr, M. J. (2005). Do humans integrate routes into a cognitive map? Map-versus landmark-based navigation of novel shortcuts. Journal of Experimental Psychology: Learning, Memory, and Cognition, 31(2), 195.

Frewer, T., & Chan, S. (2014). GIS and the 'Usual Suspects'-[Mis] understanding Land Use Change in Cambodia. Human ecology, 42(2), 267-281.

Friscira, E., Knoche, H., & Huang, J. (2012, March). Getting in touch with text: Designing a mobile phone application for illiterate users to harness SMS. In Proceedings of the 2nd ACM Symposium on Computing for Development (p. 5). ACM.

Goetz, M., Lauer, J., & Auer, M. (2012, January). An algorithm based methodology for the creation of a regularly updated global online map derived from volunteered geographic information. In Proceedings of the Fourth International Conference on Advanced Geographic Information Systems, Applications, and Services, Valencia, Spain (Vol. 30, pp. 50-58).

Golledge, R. G. (1999). Wayfinding behavior: Cognitive mapping and other spatial processes.

Goodman, R., Meltzer, H., & Bailey, V. (1998). The Strengths and Difficulties Questionnaire: A pilot study on the validity of the self-report version. European child & adolescent psychiatry, 7(3), 125-130

Graff, H. J. (1977). "Pauperism, Misery, and Vice": Illiteracy and Criminality in the Nineteenth Century. Journal of Social History, 11(2), 245-268.

Graham, S. (1998). The end of geography or the explosion of place? Conceptualizing space, place and information technology. Progress in human geography, 22(2), 165-185.

Graham, S., & Healey, P. (1999). Relational concepts of space and place: issues for planning theory and practice. European planning studies, 7(5), 623-646.

Grierson, L. E., Zelek, J., & Carnahan, H. (2009). The application of a tactile way-finding belt to facilitate navigation in older persons. Ageing International, 34(4), 203-215.

Gruteser, M., & Grunwald, D. (2003, May). Anonymous usage of location-based services through spatial and temporal cloaking. In Proceedings of the 1st international conference on Mobile systems, applications and services (pp. 31-42). ACM.
Guthrie, J. T. (1981). Reading in New Zealand: achievement and volume. Reading Research Quarterly, 6-27.

Dymon UJ. An analysis of emergency map symbology. International Journal of Emergency Management. 2003 Jan 1;1(3):227-37.

Hallpike, C. R., Blades, M., Spencer, C., & Gell, A. (1986). Maps and Wayfinding. Man, 342-346.

Handcock, H. E., Rogers, W. A., Schroeder, D., & Fisk, A. D. (2004). Safety symbol comprehension: Effects of symbol type, familiarity, and age. Human Factors: The Journal of the Human Factors and Ergonomics Society, 46(2), 183-195.

Harrower, M., & Sheesley, B. (2005). Designing better map interfaces: A framework for panning and zooming. Transactions in GIS, 9(2), 77-89.

Hassenzahl, M., & Tractinsky, N. (2006). User experience-a research agenda. Behaviour & information technology, 25(2), 91-97. Retrieved from http://www.tandfonline.com/doi/pdf/10.1080/01449290500330331

Hartley, T., Maguire, E. A., Spiers, H. J., & Burgess, N. (2003). The well-worn route and the path less traveled: distinct neural bases of route following and wayfinding in humans. Neuron, 37(5), 877-888.

Harley JB. Deconstructing the map. Cartographica: The international journal for geographic information and geovisualization. 1989 Oct 1;26(2):1-20.

Harley JB. Maps, knowledge, and power. Geographic Thought-A praxis perspective. 2009.

Head, J., Russell, P. N., Dorahy, M. J., Neumann, E., & Helton, W. S. (2012). Text-speak processing and the sustained attention to response task. *Experimental brain research*, *216*(1), 103-111.

Hearst, M. A. (1995, May). TileBars: visualization of term distribution information in full text information access. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 59-66). ACM Press/Addison-Wesley Publishing Co.

Hinze, A., & Voisard, A. (2003). Location-and time-based information delivery in tourism. In Advances in Spatial and Temporal Databases (pp. 489-507). Springer Berlin Heidelberg.

Hu S, Dai T. Online Map Application Development Using Google Maps API, SQL Database, and ASP .NET. International Journal of Information and Communication Technology Research. 2013 Mar;3(3).

Hoi, L. V., Chuc, N. T., & Lindholm, L. (2010). Health-related quality of life, and its determinants, among older people in rural Vietnam. BMC public health, 10(1), 1.

Huang, C. H., Wan, P. H., Lee, Y. Z., Su, J. Y., Lai, T., Chang, C. L., & Liu, Y. T. (2002). Some phenomena of spatial interaction in the networked spaces. In Proceedings of the Seventh Conference on CAADRIA. .

Hunsberger, J., Harrysson, O., Shirwaiker, R., Starly, B., Wysk, R., Cohen, P., ... & Atala, A. (2015). Manufacturing road map for tissue engineering and regenerative medicine technologies. Stem Cells Transl Med, 4, 130-135.

Hu Y, Janowicz K, Carral D, Scheider S, Kuhn W, Berg-Cross G, Hitzler P, Dean M, Kolas D. A geo-ontology design pattern for semantic trajectories. InInternational Conference on Spatial Information Theory 2013 Sep 2 (pp. 438-456). Springer International Publishing.

Jeng J. Usability assessment of academic digital libraries: Effectiveness, efficiency, satisfaction, and learnability. Libri. 2005;55(2-3):96-121.

Joo, S., Lin, S., & Lu, K. (2011). A usability evaluation model for academic library websites: efficiency, effectiveness and learnability. Journal of Library and Information Studies, 9(2), 11-26.

Kamil, A. C., & Cheng, K. (2001). Way-finding and landmarks: the multiple-bearings hypothesis. Journal of Experimental Biology, 204(1), 103-113.

Kang'ethe, S. M. (2010). Human-rights perspectives on caregiving of people with HIV: the case for the Kanye home-based care programme, Botswana. African journal of AIDS research, 9(2), 193-203. Retrieved from http://www.tandfonline.com/doi/pdf/10.2989/16085906.2010.517489

Kant, K., & Zucker, S. W. (1986). Toward efficient trajectory planning: The path-velocity decomposition. The International Journal of Robotics Research, 5(3), 72-89.

Kido, H., Yanagisawa, Y., & Satoh, T. (2005, July). An anonymous communication technique using dummies for location-based services. In Pervasive Services, 2005. ICPS'05. Proceedings. International Conference on (pp. 88-97).

Kitto S, Nordquist J, Peller J, Grant R, Reeves S. The disconnections between space, place and learning in interprofessional education: an overview of key issues. Journal of interprofessional care. 2013 Sep 1;27(sup2):5-8.

Kitajima, M., Blackmon, M. H., & Polson, P. G. (2005, July). Cognitive architecture for website design and usability evaluation: Comprehension and information scent in performing by exploration. In HCI international 2005 (Vol. 4). Mahwah, NJ: L. Erlbaum Associates.

Knoche, H., & Huang, J. (2012, May). Text is not the enemy-How illiterates use their mobile phones. In NUIs for New Worlds: New Interaction Forms and Interfaces for Mobile Applications in Developing Countries-CHI'2012 workshop.

Koperski, K., & Han, J. (1995, August). Discovery of spatial association rules in geographic information databases. In Advances in spatial databases (pp. 47-66). Springer Berlin Heidelberg.

Kortum, P. T., & Bangor, A. (2013). Usability ratings for everyday products measured with the System Usability Scale. International Journal of Human-Computer Interaction, 29(2), 67-76.

Kozol, J. (2011). Illiterate america. Doubleday.

Kvamme KL. Recent directions and developments in geographical information systems. Journal of Archaeological Research. 1999 Jun 1;7(2):153-201.

Lee S, Dazkir SS, Paik HS, Coskun A. Comprehensibility of universal healthcare symbols for wayfinding in healthcare facilities. Applied ergonomics. 2014 Jul 31;45(4):878-85.

Leung, L. F., & Li, Z. (2002). Experimental evaluation of the effectiveness of graphic symbols on tourist maps. Cartography, 31(1), 11-20.

Li, R., Korda, A., Radtke, M., & Schwering, A. (2014). Visualising distant off-screen landmarks on mobile devices to support spatial orientation. Journal of Location Based Services, 8(3), 166-178.

Lienhart, R., & Effelsberg, W. (2000). Automatic text segmentation and text recognition for video indexing. Multimedia systems, 8(1), 69-81.

Lienhart, R., & Wernicke, A. (2002). Localizing and segmenting text in images and videos. *Circuits and Systems for Video Technology, IEEE Transactions on*, *12*(4), 256-268.

Lin, C. C. (2013). Exploring the relationship between technology acceptance model and usability test. Information Technology and Management, 14(3), 243-255.

Lohse, G. L., & Spiller, P. (1998). Electronic shopping. Communications of the ACM, 41(7), 81-87.

Lynch, K. (1960). The image of the city (Vol. 11). MIT press.

Lysholm, J., & Gillquist, J. (1982). Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. The American journal of sports medicine, 10(3), 150-154.

Massey University (2016). CODE OF ETHICAL CONDUCT FOR RESEARCH, TEACHING AND EVALUATIONS

Matise TC, Chen F, Chen W, Francisco M, Hansen M, He C, Hyland FC, Kennedy GC, Kong X, Murray SS, Ziegle JS. A second-generation combined linkage–physical map of the human genome. Genome research. 2007 Dec 1;17(12):1783-6.

McNaughton, B. L., Battaglia, F. P., Jensen, O., Moser, E. I., & Moser, M. B. (2006). Path integration and the neural basis of the'cognitive map'. Nature Reviews Neuroscience, 7(8), 663-678.

Medhi, I., Pitti, B., & Toyama, K. (2005). Text-Free User Interfaces for Employment Search. Asian Applied Computing Conference. Nepal.

Medhi, I., & Kuriyan, R. (2007a). Text-Free UI: Prospects for Social-Inclusion. International Conference on Social Implications of Computers in Developing Countries. Brazil.

Medhi, I., & Toyama, K. (2007b, December). Full-context videos for first-time, non-literate PC users. In Information and Communication Technologies and Development, 2007. ICTD 2007. International Conference on (pp. 1-9). IEEE

Medhi, I., Gautama, S. N., & Toyama, K. (2009, April). A comparison of mobile money-transfer UIs for non-literate and semi-literate users. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1741-1750). ACM.

Medhi, I., Menon, S. R., Cutrell, E., & Toyama, K. (2010, December). Beyond strict illiteracy: abstracted learning among low-literate users. In Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development (p. 23). ACM.

Medhi, I., Patabandhige, C. R., & Toyama, K. (2007). Cartoon generation for text-free user interfaces. In Int. Workshop on Computer Vision Applications for Developing Regions. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.86.5995&rep=rep1&type=pdf

Medhi, I., Prasad, A., & Toyama, K. (2007, May). Optimal audio-visual representations for illiterate users of computers. In Proceedings of the 16th international conference on World Wide Web (pp. 873-882). ACM.

Medhi, I., Sagar, A., & Toyama, K. (2006, May). Text-free user interfaces for illiterate and semi-literate users. In Information and Communication Technologies and Development, 2006. ICTD'06. International Conference on (pp. 72-82). IEEE.

Mizutani, K., & Omori, T. (1999). Online map formation and path planning for mobile robot by associative memory with controllable attention. In Neural Networks, 1999. IJCNN'99. International Joint Conference on (Vol. 3, pp. 2051-2056). IEEE.

Molich, R., Thomsen, A. D., Karyukina, B., Schmidt, L., Ede, M., van Oel, W., & Arcuri, M. (1999, May). Comparative evaluation of usability tests. In CHI'99 extended abstracts on Human factors in computing systems (pp. 83-84). ACM.

Morrison, C., & Forrest, D. (1995). A study of point symbol design for computer based large scale tourist mapping. The Cartographic Journal, 32(2), 126-136.

Mohamed M, Yangui S, Moalla S, Tata S. Web service micro-container for service-based applications in cloud environments. InEnabling Technologies: Infrastructure for Collaborative Enterprises (WETICE), 2011 20th IEEE International Workshops on 2011 Jun 27 (pp. 61-66). IEEE.

Montello DR. Cognitive map-design research in the twentieth century: Theoretical and empirical approaches. Cartography and Geographic Information Science. 2002 Jan 1;29(3):283-304.

Morais J, Kolinsky R. The literate mind and the universal human mind. Language, brain and cognitive development: Essays in Honor of Jacques Mehle. MIT, Cambridge, Mass. 2001:463-80.

Muhlhausen J. Wayfinding is not signage. Signs of the Times. 2006.

Mungiu, A. (2006). Corruption: Diagnosis and treatment. Journal of democracy, 17(3), 86-99. Nordberg, C. (2010).

Mustafa RA, Connan PA, inventors; Colgate-Palmolive, assignee. Aligned web in a container. United States patent US 5,782,384. 1998 Jul 21.

Natapoff, Alexandra. "Speechless: The silencing of criminal defendants." NYUL Rev. 80 (2005): 1449.

Nejati, V., Shirinbayan, P., Akbari Kamrani, A., Foroughan, M., Taheri, P., & Sheikhvatan, M. (2008). Quality of life in elderly people in Kashan, Iran. Middle East Journal of Age and Ageing, 5(2), 21-5.

Nekrasovski, D., Bodnar, A., McGrenere, J., Guimbretière, F., & Munzner, T. (2006, April). An evaluation of pan & zoom and rubber sheet navigation with and without an overview. In Proceedings of the SIGCHI conference on Human Factors in computing systems (pp. 11-20). ACM.

Nianxue XW. Design Of Open Map Symbol System In Rdgis. (2003) Wtusm Bulletin of Science and Technology.

Nicol A, Tuomi S. Hazard sign comprehension among illiterate adults. Stellenbosch Papers in Linguistics. (2007). 37(1):67-88.

Nielsen, J., & Landauer, T. K. (1993, May). A mathematical model of the finding of usability problems. In Proceedings of the INTERACT'93 and CHI'93 conference on Human factors in computing systems (pp. 206-213). ACM.

Nielsen, J., & Molich, R. (1990, March). Heuristic evaluation of user interfaces. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 249-256). ACM.

O'donnell, A. M., Dansereau, D. F., & Hall, R. H. (2002). Knowledge maps as scaffolds for cognitive processing. Educational Psychology Review, 14(1), 71-86.

Oleinick, A., Amatore, C., & Svir, I. (2004). Efficient quasi-conformal map for simulation of diffusion at disk microelectrodes. Electrochemistry communications, 6(6), 588-594.

Papageorgiou EI. A new methodology for decisions in medical informatics using fuzzy cognitive maps based on fuzzy rule-extraction techniques. Applied Soft Computing. 2011 Jan 31;11(1):500-13.

Passini, R. (1996). Wayfinding design: logic, application and some thoughts on universality. Design Studies, 17(3), 319-331

Peterson, M. P. (1997, June). Trends in Internet map use. In Proceedings of the 19th ICA Conference, Ottawa (Vol. 1, No.

Pitman, R. K., Sanders, K. M., Zusman, R. M., Healy, A. R., Cheema, F., Lasko, N. B., ... & Orr, S. P. (2002). Pilot study of secondary prevention of posttraumatic stress disorder with propranolol. Biological psychiatry, 51(2), 189-192.

Plauché, M., & Nallasamy, U. (2007). Speech interfaces for equitable access to information technology. Information Technologies & International Development, 4(1), pp-69.

Radke, J., & Mu, L. (2000). Spatial decompositions, modeling and mapping service regions to predict access to social programs. Geographic Information Sciences, 6(2), 105-112

RENATE STEINMANN, A. K. (2004). Analysis of online public participatory GIS applications with respect to the differences between the US and Europe. In 24th urban data management symposium.

Richter, K. F., & Winter, S. (2014). Cognitive Aspects: How People Perceive, Memorize, Think and Talk About Landmarks. In Landmarks (pp. 41-108). Springer International Publishing.

Rieman, J., Franzke, M., & Redmiles, D. (1995, May). Usability evaluation with the cognitive walkthrough. In Conference companion on Human factors in computing systems (pp. 387-388). ACM.

Schmid, F., Richter, K. F., & Peters, D. (2010). Route aware maps: Multigranular wayfinding assistance. Spatial Cognition & Computation, 10(2-3), 184-206.

Sheikholeslami, G., Chatterjee, S., & Zhang, A. (1998, August). Wavecluster: A multi-resolution clustering approach for very large spatial databases. In VLDB (Vol. 98, pp. 428-439).

Sholl, M. J. (1988). The relation between sense of direction and mental geographic updating. Intelligence, 12(3), 299-314.

Speaking Books (2015), Global Illiteracy. Retrieved from http://www.speakingbooks.com/impact/overview.html

Steiniger, S., & Hunter, A. J. (2013). The 2012 free and open source GIS software map–A guide to facilitate research, development, and adoption. Computers, Environment and Urban Systems, 39, 136-150.

Steinmann, R., Krek, A., & Blaschke, T. (2005). Can online map-based applications improve citizen participation?. In E-Government: Towards Electronic Democracy (pp. 25-35). Springer Berlin Heidelberg.

Streitz, N. A., Geißler, J., & Holmer, T. (1998). Roomware for cooperative buildings: Integrated design of architectural spaces and information spaces. In Cooperative Buildings: Integrating Information, Organization, and Architecture (pp. 4-21). Springer Berlin Heidelberg.

Svennerberg G. Beginning Google Maps API 3. Apress; 2010 Sep 8.

Tijus, C., Barcenilla, J., De Lavalette, B. C., & Meunier, J. G. (2007). The design, understanding and usage of pictograms. Studies in writing, 21, 17.

Tolman EC. Cognitive maps in rats and men. Psychological review. 1948 Jul;55(4):189.

Tran, T. (2007). Google Maps Mashups 2.0. Google Lat-Long Blog. Posted 11/7/2007. [online]. Retrieved on 2 November 2007 from Wall Street Journal. (2007). Acquisition to Expand Microsoft's Map Services, 13 December 2007.

Tryon, W. W. (2001). Evaluating statistical difference, equivalence, and indeterminacy using inferential confidence intervals: an integrated alternative method of conducting null hypothesis statistical tests. Psychological methods, 6(4), 371.

Tversky, B. (1992). Distortions in cognitive maps. Geoforum, 23(2), 131-138.

Tversky, B. (1993). Cognitive maps, cognitive collages, and spatial mental models. In Spatial Information Theory A Theoretical Basis for GIS (pp. 14-24). Springer Berlin Heidelberg.

Tversky, B. (2002, March). What do sketches say about thinking. In 2002 AAAI Spring Symposium, Sketch Understanding Workshop, Stanford University, AAAI Technical Report SS-02-08 (pp. 148-151).

UNESCO Institute for Statistics (UIS) (2013), INTERNATIONAL LITERACY DATA 2013. Retrieved from http://www.uis.unesco.org/literacy/Pages/data-release-map-2013.aspx

UNESCO Institute for Statistics (UIS) (2015), INTERNATIONAL LITERACY DATA 2013. Retrieved from http://www.uis.unesco.org/literacy/Pages/data-release-map-2013.aspx

Vermote, E. F., Tanré, D., Deuzé, J. L., Herman, M., & Morcette, J. J. (1997). Second simulation of the satellite signal in the solar spectrum, 6S: An overview. Geoscience and Remote Sensing, IEEE Transactions on, 35(3), 675-686.

Verma P, Bhatia JS. Design and development of GPS-GSM based tracking system with Google map based monitoring. International Journal of Computer Science, Engineering and Applications. 2013 Jun 1;3(3):33.

Wang, X., Pang, X., & Luo, Y. (2010, September). LBS-p: A LBS platform supporting online map services. In Vehicular Technology Conference Fall (VTC 2010-Fall), 2010 IEEE 72nd (pp. 1-5). IEEE.

Warrilow, F. 2009. State of the World's Minorities and Indigenous Peoples 2009. "Adult literacy, vocational and tertiary education: why it matters to minorities and states."

Weiss, B. D., Hart, G., McGee, D. L., &D'Estelle, S. (1992). Health status of illiterate adults: relation between literacy and health status among persons with low literacy skills. The Journal of the American Board of Family Practice, 5(3), 257-264.

Weiwei BO. Map Symbol Design in GIS Based on ArcMap. Geospatial Information. 2006;2:026.

Wharton, C., Bradford, J., Jeffries, R., & Franzke, M. (1992, June). Applying cognitive walkthroughs to more complex user interfaces: experiences, issues, and recommendations. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 381-388). ACM.

Williams R. Culture is ordinary (1958). Cultural theory: An anthology. 2011:53-9.

XIE C, CHEN YF. Amelioration of electronic map symbol library based on GDI. Engineering of Surveying and Mapping. 2006;2:012.

You, M., Chen, C. W., Liu, H., & Lin, H. (2007). A usability evaluation of web map zoom and pan functions. International Journal of Design, 1(1).

Zahra SA, Korri JS, Yu J. Cognition and international entrepreneurship: implications for research on international opportunity recognition and exploitation. International business review. 2005 Apr 30;14(2):129-46

Zhao, J., Zheng, C., & Zhou, D. (2008, February). Design and Implementation of a Location-Based Service Platform. In Advanced Communication Technology, 2008. ICACT 2008. 10th International Conference on (Vol. 1, pp. 529-533). IEEE.

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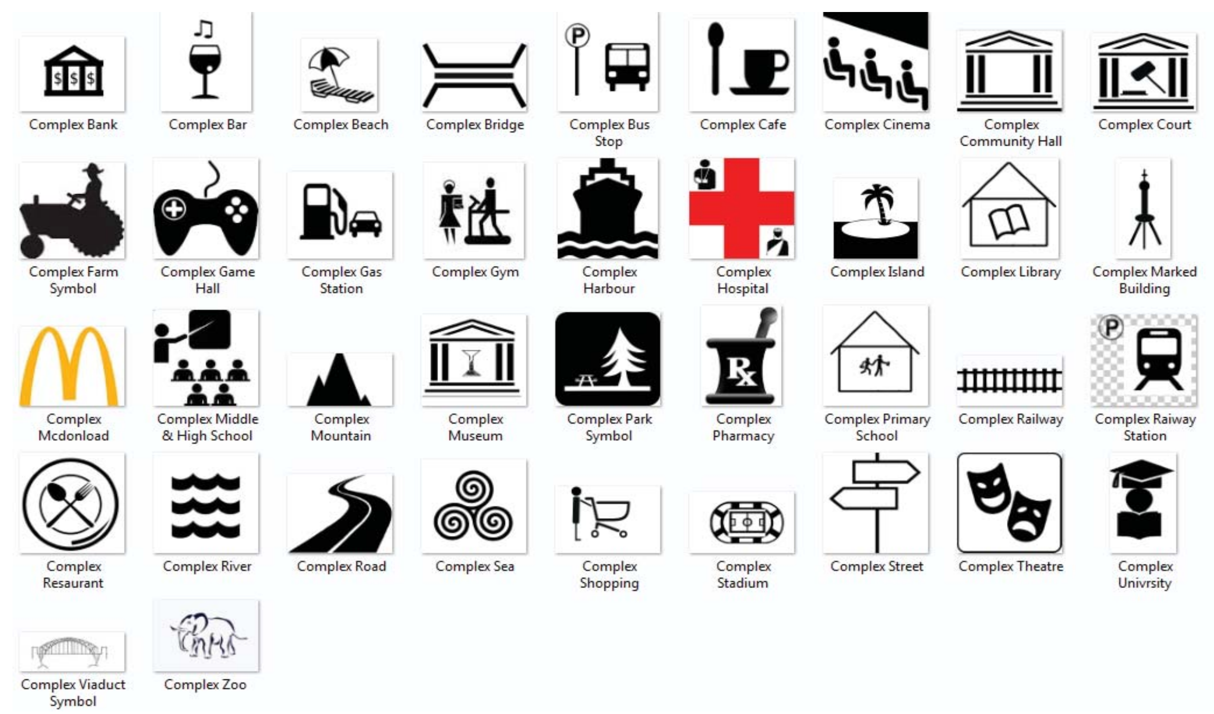
12. Appendix

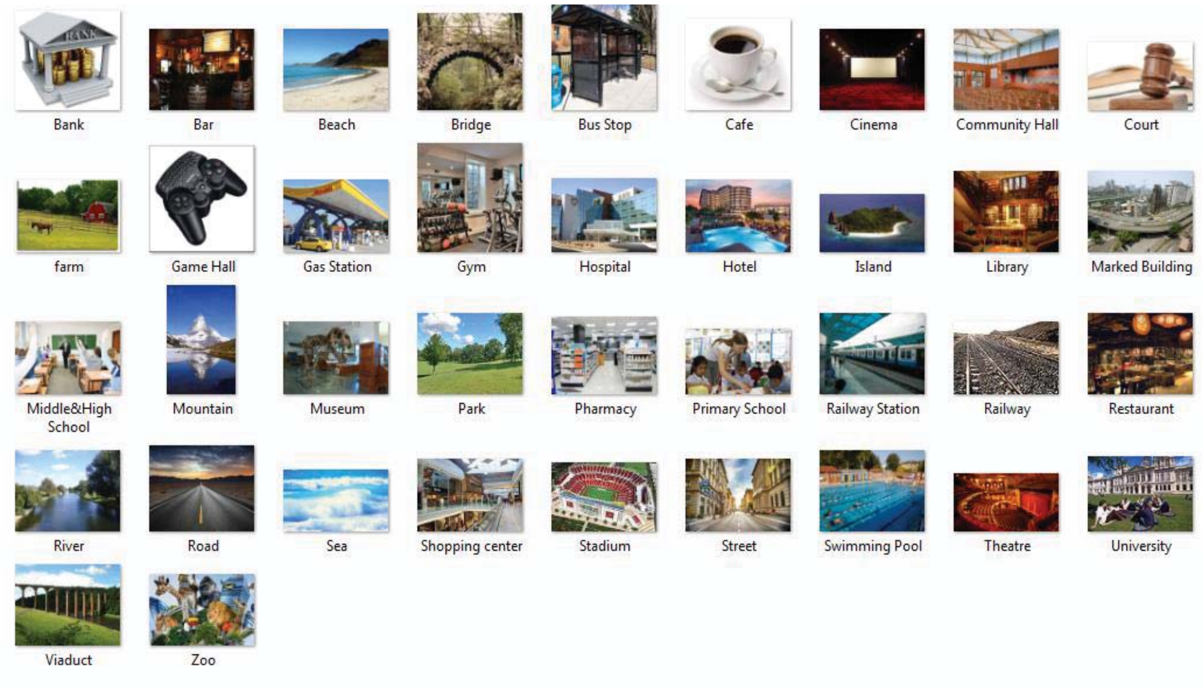
Appendix A: All Designed Symbols

Simple Symbols

Complex Symbols



Photographs



SYMBOL MATCHING GAME

Brief Project Summary

The goal of the project is to design and evaluate text-free maps. The reason for conducting this research is that online maps are being used increasingly around the world, but people who have difficulty reading or who speak other languages are not able to use them because much of their content is conveyed through text. The whole project includes:

- defining which kind of map should be designed (e.g. symbol only, audio only, symbol with text)
- designing the corresponding text-free maps
- running usability and user experience experiments to evaluate the maps.

The results of these experiments will identify which kind of text-free map is the most suitable for illiterate people.

Introduction

- This is a matching gaming. The Landmark Collection Table below contains a total of 38 Landmark Symbols. The three tables "Simple Symbols", "Complex Symbols" and "Photography" all include 20 randomly selected symbols from the Landmark Collection Table, please match the symbol with corresponding landmark.

(NB: Please do not amplify any symbol)

Landmark Collection Table

1 University	2 Gas Station	3 Museum	4 Middle & High School	5 Primary School	6 Zoo
7 Bank	8 Cinema	9 Hospital	10 Gym	11 Swimming Pool	12 Farm
13 Theatre	14 Restaurant	15 Sea	16 River	17 Park	18 Stadium
19 High way	20 Bus Station	21 Railway Station	22 Railway	23 Street	24 Road
25 Avenue	26 Hotel	27 Beach	28 Island	29 Harbour	30 Pharmacy
31 Building	32 Court	33 Mountain	34 Shopping	35 Viaduct	36 Game Hall
37 Bridge	38 Community Hall				

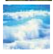
Simple Symbols

Complex Symbols

Photographic Symbols

How long did this Matching Game take you to complete?

Which Symbol type do you like best?

Do you have any suggestons about how these symbols should be used on a map?

DESIGN AND EVALUATION OF TEXT-FREE MAPS

Brief Project Summary

The goal of the project is to design and evaluate text-free maps. The reason for conducting this research is that online maps are being used increasingly around the world, but people who have difficulty reading or who speak other languages are not able to use them because much of their content is conveyed through text. The whole project includes: defining which kind of map should be designed (e.g. symbol only, audio only, symbol with text); designing the corresponding text-free maps and running usability and user experience experiments to evaluate the maps. The results of these experiments will identify which kind of text-free map is the most suitable for illiterate people. You are required to say each feature is good or not for text-free maps and show your reasons. Each meaning of function will be described verbally in chatting software (e.g. Skype, QQ). For this part, we did not use a 5 point Likert scale to replace the table below since we were relying on the qualitative description of reasons for a function being important or not.

Feature	**Good/ Not Good**	**Reason**
Search Bar		
Pan and Zoom		
Position		
Satellite View		
History Records		
Showpicture of place when click symbol		
Audio Notice		
Favorite		
Add location		

This survey is for evaluating each feature of current online map… should there be more here?

Appendix D – Insert Symbols

The process of inserting the created symbols onto the map applications involves firstly, collecting the data of the landmarks as Points of Interest (POI) and storing the name, type, longitude, latitude and scale of each in the form of JSON, then calling the OpenStreetMap service to read the POT JSON (ivjson) and insert the symbol at the appropriate location for the corresponding POI.

```
closer.onclick = function () {
    popup.setPosition(undefined);
    videoElement.pause();
    videoElement.currentTime = 0;

    var imageElement = document.getElementById("imageElement");
        imageElement.src = "";

    imageCtx.clearRect(0, 0, 8000, 8000);
//     videoCtx.clearRect(0, 0, 2000, 2000);

    closer.blur();
    return false;
};
```

```
var ivJson = [
    {
        "name":"Albany Bus Station","ftype":"image&video","lon":174.712497,"lat":-36.722263,scale: 1.0,image_src:'resources/AlbanyBusStation.png'
    },
    {
        "name":"Browns bay","ftype":"image&video","lon":174.7470226,"lat":-36.7144266,scale: 1.0,image_src:'resources/Brownsbay.png'
    },
    {
        "name":"Ponsonby","ftype":"image&video","lon":174.7442273,"lat":-36.8473223,scale: 1.0,image_src:'resources/Ponsonby.png'
    },
    {
        "name":"Sky Tower","ftype":"image&video","lon":174.7624,"lat":-36.848169,scale: 1.0,image_src:'resources/SkyTower.png'
    },
    {
        "name":"Westfield","ftype":"image&video","lon":174.705670,"lat":-36.726376,scale: 1.0,image_src:'resources/Westfield.png'
    },
    {
        "name":"Massey University","ftype":"image&video","lon":174.703408,"lat":-36.733737,scale: 1.0,image_src:'resources/MasseyUniversity.png'
    },
    {
        "name":"1","ftype":"null","lon":174.701584,"lat":-36.726678,scale: 1.0,image_src:'resources/1.png'
    },
    {
        "name":"2","ftype":"null","lon":174.698118,"lat":-36.725061,scale: 1.0,image_src:'resources/2.png'
    },
    {
        "name":"3","ftype":"null","lon":174.694981,"lat":-36.725764,scale: 1.0,image_src:'resources/3.png'
    },
    {
        "name":"4","ftype":"null","lon":174.703600,"lat":-36.733636,scale: 1.0,image_src:'resources/4.png'
    },
```

```
//Create icon Element
var vectorSource1 = new ol.source.Vector();
var vectorSource2 = new ol.source.Vector();
for(var p in ivJson){
    var iconFeature = new ol.Feature({
        geometry: new ol.geom.Point([ivJson[p].lon,ivJson[p].lat]),
        name: ivJson[p].name,
        ftype: ivJson[p].ftype
    });

    var iconStyle = new ol.style.Style({
        image: new ol.style.Icon(/** @type {olx.style.IconOptions} */({
            scale: ivJson[p].scale,
            src: ivJson[p].image_src
```

Appendix E —Detailed Design of Pan and Zoom

Pan is set as from "Bottom to Center". Zoom is amplified four times for the center [-10997148, 4569099]. The code below is for setting the view of the interface. The longitude for the center of enlargement is set at 174.703408, the latitude at -36.733737, 4 * magnification.

```
var layers = [
    new ol.layer.Tile({
      source: new ol.source.MapQuest({layer: 'sat'})
    }),

  ];
  var map = new ol.Map({
    layers: layers,
    target: 'map',
    view: new ol.View({
      center: [-10997148, 4569099],
      zoom: 4
    })
  });
```

Code of Zoom

From New Zealand to North Island of New Zealand through Zoom

New Zealand **North Island of New Zealand**

The route of pan is from the bottom center.

```
var popup = new ol.Overlay({
    element: container,
    positioning: 'bottom-center',
        autoPan: true,
    stopEvent: false,
    autoPanAnimation: {
        duration: 250}
});
```

Code of Pan

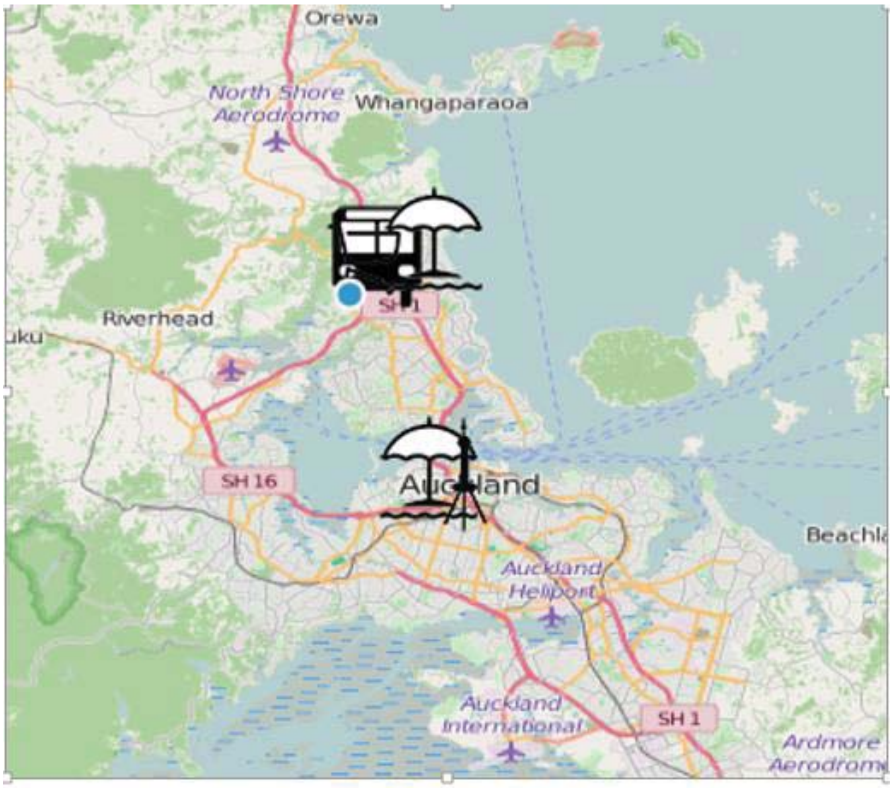
From Albany Shopping Centre to Albany Browns Bay:

Albany Shopping Centre

Albany Browns Bay

Appendix F - Obtain Current Location

HTML5 provides the Location Based Service (Geolocation API) allowing users to share their location in the web map application, which offers GPS (Global Positioning System) data.



Geolocation

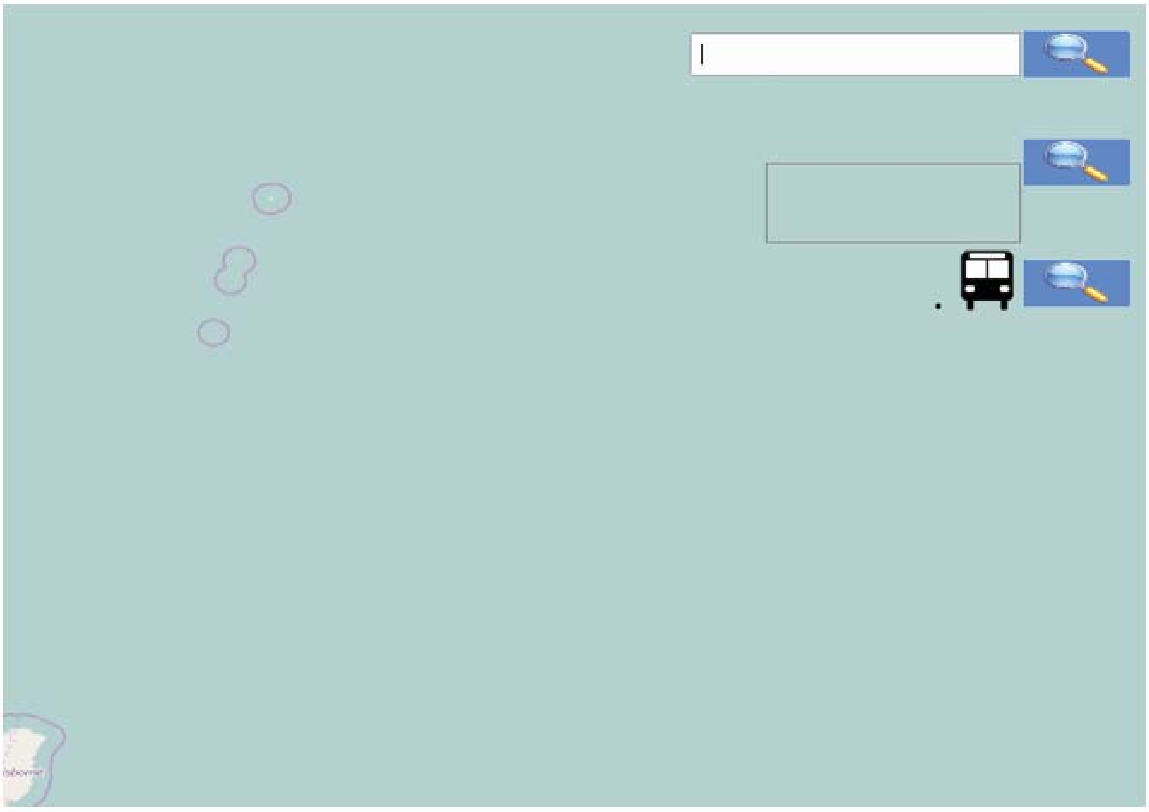
```
geolocateBtn.addEventListener('click', function () {

    var positionFeature = new ol.Feature({
        name: 'MessyUniversity',
        ftype: 'null'
    });

    positionFeature.setStyle(new ol.style.Style({
        image: new ol.style.Circle({
            radius: 6,
            fill: new ol.style.Fill({
                color: '#3399CC'
            }),
            stroke: new ol.style.Stroke({
                color: '#fff',
                width: 2
            })
        })
    }));

    var options = {
        enableHighAccuracy: true,
        maximumAge: 1000
    }
    if (navigator.geolocation) {
        //Browser supports geolocation
        navigator.geolocation.getCurrentPosition(onSuccess, onError, options);

    } else {
        //Browers doesn't support geolocation
    };
```

```
        //Sucess finding the position
        function onSuccess(position) {
            //return users' poistion
            //Longitude
            var longitude = position.coords.longitude;
            //Latitude
            var latitude = position.coords.latitude;
            //  var polygon = /** @type {ol.geom.SimpleGeometry} */(feature.getGeometry());
            //Create a Point
            // var point = new Point(longitude, latitude);

           var coordinates = [longitude, latitude];
            positionFeature.setGeometry(coordinates ?
    new ol.geom.Point(coordinates) : null);
            vectorSourceCX.addFeature(positionFeature);

//                  var featuresOverlay = new ol.FeatureOverlay({
//                      map: map,
//                      features: [positionFeature]
//                  });

            view.setCenter(coordinates);
            view.setZoom(10);
            //   map.centerAndZoom(point, 15);
        };
```

```
        //Failure in finding users' postion
        function onError(error) {
            switch (error.code) {
                case 1:
                    alert("Position service is rejected");
                    break;
                case 2:
                    alert("Can't obtain the position data");
                    break;
                case 3:
                    alert("Delay obtain the Position Information");
                    break;
                case 4:
                    alert("Unkown Error");
                    break;
            }
        };
    }, false);
```

Appendix G – Search Bar

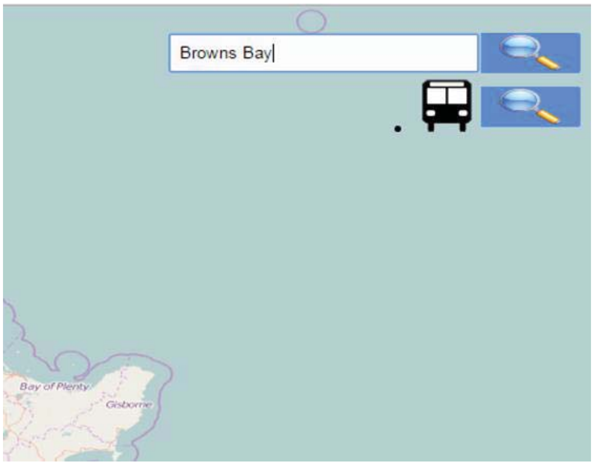
The search bar is implemented by setting a DIV at the right top of the interface, which includes a table with four rows. The first row is the “Text Search”, the second row is the “Audio Search”, the third row is the “Icon (symbol) Search”, the last row is the “Icons Tab”.



Layout of Search Bar

Text Search Bar

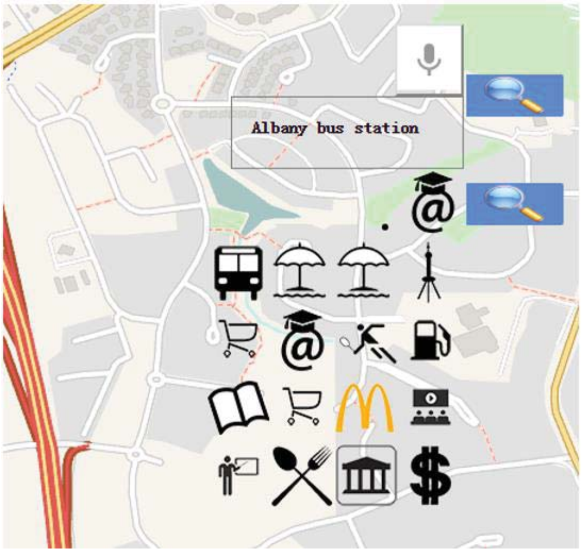
The text search bar is implemented by creating an “Input Box” in the first column of first row, defining a “Click Event” in the “Javascript” and using the function SearchFeatureFromName(name) to handle this Event that then searches the corresponding “value“ stored in the “JSON format” for the parameter” of “Input Box”.

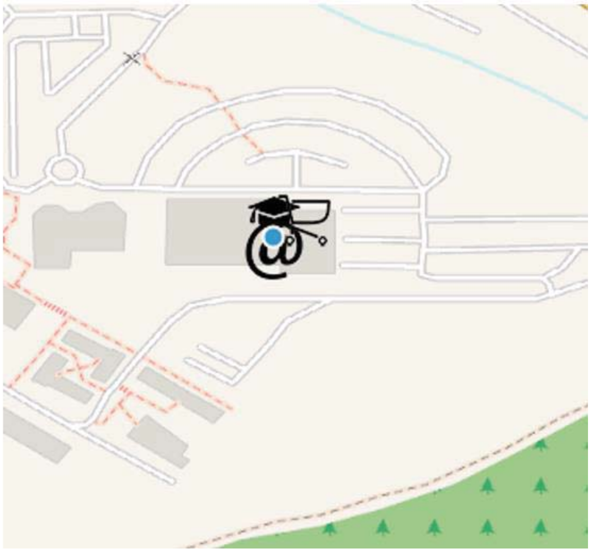



```javascript
// name search
var btnSearch = document.getElementById('btnSearch');
btnSearch.addEventListener('click', function () {
    yyname = eval(document.getElementById('name')).value;
    SearchFeatureFromName(yyname);

}, false);

function SearchFeatureFromName(name)
{
    removeAllFeatures();

    for(var p in ivJson) {
        var sname = ivJson[p].name;
        if(name.toLowerCase() == sname.toLowerCase())
        {
            var positionFeature = new ol.Feature({
                name: ivJson[p].name,
                ftype: 'null'
            });
            positionFeature.setStyle(positionStyle);
            vectorSourceCX.addFeature(positionFeature);
            var coordinates = [ivJson[p].lon, ivJson[p].lat];
            positionFeature.setGeometry(coordinates ?
            new ol.geom.Point(coordinates) : null);
            view.setCenter(coordinates);
            view.setZoom(15);
        }
    }
}
```

Symbol Search Bar

The symbol search bar is implemented by firstly creating an “IconImage”, then defining a “Click Event” in the javascript for setting and displaying the “Icon”. The function selecticonimage (name) is to replace the selected “Icon” and hide the “Icon Tab”.



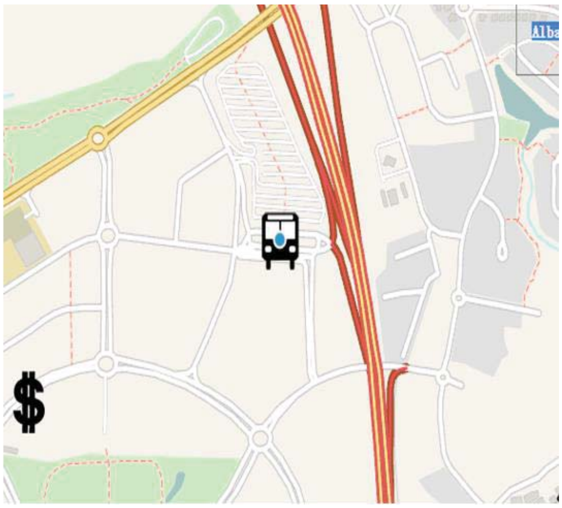


```
var btnIconSearch = document.getElementById('btnIconSearch');
btnIconSearch.addEventListener('click', function () {
    iconname = eval(document.getElementById('iconname')).value;
    SearchFeatureFromName(iconname);

}, false);
```

```
var iconsTab = document.getElementById('iconsTab');
var iconimage = document.getElementById('iconimage');
iconimage.addEventListener('click', function () {
    iconsTab.style.display = iconsTab.style.display=="block" ? "none" : "block";
}, false);

function selecticonimage(name)
{
    var iconname=document.getElementById("iconname");
    iconname.value = name;

    var obj = document.getElementById("iconimage");
    var sname = name.replace(/\s+/g, "");
    obj.innerHTML=document.getElementById(sname).innerHTML;
    iconsTab.style.display = "none";
}
```

Audio Search Bar

The "Google Web Speech API" is used to convert audio to text, then execute the same task as the "Text Search Bar" (YY means the Audio).



```
var btnYYSearch = document.getElementById('btnYYSearch');
btnYYSearch.addEventListener('click', function () {
    yyname = final_span.innerHTML;
    SearchFeatureFromName(yyname);

}, false);
```

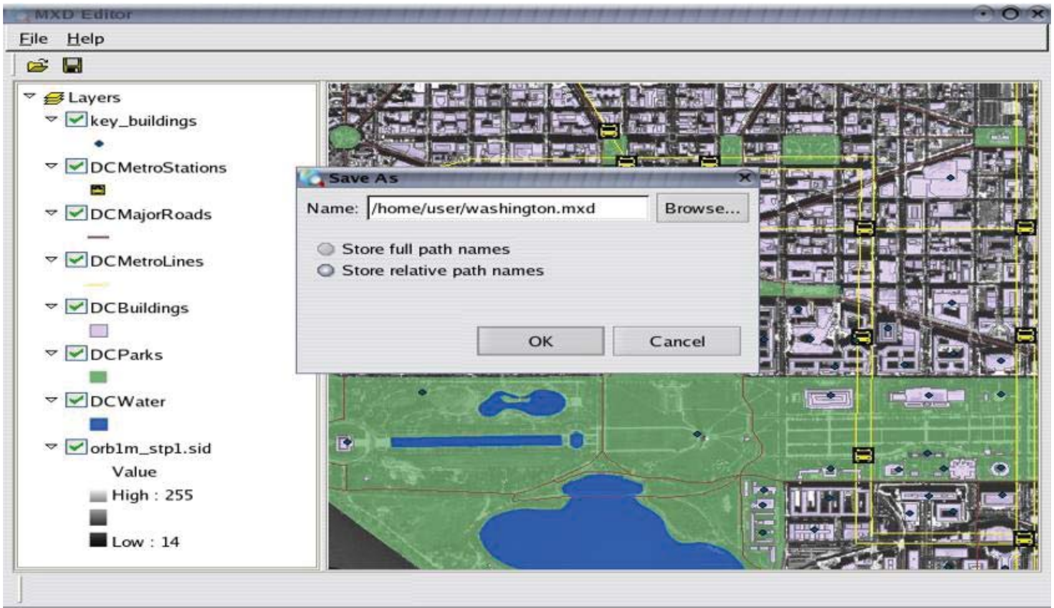
The voice recognition process only runs in Google Chrome.

```
var recognizing = false;
var ignore_onend;
var start_timestamp;
var yycx = false;
if (!('webkitSpeechRecognition' in window)) {
  upgrade();
} else {
  start_button.style.display = 'inline-block';
  var recognition = new webkitSpeechRecognition();
  recognition.continuous = true;
  recognition.interimResults = true;

  recognition.onstart = function() {
    recognizing = true;
    start_img.src = 'https://www.google.com/intl/en/chrome/assets/common/images/content/mic-animate.gif';
  };

  recognition.onerror = function(event) {
    if (event.error == 'no-speech') {
      start_img.src = 'https://www.google.com/intl/en/chrome/assets/common/images/content/mic.gif';
      ignore_onend = true;
    }
    if (event.error == 'audio-capture') {
      start_img.src = 'https://www.google.com/intl/en/chrome/assets/common/images/content/mic.gif';
     ignore_onend = true;
    }
    if (event.error == 'not-allowed') {

      ignore_onend = true;
    }
  };
```

```
  recognition.onend = function() {
    recognizing = false;
    if (ignore_onend) {
      return;
    }
    start_img.src = 'https://www.google.com/intl/en/chrome/assets/common/images/content/mic.gif';
    if (!final_transcript) {
      return;
    }
    if (window.getSelection) {
      window.getSelection().removeAllRanges();
      var range = document.createRange();
      range.selectNode(document.getElementById('final_span'));
      window.getSelection().addRange(range);
    }
  };
```

Appendix H – Cut the Text

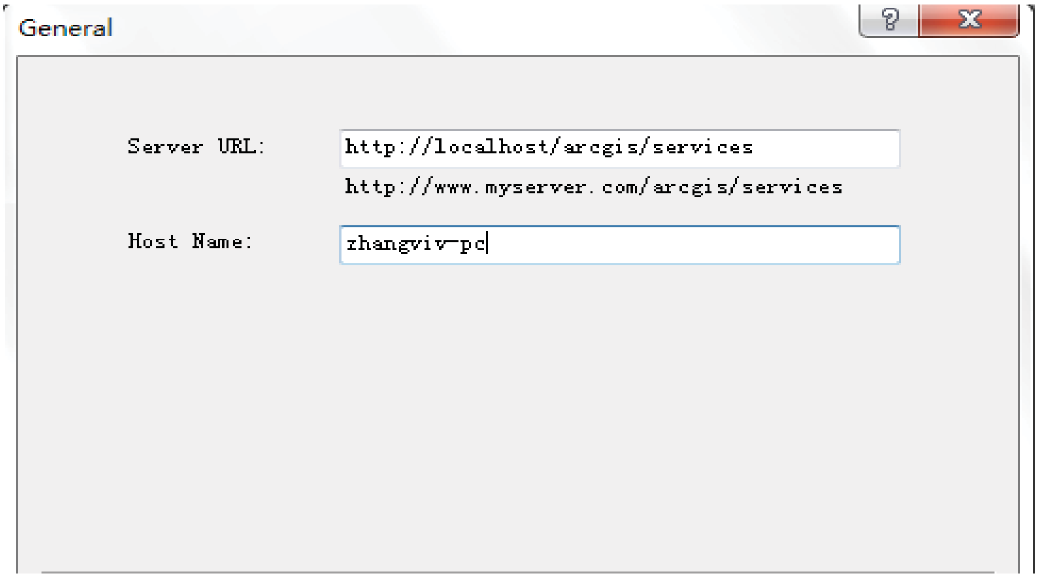
The process of removing the text from the online map involves firstly downloading all vector data from OpenStreetMap and running the symbol settings of each Point, Line and Face according to the scale of OpenStreetMap. This is followed by saving each scale data as the Mxd file in the ArcGIS, then converting these scale data into tile data (tile data includes Road, Traffic lines and other map elements). The third stage involves using the API function "ol.source.TileArcGISRest" of ArcGIS Tile Data to add the layer, insert the POI and set the distinguishability of the interface. The final stage involves using the same method as for the text map to add all of the map functions.



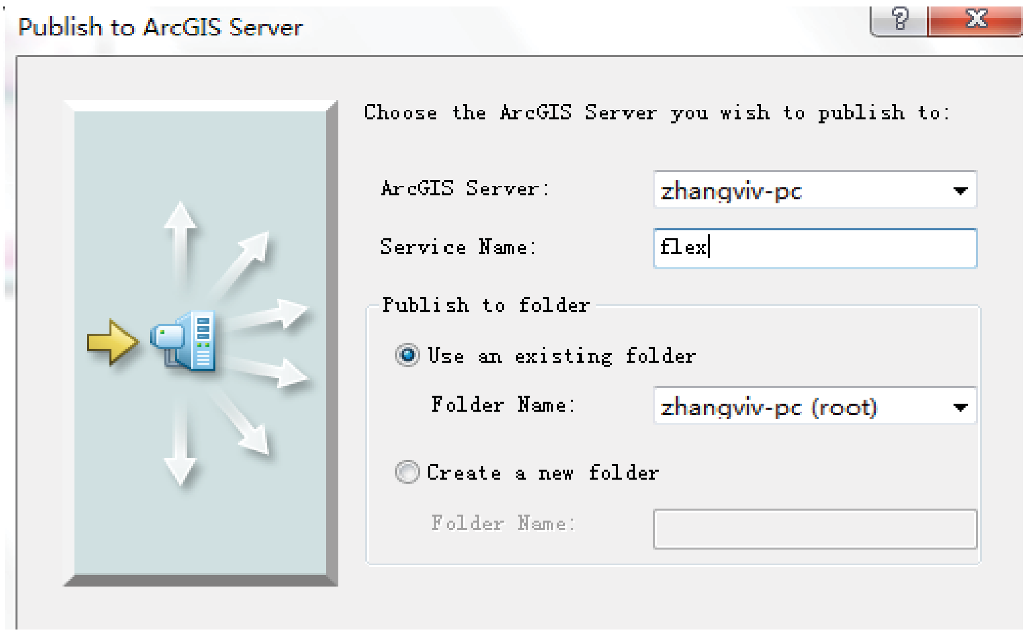
MXD File

All vector data besides text

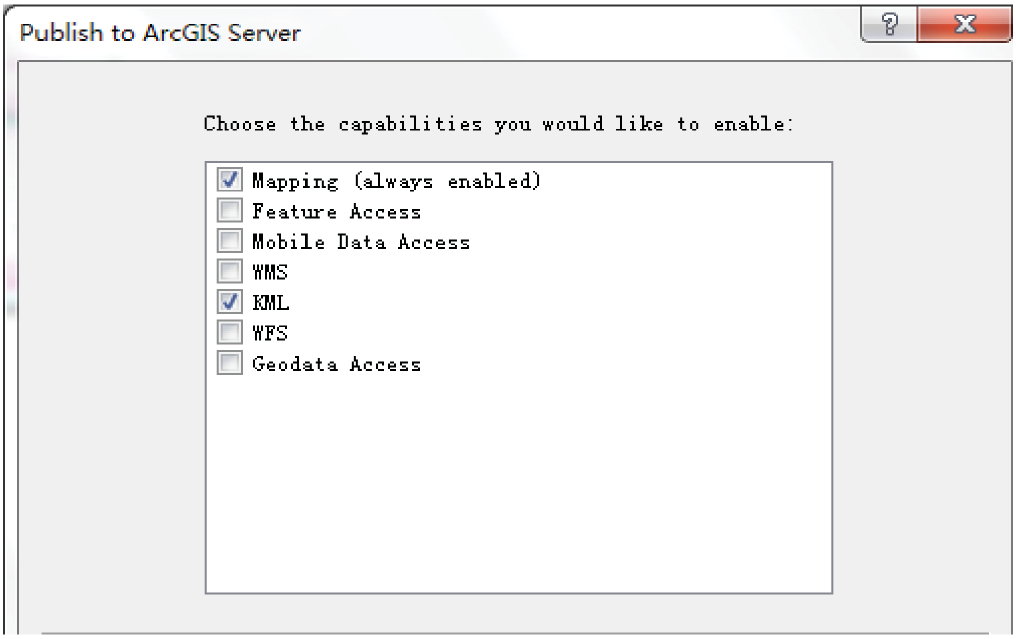
Appendix I - Map Published



Choose the Manager GIS Server



Publish the "MXD" file to the ArcGIS Server



Select the service

Appendix J – Questionnaire for Map Evaluation

TEXT-FREE MAPS PROJECT

Brief Project Summary

The goal of the project is to design and evaluate text-free maps. The reason for conducting this research is that online maps are being used increasingly around the world, but people who have difficulty reading or who speak other languages are not able to use them because much of their content is conveyed through text. The whole project includes:

- defining which kind of map should be designed (e.g. symbol only, audio only, symbol with text)
- designing the corresponding text-free maps and running usability
- use experience experiments to evaluate the maps.

The results of these experiments will identify which kind of text-free map is the most suitable for illiterate people.

This survey is for evaluating each designed map. You will be asked to complete 5 tasks and give feedback about how you use the map. For illiterate people, I will read out the questionnaire out for them to enable them to finish this questionnaire. Sincerest thanks for your help!

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Pre-Question

Please circle your age range.

15~25	**25~35**	**35~45**	**45~55**	**55~65**

What is your occupation?

____

How often do you use maps? (Please circle your answer)

Never	**Rarely Used**	**General**	**Very Often**

How often do you use online maps? (Please circle your answer)

Never	**Rarely Used**	**General**	**Very Often**

What is your first language? (Please circle your answer)

English	**Chinese**	**Other**

How well do you speak English? (Please circle your answer)

Can't speak any English	**Poor**	**General**	**Native English Speaker**

Part One: Route Searching

Start recoding

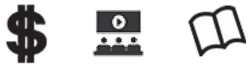
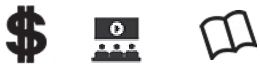
Please find the shortest route between the two places listed in the first column of the table below (you need to find 2 routes in total).

For each route, please find two landmarks you will pass along the way if you follow your chosen route.

Route	List two landmarks on the way
Massey University ↓ **Albany Bus Station**	
Albany Bus Station ↓ **Sky Tower**	

Part Two: Usability Testing

Task No	Task
1.	**Please find the following three places on the map using any method you choose (Massey University, Sky Tower, Albany Bus Station)**
2.	**Please find your current location on the map using any method you choose.**

3.	**Please use Pan and/or Zoom to find the following symbols.** 
4.	**Please write down the place name for symbols below (found in Task No 3)** 

Part Three: System Usability Scale & Satisfaction Test

Usability Evaluation	Strongly Disagree	Disagree	Undecided	Agree	Strong Agree
I think that I would use this map frequently					
I found this map unnecessarily complex					
I thought this map was easy to use					
I think that I would need the support of a technical person to be able to use this map					
I think all functions in this map are well integrated					
I thought there was too much inconsistency in this system.					
I would imagine that most people would learn to use this system very quickly					
I found the system very cumbersome to use					
I felt very confident in using this map					
I needed to learn a lot of things before I could get going with this map					

Part Four: Question and Answer

1. Do you like the interface layout of the map? (Yes/No) Any suggestions about the layout improvement?

2. Which part is the most difficult in learning to use this web map?

3. Do you think it is easy to understand the meaning of the symbols? If not, which symbols need to be changed?

4. Which functions in the web map did you find most difficult to use?

5. Do you think the search bar is useful in the map? Why?

6. Do you think there are any new functions that need to be added? What are they?

7. Do you like this map? (Yes/ No). Can you share some ideas about how to improve this map?

Appendix K: Analysis of the Statistical Significance of Differences in Time-Taken

The statistical significance of the differences in time-taken was calculated in Microsoft Excel 2007. All the units of time are converted into numeric data. This Appendix provides an example calculation.

Native English Speakers	Non- English Speakers	Illiterate People
17.15	25.38	67.49
12.1	32.17	75.32
21.15	14.05	65.43
9.07	29.11	57.31
22.41	41.09	81.57
19.59	32.11	66.46
10	27.08	42.15
13.41	33.31	71.67
14.01	19	35.52
15.23	44.21	56.94
7.07	27.54	66.37
26.34	33.21	78.44
31.52	20.51	57.75
17.05	50.07	46.38
19.11	24.33	51.43
22.34	17.09	59.59
30.11	9.04	47.78
18.21	30.08	68.34
21.28	34.57	57.01
9.45	22.31	57.5
24.41	16.24	59.27
13.77	32.54	69.22
30.42	27.34	46
27.12	50.45	74.49

34.01	24.59	55.33
10.48	26.33	46.21
12.37	27.11	39
15.44	17.41	43.42
18.08	33.33	55.58
28.05	26.38	69.13

The result illustrate the analysis for both rows and columns, the key information for measuring the significance is “F”, “P-value” and “F crit” of the columns.

Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Rows	1915.561	29	66.05383569	0.790321838	0.734818325	1.860811435
Columns	1280.941	1	1280.941215	15.326223	0.000503857	4.182964289
Error	2423.774	29	83.57840121			

Appendix L: How to calculate SUS Score

To calculate the SUS score, each item's score ranges from 0 to 4. For items of an uneven number (13.5….9), the score contribution is the scale position minus 1. For items with an even number (2,4….10), the score contribution is 5 minus the scale position. All score contributions were added together and then multiplied by 2.5 to convert the conventional score (0~40) to the final score (0~100) (Brooke, 1996). Based on previous study, a SUS score above a 68 would be considered above average and anything below 68 is below average (Brooke, 1996; Borsci, 2009; Bangor et al., 2009).

An example is shown below:

In the following example, the score contribution of items with uneven numbers is 2, 3, 1, 2 and 1 respectively. The score contribution of items with even number are 3, 2, 4, 1,0. The sum of score contributions is 2+3+1+2+1+3+2+4+1+0 = 18. The SU score is 18 * 2.5 =45. As 45 is much smaller than 68 (average score), the usability of this product is not high, as assessed by this individual

Usability Evaluation	Strongly Disagree	Disagree	Undecided	Agree	Strong Agree
I think that I would use this map frequently	**1**	**2**	**3** √	**4**	**5**
I found this map unnecessarily complex	**1**	**2** √	**3**	**4**	**5**
I thought this map is easy to use	**1**	**2**	**3**	**4** √	**5**
I think that I would need the support of a technical person to be able to use this map	**1**	**2**	**3** √	**4**	**5**
I think all functions in this map are well integrated	**1**	**2** √	**3**	**4**	**5**
I thought there was too much inconsistency in this system	**1** √	**2**	**3**	**4**	**5**

I would imagine that most people would learn to use this system very quickly	**1**	**2**	**3** √	**4**	**5**
I found the system very cumbersome to use	**1**	**2**	**3**	**4** √	**5**
I felt very confident in using this map	**1**	**2** √	**3**	**4**	**5**
I needed to learn a lot of things before I could get going with this map.	**1**	**2**	**3**	**4**	**5** √

Appendix M: Significant Difference of SUS scores for each Group

To calculate the significance of the difference in SUS scores for each kind of map, the first step was to list all SUS scores for each map within one participant category, then calculate the significance measures in Microsoft Excel 2007 as shown in Appendix F. The example below is intended to show the listing of SUS scores of different all kinds of maps for each specific participant:

Native English Speakers				
Text with Symbol-only	**Text-free with symbol-only**	**Text with Audio-only**	**Text-free with Audio-only**	**Text-free with Symbol and Audio**
82.5	**67.5**	**87.5**	**55**	**57.5**
77.5	**62.5**	**85**	**57.5**	**80**
72.5	**57.5**	**75**	**57.5**	**60**
67.5	**70**	**85**	**75**	**67.5**
87.5	**67.5**	**77.5**	**50**	**75**
77.5	**65**	**85**	**65**	**65**

Non- English Speakers				
Text with Symbol-only	Text-free with symbol-only	Text with Audio-only	Text-free with Audio-only	Text-free with Symbol and Audio
55	67.5	52.5	30	45
70	65	35	27.5	55
62.5	62.5	57.5	47.5	72.5
65	65	40	35	65
70	70	37.5	45	65
67.5	75	47.5	40	57.5

Illiterate People				
Text with Symbol-only	Text-free with symbol-only	Text with Audio-only	Text-free with Audio-only	Text-free with Symbol and Audio
42.5	17.5	45	30	50
37.5	27.5	32.5	15	42.5
30	7.5	35	27.5	75

22.5	**35**	**35**	**32.5**	**70**
37.5	**20**	**35**	**20**	**55**
40	**27.5**	**42.5**	**25**	**52.5**

Test Record

Test One

Time Recording

Task One	
How long is the route (Massey University to Albany Bus Station)	
How long is the route (Albany Bus Station to Sky Tower)	
Task Two	
How long for first place Search (Massey University)	
How long for second place Search (Albany Bus Station)	
How long for third place Search (Sky Tower)	
How long for first symbol Search	
How long for second symbol Search	
How long for third symbol Search	

<table>
<tr><td>Task No</td><td colspan="6">How did you finish the task</td></tr>
<tr><td colspan="2">Is it the shortest route? (M to A)</td><td>Yes</td><td colspan="2">Not Shortest Route</td><td colspan="2">Wrong Landmark</td></tr>
<tr><td colspan="2">Is it the shortest route? (A to S)</td><td>Yes</td><td colspan="2">Not Shortest Route</td><td colspan="2">Wrong Landmark</td></tr>
<tr><td rowspan="3">1.</td><td>How do you finish the first place search?</td><td>Text Search Bar</td><td>Symbol Search Bar</td><td>Audio Search Bar</td><td>Observation</td><td>Not Finished</td></tr>
<tr><td>How do you finish the second place search?</td><td>Text Search Bar</td><td>Symbol Search Bar</td><td>Audio Search Bar</td><td>Observation</td><td>Not Finished</td></tr>
<tr><td>How do you finish the third place search?</td><td>Text Search Bar</td><td>Symbol Search Bar</td><td>Audio Search Bar</td><td>Observation</td><td>Not Finished</td></tr>
<tr><td>2.</td><td colspan="2">Find my position successfully?</td><td colspan="2">YES</td><td colspan="2">NO</td></tr>
<tr><td rowspan="3">3.</td><td colspan="2">Find first symbol successfully?</td><td colspan="2">YES</td><td colspan="2">NO</td></tr>
<tr><td colspan="2">Find second symbol successfully?</td><td colspan="2">YES</td><td colspan="2">NO</td></tr>
<tr><td colspan="2">Find third symbol successfully?</td><td colspan="2">YES</td><td colspan="2">NO</td></tr>
</table>

4.	**Can you tell place names of all three symbols correctly?**	**YES**	**NO**
	If No, what are these incorrect symbols?	**YES**	**NO**

Appendix O: Questionnaire for Map Evaluation (Chinese Version)

无字地图的设计及评估

项目摘要

这次实验的目标是对无字地图的设计及评估。由于网页地图非常流行，但是许多不知字或只会说母语的人无法使用它们因为这些地图都是基于文字。 整个研究过程包括：确定要设计的地图种类(例如，纯图标，纯语音，图标和文字); 设计相应的地图并且对地图的可用性进行评估。最终结果会展示最适合文盲使用的地图。

此次是对已设计的地图的评估调查。在此次调查中您会被要求完成 5 个任务，并且需要您给出反馈。对于文盲我会叫报告读出并且帮助他们完成。

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

个人问题

请圈出你的年龄范围

15~25	**25~35**	**35~45**	**45~55**	**55~65**

你的职业?

使用地图的频率？(请圈出答案)

从未	很少用	一般	很常用

使用网页地图的频率？(请圈出答案)

从未	很少用	一般	很常用

你的母语是什么？(请圈出答案)

英语	中文	其他

你英语说得怎样？(请圈出答案)

完全不会	会一点	一般	很好

任务 1：路线查询

开始记录

根据以下表格列出的地名找出两条最近的路线，在每一条线路上你需要定义 2 个地标。

路线	两个地标
梅西大学 ↓ 奥尔巴尼车站	
奥尔巴尼车站 ↓ 天空塔	

任务 2: 使用性测试

性能评估	强烈不同意	不同意	不确定	同意	非常同意

任务序列	任务
1.	使用任何方法找出以下 **3** 个地名 **(**梅西大学，天空塔，奥尔巴尼车站**)**
2.	使用任何方法找出你目前的位置
3.	请使用平移和放大的方法找出以下 **3** 个图标**.** 
4.	请找出以下 **3** 个图标写出他们的地名

我认为我会频繁地使用该地图					
我发现该地图不必要得复杂					
我认为地图使用简单					
我认为我需要别人帮我使用该地图					
我认为地图的功能很完整					
我认为地图中有太多不一致					
我认为人们会很快地学会使用地图					
我发现地图难以使用					
我使用地图时很自信					
在我使用地图前要学习很多东西					

第 3 部分: 系统性能 & 满意度测试

第 4 部分: 整体评估

3. 你喜欢界面的布局么？（喜欢/不喜欢)。有什么改进意见。

4. 你认为该地图最难学习是那部分?

5. 你能很快了解这些图标的意思么? 如果不能，哪些图标需要被改进?

6. 你认为哪个功能是最难使用的?

7. 你认为搜索框有用么? 为什么?

8. 你认为需要添加哪些新功能？

9. 你喜欢该地图么？（喜欢/不喜欢）有哪些需要改进的